THE DEVELOPMENT OF PERCEPTIONS OF FACIAL ATTRACTIVENESS

The Development of Perceptions of Facial Attractiveness

By
Larissa N. Vingilis-Jaremko, Hon. B.Sc.

A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy

McMaster University

DOCTOR OF PHILOSOPHY (2013)   McMaster University

Psychology, Neuroscience & Behaviour

TITLE: The Development of Perceptions of Facial Attractiveness

AUTHOR: Larissa N. Vingilis-Jaremko, Hon. B.Sc. (University of Toronto)

SUPERVISOR: Professor Daphne Maurer

NUMBER OF PAGES: x, 162

Abstract

There is strong agreement among adults both within and across cultures as to which faces are attractive (Langlois et al., 2000), and these perceptions can affect social interactions via the 'beauty is good' stereotype (Dion, Berscheid, & Walster, 1972). Adults perceive faces that are symmetrical to be more attractive than faces that are less symmetrical (Perrett et al., 1999), and faces that approximate the population average to be more attractive than most other faces (Langlois & Roggman, 1990). I examined the development of the influence of symmetry and averageness on children's judgments of facial attractiveness in the faces of children and adults. In the work presented in chapters 2 and 3, I presented children and adults with pairs of faces that had been transformed to be more symmetrical and less symmetrical (chapter 2) or closer and farther from their group average (chapter 3). On each trial, participants selected which face was more attractive from the pair. I found that symmetry did not influence 5-year-olds' judgments of attractiveness, but it did influence 9-year-olds' judgments of attractiveness although to a lesser extent than those of adults. I additionally found that averageness strongly influenced 5-year-olds' attractiveness judgments, and the strength of the preference increased from age 5 to 9, and from age 9 to adulthood. These findings are the first demonstrations that symmetry and averageness influence attractiveness judgments prior to adolescence, and that they influence attractiveness judgments in children's faces. To assess whether natural differences in face experience can affect how strongly averageness is preferred in different face categories, I tested children attending single-sex schools and expected averageness to influence attractiveness judgments more strongly in same-sex than opposite-sex faces of their own age (chapter 4). I did not find that pattern of results. Averageness might influence attractiveness judgments regardless of the age and sex of face because a minimum level of face experience could be adequate for attractiveness judgments based on a prototype and/or because of similarities among averages of different ages and sexes. Together, the findings of this thesis demonstrate that children assess facial attractiveness based on some of the same dimensions as do adults, but that children are more tolerant of deviations from averageness and symmetry. Developmental changes might reflect the refinement of a face prototype as experience with faces increase, increased visual sensitivity as the visual system develops, and/or increased salience of cues for mate choice after puberty.

Acknowledgements

I would like to thank Daphne Maurer, my supervisor, whom I deeply admire. Thank you for your guidance, support, and rigorous research training. I feel very privileged to have the opportunity to learn from you.

I would also like to thank my committee members, Laurel Trainor and David Feinberg. Laurel, your unique perspective and thoughtful questions have provided wonderful new insight into my research. David, your wealth of knowledge and training on stimulus creation methods have been invaluable.

I would also like to thank Terri Lewis, Sally Stafford, and all other past and current members of the Visual Development Lab for their assistance and thoughtful feedback. Thank you as well to the undergraduate students, lab volunteers, and participants who assisted with the research presented in this thesis.

Thank you to the wonderful friends I made at McMaster for their support and for the good times.

Finally, special thanks to my family. Dad, thank you for always being my biggest fan and for always being there. Mom, thank you for all of your support and for everything you do for me. Thank you to my grandparents, aunt, uncle, and cousins for their support.

Table of Contents

Preface

This thesis is composed of three manuscripts. The work presented in chapter 2 has been accepted for publication in a peer-reviewed journal, and the manuscripts presented in chapters 3 and 4 are under review for publication in peer-reviewed journals. I am the primary author on all three manuscripts.

The first empirical chapter is the following publication: Vingilis-Jaremko, L., Maurer, D. (2013). The Influence of Symmetry on Children's Judgments of Facial Attractiveness. *Perception*, 42, 302-320. I was responsible for experimental design, stimulus creation, data collection, data analysis, and manuscript preparation.

The second empirical chapter is the following manuscript: Vingilis-Jaremko, L., Maurer, D. (in press). The Influence of Averageness on Children's Judgments of Facial Attractiveness. *Journal of Experimental Child Psychology*, http://dx.doi.org/10.1016/j.jecp.2013.03.014. I was responsible for experimental design, stimulus creation, data collection, data analysis, and manuscript preparation.

The third empirical chapter is the following manuscript: Vingilis-Jaremko, L., Maurer, D. & Gao, X. (submitted). The Influence of Attending a Single-Sex School on Children's Judgments of Facial Attractiveness. *Journal of Experimental Child Psychology*, Manuscript ID JECP- D-13-00026. I was responsible for experimental design, stimulus creation, data collection, data analysis, and manuscript preparation.

List of Figures

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 1: Introduction

Adults, both within and across cultures, tend to agree on which faces are attractive (Bernstein, Lin, & McClellan, 1982; Cunningham, Roberts, Barbee, & Druen, 1995; Johnson, Dannenbring, Anderson, & Villa, 1983; Langlois et al., 2000; Perrett, May, & Yoshikawa, 1994; Rhodes et al., 2001) and infants look longer at faces judged by adults to be attractive than at faces judged as unattractive (Langlois et al., 1987; Samuels, Butterworth, Roberts, Graupner, Hole, 1994; Slater et al., 1998; Slater, Quinn, Hayes, & Brown, 2000). These findings suggest some universality in perceptions of attractiveness. Perceptions of attractiveness can influence social interactions via the 'beauty is good' stereotype, as many positive qualities are attributed to those judged as attractive (Dion, Berscheid, & Walster, 1972). Adults and children judged as attractive are perceived to have greater academic or occupational competence, to have greater social appeal, and to be better adjusted than individuals judged as unattractive (Langlois et al., 2000). They also receive better treatment from other adults and children, including more attention, greater reward, and more cooperative behaviours (Langlois et al., 2000). They additionally tend to possess more positive traits than those judged as unattractive, including greater academic or occupational success, greater popularity, and slightly higher intelligence (see Langlois et al., 2000 for a meta analysis). The more positive perceptions and treatment of those judged as attractive may provide an enriched environment for development, leading to more positive outcomes. As attractiveness can affect the lives of both children and adults, it is of interest to determine what factors are considered attractive in children.

Three major influences on adults' judgements of attractiveness in adult faces have been identified: faces that are more symmetrical are judged to be more attractive than faces that are less symmetrical (Perrett et al., 1999; Rhodes et al., 1998), faces that are closer to their group average are judged to be more attractive than faces that are farther from their group average (Langlois & Rogmann, 1990), and faces that are more sexually dimorphic are often judged to be more attractive than less sexually dimorphic faces (Perrett et al., 1998). Very little research, however, has studied these influences developmentally, and there are no published data, to our knowledge, on these influences between infancy and adolescence, or in children's faces. The work presented in this thesis compares the influence of symmetry and averageness on children's and adults' judgments of facial attractiveness using adult and child faces, and examines how natural differences in experience with faces affects the influence of averageness on judgments of attractiveness.

Influences on Judgments of Facial Attractiveness

Symmetry

Adults judge adult faces that are more symmetrical to be more attractive than faces that are less symmetrical (Grammar & Thornhill, 1994; Little, Apicella, & Marlowe, 2007; Little & Jones, 2006; Mealey, Bridgestock, & Towsend, 1999; Perrett et al., 1999; Rhodes, 2006; Rhodes et al., 2001; Rhodes, Proffitt, Grady, & Sumich, 1998; Scheib, Gangestad, Thornhill, 1999). This is true both in faces that naturally covary in their degree of asymmetry (Jones et al., 2001; Mealey et al., 1999; Rhodes, 2006; Scheib et al., 1999), and in faces that have been transformed to increase or decrease their level of asymmetry (Perrett et al., 1999; Little et al., 2007; Rhodes, 2006; Rhodes et al., 1998; Scheib et al., 1999).

Although some studies in the past found mixed results with respect to the attractiveness of symmetry in faces (eg. Samuels, et al., 1994; Kowner, 1996), those studies used a chimeric method of manipulating symmetry, in which the left side of a face was mirrored onto the right side of the face, and vice versa, creating two symmetrical faces: one made of two left hemifaces, and the other made of two right hemifaces. This method, however, can lead to structural abnormalities in the faces; a nose twisted to the left, for example, is abnormally large in the left chimera, and abnormally small in the right chimera (Rhodes et al., 1998). Others have overcome this problem by averaging a face with its mirror image, which leads to a single face that is the average of both sides of the face. When viewing faces that have been transformed with this method, adults judge perfectly symmetrical faces to be more attractive than the original versions of the same face (Perrett, et al., 1999; Little, Apicella, & Marlowe, 2007; Little & Jones, 2006; Rhodes et al., 2001).

There is less research on the influence of symmetry on attractiveness judgments developmentally. By age 11, adolescents[1] find perfectly symmetrical faces to be more attractive than the original versions of the same face (Saxton, Debruine, Jones, Little, Roberts, 2009; 2011; Saxton et al., 2010). When younger (around age 11 or 12) and mid (around age 13 or 14) adolescents view faces of their own age, symmetry influences attractiveness judgments more strongly in the mid than younger adolescent participants when they view male, but not female faces (Saxton et al., 2009; 2011). However, when both age groups view both ages of faces, there are no differences in the strength of the preference between age groups (Saxton et al., 2010). Because there were no adult comparison groups, it is not known whether adolescents are adult-like in the strength of their preference for symmetry. The only other developmental study on the influence of symmetry on attractiveness judgments examined the looking preferences in 5- to 8-month-old infants. When shown pairs of faces in which one version had been transformed 50%

[1] Adolescence is a period of transition from childhood to adulthood beginning approximately at age 10 (World Health Organization [WHO], 2013)

toward perfect symmetry, and the other version had had its asymmetries exaggerated by 50%, the infants did not look longer at either face, and their longest look was to the more asymmetrical face. Adults, by contrast, judged the more symmetrical faces to be more attractive than the less symmetrical faces (Rhodes et al., 2002). From the previous developmental literature, we do not know when the influence of symmetry on attractiveness judgments emerges, when it becomes adult-like, or the nature of the developmental changes.

Symmetry may be attractive because it conveys information about the phenotypic quality of an organism, with lower levels of asymmetry corresponding to higher levels of phenotypic quality (Møller, 1990; Thornhill & Sauer, 1992; Møller & Pomiankowski 1993; Møller, 1997; Møller & Swaddle, 1997). During development, environmental stressors (eg. extreme climactic conditions, limited resource availability, parasitism, pollution), and/or genetic stressors (eg. genetic mutations, homozygosity, inbreeding depression) can lead to asymmetries in the face and body (Thornhill & Møller, 1997; Møller & Swaddle, 1997). These asymmetries, termed fluctuating asymmetries, vary randomly in direction and magnitude across traits (Møller & Swaddle, 1997)[2]. Indeed, experimentally manipulating the pre-natal environment of rodents by invoking a dietary deficiency (Erway, Hurley & Fraser, 1970), or exposing the animals to cold, heat, or noise (Mooney, Siegel & Gest, 1985) leads to higher levels of asymmetry among the experimental than control offspring (see Thornhill & Møller, 1997 for a review on fluctuating asymmetry as a measure of phenotypic quality). Additional evidence is provided by

[2] Directional asymmetries refer to a trait that is larger on one side of the midline in most members of a species (e.g. the right side of the face is larger than the left side of the face in most humans, Simmons et al., 2004). Fluctuating asymmetries likely have a stronger effect on attractiveness judgments than directional asymmetries because adults adapt to the directional asymmetries they see in most faces (Rhodes, Louw, & Evangelista, 2009). Studies that have manipulated asymmetries in faces have manipulated both fluctuating and directional asymmetries.

correlational studies. For example, female rhesus macaque monkeys with lower levels of asymmetry are healthier than those with higher levels of facial asymmetry (males were not tested; Little & Paukner, 2012). This is also true in humans, with higher levels of body asymmetry among men who have had serious illness (women were not tested; Waynforth, 1998). Additionally, adolescents living in slum areas of Ankara, Turkey have higher levels of facial asymmetry than those living nearby in wealthier neighbourhoods (Özener, 2010; Özener & Fink, 2010). Relatedly, lower levels of asymmetry are associated with increased mating success in several species, including humans (see Møller & Thornhill, 1998 for a meta-analysis). For example, in a natural fertility population of Mayans, men with lower levels of body asymmetry tend to have more children than those with higher levels of body asymmetry (Waynforth, 1998). Additionally, men and women with lower levels of body asymmetry report more lifetime sexual partners than those with higher levels of asymmetry (Thornhill & Gangestad, 1994). A preference for symmetrical mates, then, may have evolved because of their association with high phenotypic quality.

Symmetry may also be preferred because it is processed more quickly and easily than asymmetry because of the redundancy of information. Adults respond to symmetrical stimuli more quickly than asymmetrical stimuli (Garner & Sutliff, 1974; Pomerantz, 1977), and remember symmetrical stimuli better than asymmetrical stimuli (Howe & Jung, 1986). According to the processing fluency hypothesis, stimuli that are cognitively processed more fluently are preferred (Reber, Schwartz & Winkielman, 2004). This hypothesis is supported by studies of random dot patterns and non-face objects, as prototypical objects and patterns are also processed more fluently and preferred to less prototypical exemplars (Halberstadt & Rhodes, 2000; Winkielman, Halberstadt, Fazendeiro, & Catty, 2006). Additionally, a preference for symmetry in faces may be influenced by higher level mechanisms as the perception of vertical symmetry, as is present in faces and bodies, has a processing advantage over symmetry with other axis orientations (Wenderoth, 1994). Moreover, adults have a stronger preference for perfect symmetry in upright than inverted faces (Little & Jones, 2006), and are better at detecting perfect symmetry in upright than inverted or contrast reversed faces (Rhodes, Peters, Lee, Morrone, & Burr, 2005). Although adults find symmetry attractive in both familiar and unfamiliar face categories (Little, Apicella, & Marlowe, 2007), experience with upright faces could increase detection and preference for symmetry in upright over inverted faces.

Averageness

Another influence on adults' judgments of attractiveness is a face's proximity to the population average. Langlois and Roggman (1990) created composite images of 2, 4, 8, 16, and 32 faces by averaging the luminance values of each pixel across images. Adults rated composite images that were averaged from 16 or 32 faces to be more attractive than the mean rating of the original faces used to create the composites. Additionally, attractiveness ratings increased with the number of faces in the composites. These results provide evidence that faces near the population average are attractive.

Although Langlois and Roggman's (1990) averaging method artificially increased the smoothness of skin texture, which could have led to the increased attractiveness of the composite faces (Alley & Cunningham, 1991; Benson & Perrett, 1992), others have manipulated face shape and texture independently by manually outlining the features and shape of each face with landmark points, which can be used to calculate an average face shape across images (Rowland & Perrett, 1995; Tiddeman et al., 2001). Face shape can then be transformed toward or away from the average while maintaining the original skin texture. Little & Hancock (2002) found that separate manipulations that averaged face shape or averaged skin texture each increased attractiveness independently in men's faces (women's faces were not tested). Additional studies that have used this method to manipulate face shape while maintaining the original skin tone have found that adults, both within and across cultures, judge averageness of face shape to be attractive (eg. Jones, DeBruine, & Little, 2007; Rubenstein, Kalakanis & Langlois, 1999; Rhodes, Geddes, Jeffery, Dziurawiek, & Clark, 2002; Rhodes, Harwood, Yoshikawa, Nishitani, & McLean, 2002; Rhodes et al., 2001; but see Apicella, Little, & Marlowe, 2007). Additionally, adults judge line drawings of faces that have been transformed toward average to be more attractive than line drawings of faces that have been transformed away from average, despite the fact that textural cues are absent from all faces (Rhodes & Tremewan, 1996). Thus, average face shape is attractive independent of skin texture.

Although averageness and symmetry are confounded because a face becomes more symmetrical as it becomes more average, symmetry and averageness make separable contributions to facial attractiveness (see Rhodes, 2006 for a meta-analysis). For example, faces photographed in profile in which direct cues to bilateral symmetry are absent, are judged by adults to be more attractive when transformed toward their group average than away from their group average (Valentine, Darling, & Donnelly, 2004). Additionally, faces that have been transformed toward their group average are judged by adults to be more attractive than faces that have been transformed away from their group average, even when all faces have been made perfectly symmetrical (Jones, Debruine, & Little, 2007; Rhodes, Sumich, & Byatt, 1999; Rhodes et al., 2001). However, the preference for the more average faces is greater when symmetry is allowed to covary during the transformations than when it is held constant by making all faces perfectly symmetrical (Jones, et al., 2007), a finding providing evidence that symmetry and averageness each provide separable contributions to perceptions of facial attractiveness.

Very little research has been done on the attractiveness of facial averageness developmentally. Averageness influences adolescents' judgments of attractiveness (Saxton et al., 2009; 2011; Saxton et al., 2010), although it is not known whether adolescents are adult-like in the strength of their preference as these studies did not have adult comparison groups. However, there does not appear to be any development in the strength of the influence of averageness from early to mid adolescence; the preference for averageness does not increase in strength from around age 12 to around age 14 when participants view the same sets of faces, nor is there any change when the adolescents are retested after a year (Saxton et al., 2010; Saxton et al., 2011). The only other studies, to our knowledge, that have examined the influence of averageness on attractiveness judgments in children have examined infants' looking preference behaviour. Infants' spontaneous looking preferences are often used as a measure of liking, with longer looking time considered a measure of interest in a stimulus (Fantz, 1961). This is true unless the infants have been habituated to a particular stimulus, in which case they tend to look longer toward the novel stimulus (Horowitz, 1974). In studies of spontaneous looking preferences, 6-month-old infants look longer at an average face than a face judged by adults to be unattractive (Rubenstein et al., 1999). However, another study that tested averageness more subtly found no differences in mean looking time to faces that have been transformed 50% toward average paired with faces that have been transformed 50% away from average among 5- to 8-month-old infants (Rhodes et al., 2002). Additional research is needed to assess the extent to which facial averageness influences infants' looking behaviour, to understand its developmental trajectory in childhood, and to determine the age at which the influence of averageness on judgments of attractiveness becomes adult-like.

Averageness might be attractive because of stabilizing selection, which selects against extremes within a population in favour of the mean (Dobzhansky, 1982). Averageness can be a signal of heterozygosity, or having different gene pairs for heritable traits (Thornhill & Gangestad, 1993; Fink & Penton-Voak, 2002). Indeed, heterozygosity of the major histocompatibility complex is linked to more efficient immune function in humans (Thursz et al. 1997; Carrington et al. 1999), and is also associated with greater attractiveness and averageness of male faces, as rated by women (Lie, Rhodes, & Simmons, 2008). Heterozygotes are often outbred individuals with high genetic diversity, fewer harmful mutations, and greater parasitic resistance (Dobzhansky, 1982; Thornhill & Gangestad, 1993; 1999), all of which could lead to a mate preference.

From a cognitive perspective, it has been hypothesized that faces are represented in a multidimensional face-space, which is centred on a prototypical, or average face (Valentine, 1991). Individual faces are represented by how they differ from the prototype in direction and distance, and faces near the prototype may be processed more quickly and easily than faces farther from the prototype, and thus preferred (Valentine, 1991; Winkielman, Halberstadt, Fazendeiro, & Catty, 2006). This hypothesis is supported by studies of random dot and geometric patterns, in which patterns that are closer to a prototype of patterns that were presented to adults in a training phase, are processed more fluently and preferred to patterns that are farther from the prototype (Winkielman et al., 2006). Similarly, adults rate dogs, wristwatches, and birds that they consider to be prototypical to be more attractive than less prototypical exemplars (Halberstadt & Rhodes, 2000). It is hypothesized that the prototype is constantly being updated as new faces are encountered. Indeed, adapting adults to faces with low (or high) feature height subsequently shifts their attractiveness judgments in the direction of the distortion, as would be expected with updating of the norm (Cooper & Maurer, 2008; see Rhodes, Jeffery, Watson, Clifford, Nakayama, 2003 for similar evidence with adaptation to compressed or expanded features in adults).

There is evidence that infants have the ability to form an average, as 3-month-olds (but not 1-month-olds) treat an average 4-face composite as familiar, even though they had only been familiarized to each of the individual component faces (de Haan, Johnson, Maurer, Perrett, 2001; see Rubenstein, Kalakanis, & Langlois, 1999 for evidence in 6-month-olds). Additionally, there is evidence that children process faces relative to a norm: adapting 4- to 6-year-olds to a distorted face or to a specific face identity shifts their recognition of other faces in the opposite direction of the adaption (Jeffery et al., 2010; Jeffery et al., 2011; 8-year-olds, Nishimura, Maurer, Jeffery, Pellicano, & Rhodes, 2008; Pimperton, Pellicano, Jeffery, & Rhodes, 2009), and the aftereffects are stronger for adapters farther from the norm (demonstrated at age 4-5 for figural aftereffects, Jeffery et al., 2010; demonstrated at age 7 for identity aftereffects, Jeffery et al., 2011). Additionally, for adaptations to facial identity, the aftereffects are specific to vectors passing through the norm, consistent with the predictions of norm-based coding (8-year-olds; Jeffery et al., 2011).

Judgments of attractiveness based on averageness can also shift in response to natural differences in face experience because of the updating of the norm. For example, shorter adults tend to find female faces with high feature height to be more attractive than average feature height, consistent with the foreshortening they see when they look up at faces (Geldart, 2008). Infants also tend to look up at faces, and look longer at faces with high feature height than low feature height (Geldart, Maurer, & Henderson, 1999). However, pre-school children, who tend to interact with their peers at eye-level, find female faces with low-feature height similar to the proportions of their peers' faces, to be more attractive than female faces with high feature height, presumably because their prototype is tuned toward those faces (Cooper, Geldart, Mondloch, Maurer, 2006). Further evidence comes from newborn infants, who show no spontaneous looking preference for same or other race faces, show a looking preference for same race faces by 3 months, presumably as they build experience with those faces (Bar-Haim et al., 2006; Kelly et al., 2005; Kelly et al., 2007), and infants who were raised by female caregivers and show a looking preference for female faces, which seems to reverse in infants who were raised by male caregivers (Quinn et al. 2002). Among the Hadza, a hunter-gatherer tribe in Africa, averageness influences attractiveness judgments in Hadza faces but not in White British faces, a group with whom they have little to no experience (Apicella, Little, & Marlowe, 2007).

Attractiveness judgments can also shift in response to changes in face experience in the lab. For example, repeated exposure to faces with compressed/expanded features (8-year-olds, Anzures et al., 2009; adults tested with women's faces, Rhodes et al., 2003), or low/high feature height (adults tested with women's faces, Cooper & Maurer, 2008) leads children and adults to shift their attractiveness judgments in the adapted direction. Children also shift their judgments of oddness (an inverse of averageness) in the opposite direction of adaptation after repeated exposure to low or high feature height (6- to 9-year-olds tested with men's faces; Hills, Holland, & Lewis, 2010). Children, however, can be adapted to unnatural distortions such as asymmetric manipulations of eye height in which one eye is moved up and the other eye is moved down, a distortion that does not affect adolescents' oddness judgments (Hills, Holland, & Lewis, 2010), and for attractiveness, children sometimes require larger distortions than adults for adaptation

(Anzures et al., 2009). These results suggest that children may have a less stable norm than adults, possibly because children have less face experience than do adults.

Although averageness is attractive, it is not the peak of attractiveness. An averaged composite created from 15 faces rated as attractive is judged by adults to be more attractive than a composite created from 60 faces of varying attractiveness (Perrett, May, & Yoshikawa, 1994). Exaggerating the differences between the two composites to create a caricaturized version of the attractive average leads to even higher attractiveness ratings in women's faces (DeBruine, Jones, Unger, Little, Feinberg, 2007; Perrett et al., 1994). These findings provide evidence that average faces are attractive, but that highly attractive faces differ from the average in similar ways. It has been hypothesized that these 'more than average' faces differ from the average based on sexual dimorphism (DeBruine, Jones, Unger, Little, Feinberg, 2007; Perrett et al., 1994).

Sexual Dimorphism

Sexual dimorphism refers to the occurrence of males and females that are morphologically different from each other within a particular species. Many of these differences are caused by a shift in the ratio of sex hormones at puberty. For example, within human faces, high levels of testosterone in males leads to growth of the jaw and lower face, the brow ridge, and the middle of the face, while high levels of oestrogen in females prevent this growth, but increase lip size (Thornhill & Møller, 1997). Men with more masculine faces have higher circulating levels of testosterone following success in competition than men with less masculine faces (Pound, Penton-Voak, & Surridge, 2009; see Neave, Laing, Fink, & Manning, 2003; Penton-Voak & Chen, 2004; Pound et al. 2009; Roney, Hanson, Durante, Maestripieri, 2006 for mixed evidence of an association between baseline levels of testosterone and facial masculinity), and adults judge women with higher levels of oestrogen to have more feminine faces than those with lower levels of oestrogen (Smith et al., 2006).

Adults judge women's faces that have been rated as feminine (Dunkle & Francis, 1990; Koehler et al., 2004; adolescent faces, Rhodes, Chan, Zebrowitz, & Simmons, 2003), or measured to have feminine features (Cunningham et al., 1995; Johnston & Franklin, 1993; Jones & Hill, 1993; Koehler, Simmons, Rhodes, & Peters, 2004; Penton-Voak, Jacobson, & Trivers, 2004; Smith et al., 2006) to be more attractive than less feminine faces. Additionally, women's faces that have been transformed to increase femininity are judged to be more attractive than less feminized faces, whether the transformations were based on the differences between an average female and average male face (Perrett et al., 1998; Rhodes, Hickford, & Jeffery, 2000; Welling, Jones, & DeBruine, 2008), or between an average female face and an average of female faces perceived as feminine (Johnson, Hagel, Franklin, Fink, & Grammer, 2001).

The influence of sexual dimorphism on adults' judgments of attractiveness in men's faces is more complex. Studies that have used unmanipulated faces have found that faces rated as masculine (Koehler et al., 2004; Peters, Simmons, & Rhodes, 2008; Peters, Rhodes, & Simmons; 2009), or faces measured to have masculine features (Grammer & Thornhill, 1994; Neave, Laing, Fink, & Manning, 2003; Penton-Voak et al., 2001; Scheib, Gangestad, & Thornhill, 1999; but see Soler et al. 2012) are judged by adults to be more attractive than less masculine faces. Masculinity is also judged to be attractive in men's faces that have been transformed to be more masculine based on the differences between an average male face, and an average of male faces that were judged to be masculine (Johnston et al. 2001). However, among studies that have transformed men's faces to be more masculine based on the differences between an average male and average female face, some have found that adults prefer feminized versions of men's faces

(Little, Burt, Penton-Voak, & Perrett, 2001; Little, Jones, Penton-Voak, Burt, & Perrett, 2002; Penton-Voak et al., 1999; Penton Voak et al., 2004; Perrett et al., 1998; Rhodes et al., 2000; Rhodes, Chan, et al., 2003; Welling et al., 2007; Welling, Jones, & DeBruine, 2008, Study 1), while others have found preferences for more masculinized versions of men's faces (DeBruine et al. 2006; Feinberg, DeBruine, Jones, & Little, 2008; Little, Jones, DeBruine, & Feinberg, 2008).

Some have suggested that methodological differences could account for the differences in findings with respect to the attractiveness of masculinity in male faces (Fink et al., 2005; Johnston et al., 2001; Rennels, Bronstad, & Langlois, 2008; Rhodes, 2006; Swaddle & Riersen, 2002), and a meta-analysis found that masculinity is attractive in unmanipulated men's faces, but not in faces that were transformed based on the differences between average male and female faces (Rhodes, 2006). However, others have found correlated preferences for masculinity when the same group of women are tested with faces that were manipulated using different methods (DeBruine et al., 2006). These authors suggested that individual differences between women and between study populations could contribute to the strength of a preference for masculinity or femininity in men's faces: increased self perceived attractiveness (e.g. Little et al. 2000), decreased availability and predictability of resources (Little et al., 2007; Penton-Voak, Jacobson, & Trivers, 2004), increased pathogen disgust (e.g. DeBruine et al. 2010; Jones et al., in press), increased salivary testosterone (Welling et al. 2007), increased sex drive (Welling et al., 2008), having a partner (Little et al. 2002), considering a short-term relationship (Little et al., 2002; Penton-Voak et al., 2003), and the fertile phase of the menstrual cycle (see Jones et al., 2008 for a review) are all associated with an increased preference for masculinity in men's faces among women.

Little research has been done on the influence of sexual dimorphism on attractiveness judgments developmentally. Adolescents find faces that have been transformed to be more feminine based on the differences between an average adolescent girl and boy face, to be more attractive than less feminized versions of the faces, for both male and female faces (Saxton et al., 2009; 2011; Saxton et al., 2010). When younger adolescents and mid adolescents view faces of their own age, the older group has a stronger preference for femininity in male faces than the younger group (Saxton et al. 2009; 2011). However, when both age groups view faces of both younger and mid-adolescents, and the participants are broken down into whether they have reached an early or late stage of pubertal development, femininity influences attractiveness judgments more strongly for both male and female faces in the adolescents who had reached the late stage of pubertal development (Saxton et al., 2010). Thus, the strength of the influence of sexual dimorphism on attractiveness judgments may still be developing in adolescence, although it is not known when this preference is adult-like as none of the studies had adult comparison groups. To our knowledge, no other study has tested the influence of sexual dimorphism on judgments of facial attractiveness prior to adolescence.

Sexually dimorphic features might be attractive because they are a sign of sexual maturity and reproductive potential because sexual dimorphism increases at puberty (Johnston & Franklin 1993; Thornhill & Gangestad 1996). Feminine features in women’s faces might be a sign of phenotypic quality (Thornhill & Gangestad, 1993; Thornhill & Grammer, 1999). Adults rate feminine faces to be healthier than more masculine women’s faces (Johnston et al., 2001; Moore et al., 2011; Scott et al., 2008), and femininity in women’s faces is negatively correlated with the number and duration of respiratory illnesses (Thornhill & Gangestad, 2006). Additionally, oestrogen levels in women are positively correlated with levels of immunoglobulin

A, a marker of mucosal humoral immunity (van Anders, 2010). Masculine traits in men's faces might also be a cue to phenotypic quality because they are costly to produce, and can thus only be developed by individuals of high phenotypic quality (Haywood, 1989; Iwasa, Pomiankowski & Nee, 1991; Thornhill & Møller, 1997). Masculine features are associated with several measures of good health including high indices of health from medical records (Rhodes et al. 2003), low susceptibility to disease (Thornhill & Gangestad, 2006), low levels of oxidative stress (Gangestad et al. 2010), and low levels of facial asymmetry (Little, Jones, DeBruine, & Feinberg, 2008; Little, Jones, Waitt, et al., 2008; Scheib , Gangestad, & Thornhill, 1999; but see Koehler et al., 2004; Penton-Voak et al., 2001). Additionally, men with higher levels of salivary testosterone have a stronger immune response to the hepatitis B vaccine, and are rated by women to be more attractive than men with lower levels of testosterone or a weaker immune response (Rantala et al., 2012). There are costs, however, to choosing men with high levels of masculinity; they are perceived to invest less parental effort (e.g. Kruger, 2006), they are less likely to respond to a crying infant (Fleming, Corter, Sallings, & Steiner, 2002), and they are perceived to be lower in warmth, emotionality, and cooperativeness (Boothroyd, Jones, Burt & Perrett, 2007; Perrett et al., 1998) than less masculine men. Women might face a trade-off when selecting for masculinity in men's faces, which might account for some of the individual differences in preferences for masculinity in men's faces.

Masculine and feminine features might also be important because they facilitate categorization of male and female faces. Infants as young as 9 months can discriminate the faces of adult men and women (Lienbach & Fagot, 1993), and adults can quickly and reliably categorize men's and women's faces (Bruce et al., 1993; Bruce, Ellis, Gibling, & Young, 1987). According to processing fluency theory, information that is processed quickly and easily is preferred (Reber et al., 2004). Sexually dimorphic faces might be classified as male or female more quickly than less dimorphic faces, leading to a preference. Indeed, adults and 4- to 5-year-old children are faster at classifying faces rated as highly attractive to be male or female, than faces rated as less attractive (Hoss, Ramsey, Griffin, & Langlois, 2005; O'Toole et al., 1998). However, it is unclear whether sexual dimorphism also facilitates classification of male and female faces. O'Toole et al. (1998) found that adults are faster at classifying faces judged as very feminine to be female, and faces judged as very masculine to be male, as one would predict if sexual dimorphism facilitates sex classification in faces. Hoss et al. (2005) similarly found that adults were faster at classifying faces rated as masculine to be male, but they found no difference in classification speed of women's faces that differed in femininity. Among 4- to 5-year-old children, they found the opposite pattern of results: children were faster at classifying faces rated feminine as women, but there was no difference in classification speed of men's faces that differed in masculinity (Hoss et al., 2005). Thus, a face's attractiveness appears to facilitate the speed of classifying it as male or female among adults and children, but the extent to which sexually dimorphic cues contribute to the facilitation in speed of classification is unclear.

Present Studies

The studies presented in this thesis examine the development of perceptions of attractiveness. They do so by examining (1) developmental changes by comparing the attractiveness judgments of children and adults, and (2) the role of experience by comparing the attractiveness judgments of children who have recent biased experience with different groups of faces. For these studies we chose to test 5-year-olds because it is an age at which children process facial identity relative to a norm (Jeffery et al., 2010), and it is the youngest age able to complete enough trials to allow for reliable individual data with a behavioural procedure similar to that used in the adult literature. We additionally tested 9-year-olds, an intermediate age between 5 and adolescence, and an age at which most aspects of basic vision are adult-like (Adams & Courage, 2002; Ellemberg, Lewis, Liu, & Maurer, 1999; Lewis et al., 2004).

The study presented in chapter 2 explores the influence of symmetry on children's judgments of attractiveness. Adults find faces that are more symmetrical to be more attractive than faces that are less symmetrical (Perrett et al. 1999). This study tested whether symmetry influences judgments of facial attractiveness at ages 5 and 9 using both child and adult faces, and how the strength of the preference compares to that of adults. This study is the first to our knowledge to examine whether symmetry influences children's judgments of attractiveness, and whether symmetry has an influence on attractiveness judgments in children's faces.

The study presented in chapter 3 explores the influence of averageness on children's judgments of attractiveness. Adults find faces approximating the population average to be more attractive than most other faces (Langlois & Roggman, 1990). This study tested whether averageness influences judgments of attractiveness among 5-year-olds and 9-year-olds using both child and adult faces, and how the strength of the preference compares to that of adults. This is the first study to our knowledge to examine whether averageness influences children's attractiveness judgments, and whether averageness is an influence on attractiveness judgments in children's faces.

The study presented in chapter 4 explores the influence of recent biased face experience on the influence of averageness on judgments of attractiveness. Other studies in adults and children have found that biasing face experience can shift attractiveness judgments because of updating of the norm (eg. Apicella et al., 2007; Anzures et al., 2009; Cooper et al., 2006; Geldart, 2008; Geldart et al., 1999; Rhodes et al., 2003). To explore whether natural differences in face experience could shift attractiveness judgments based on averageness, we took advantage of a natural experiment and tested grade 4 children attending a girls' school, a boys' school, and a mixed-sex school to assess whether recent biased experience affects the strength of their preference for averageness in boy and girl faces.

The studies presented in this thesis provide new insights into how judgments of attractiveness develop, and how experience influences those judgments. In chapter 5, I summarize the findings, and discuss contributions to the literature, limitations, and future directions.

CHAPTER 2: The Influence of Symmetry on Children's Judgments of Facial Attractiveness

Vingilis-Jaremko, L., Maurer, D. (2013). The Influence of Symmetry on Children's Judgments of Facial Attractiveness. *Perception*, 42, 302-320.

Preface

Adults find faces that are more symmetrical to be more attractive than faces that are less symmetrical (Perrett et al., 1999). In the work presented in chapter 2, I explored whether symmetry also influences children's judgments of attractiveness. To do so I tested 5-year-olds, 9-year-olds, and adults with pairs of faces in which one version of the face had been transformed to be more symmetrical, while the other version of the face had been transformed to be less symmetrical. On each trial participants selected which face they found to be more attractive. I found that symmetry did not influence 5-year-olds' attractiveness judgments, but it influenced 9-year-olds' attractiveness judgments although to a lesser extent than those of adults. This is the first demonstration, to our knowledge, that symmetry influences attractiveness judgments prior to adolescence.

I used faces of 5-year-olds, 9-year-olds, and adults in different blocks to assess whether symmetry influences attractiveness judgments in children's and adults' faces. I found that among 9-year-olds and adults, symmetry influenced attractiveness judgments in both children's and adults' faces, which is the first demonstration to our knowledge that symmetry influences attractiveness judgments in children's faces. Overall, the results demonstrate that the influence of symmetry on attractiveness judgments emerges after age 5, matures after age 9, and is present for both adult and child faces.

Abstract

In Experiment 1, we examined developmental changes in the influence of symmetry on judgments of attractiveness by showing adults and children pairs of individual faces in which one face was transformed 75% toward perfect symmetry, while the other face was transformed by exaggerating its asymmetries by 75%. Adults and 9-year-olds, but not 5-year-olds, rated the more symmetric faces as more attractive than the less symmetric faces, although the effect was stronger in adults than 9-year-olds. The preference for symmetry was stronger for male than female faces and stronger for adults' than children's faces. In Experiment 2, comparisons of the symmetry of the original male and female faces revealed no measured differences but lower ratings by adults of symmetry in the male faces. Overall the results suggest that the influence of symmetry on attractiveness judgments emerges after age 5, and matures after age 9. The stronger effects for adult viewers may reflect an increase in sensitivity to symmetry as experience with faces increases and/or as the visual system matures. As well, attractiveness may become more salient after puberty so that honest signals of mate quality, such as symmetry, have a stronger effect for adult viewers, especially when judging adult faces.

Keywords: face perception, attractiveness, symmetry, development

1 Introduction

While it is often stated that "beauty is in the eye of the beholder", there is actually a high degree of agreement among individuals on what is attractive. Cross-cultural studies find high inter-rater agreement in attractiveness judgments (Bernstein et al 1982; Cunningham et al 1995; Johnson et al 1983; Langlois et al 2000; Perrett et al 1994) and, developmentally, infants look longer at faces rated by adults as attractive than those rated as unattractive (Langlois et al 1987; Samuels et al 1994; Slater et al 1998, 2000). Together, this evidence suggests that there is some universality in what people find to be attractive. These judgments influence interpersonal interactions through the "what is beautiful is good" stereotype, whereby more attractive individuals, including children, are judged as having more positive traits and treated more favourably than those judged as less attractive (Dion et al 1972; Langlois et al 2000).

One influence on adults' judgments of attractiveness is bilateral symmetry (see Wade 2010 for a review).[1] For example, when photographs of faces are manipulated to be perfectly symmetric by averaging each face with its mirror image, adults judge the perfectly symmetric versions to be more attractive than the original versions of the faces (Perrett et al 1999). Similarly, they rate faces manipulated to have increasing levels of symmetry to be increasingly attractive (Rhodes et al 1998). These studies, along with evidence that judged attractiveness covaries with natural variations in facial asymmetry, provide strong support for the conclusion

[1] Some studies published prior to 1999 did not find facial symmetry to be attractive (eg Kowner 1996; Langlois et al 1994; Samuels et al 1994). These studies used chimeric methods of manipulating symmetry in which the left side of the face was mirrored onto the right, and vice versa, creating two symmetric faces: one made of two left hemifaces, and the other of two right hemifaces. Chimeras, however, may not be appropriate for assessing the influence of symmetry on attractiveness judgments because they can create structural abnormalities in the face and can lead to odd-looking faces. A meta-analysis by Rhodes (2006) found that symmetry is attractive when faces are averaged with their mirror image to create symmetric stimuli, but not when chimeras are used. For that reason, we have not included studies using a chimeric method in our discussion of the adult literature.

that adults find bilateral symmetry attractive in faces (Grammar and Thornhill 1994; Mealey et al 1999; Perret et al 1999; Rhodes 2006; Rhodes et al 1998, 2001; Scheib et al 1999).

These studies manipulated two types of asymmetry that occur in faces: directional asymmetries, in which a trait is larger on one side of the midline in nearly all members of a species (eg in humans, the right side of the face is larger than the left side of the face; Simmons et al 2004), and fluctuating asymmetries that vary in direction and magnitude across members of a species and that have a normal distribution around the midline (Møller and Swaddle 1997). Because adults can adapt to the directional asymmetries that they see in virtually every face (Rhodes et al 2009), fluctuating asymmetries are likely to have more influence on judgments of attractiveness. Their influence might arise from the information they convey about phenotypic quality. Fluctuating asymmetries can arise from developmental instabilities, caused by a range of environmental (eg unusual climatic conditions, pollution, parasitism, high population density, low food quantity and quality) and genetic (eg genetic mutations, inbreeding, homozygosity) stressors (Møller and Swaddle 1997; Thornhill and Møller 1997). As such, fluctuating asymmetries may be an honest signal of phenotypic quality with lower levels signaling higher phenotypic quality (Møller 1990, 1997; Møller and Pomiankowski 1993; Møller and Swaddle 1997; Thornhill and Sauer 1992). Indeed, male and female high-school students living in slum districts of Ankara, Turkey have higher levels of facial asymmetry than those living in higher SES neighbourhoods (Özener 2010; Özener and Fink 2010). For the slum districts, the asymmetries were larger in male than in female faces. Additionally, men with higher levels of oxidative stress have higher levels of body asymmetry (women were not tested; Gangestad et al 2010). Consistent with this hypothesis, low levels of fluctuating asymmetries are related to mating success in several species, including humans (see Møller and Thornhill 1998 for a meta-analysis). For example, among humans, men and women with more symmetric bodies report more lifetime sexual partners than those with less symmetrical bodies (Thornhill and Gangestad 1994). Additionally, in a population of Mayans, where birth control does not influence fertility, more symmetric men had fewer serious illnesses, and more offspring, than less symmetrical men (women were not tested; Waynforth 1998). Symmetric mates, then, may have come to be preferred among many species, including humans, because they are associated with higher phenotypic quality. Symmetry may additionally be a stronger influence on the assessment of males than females (Møller and Thornhill 1998), as more males are available to reproduce than females in most human populations (Low 2001), creating stronger male–male than female–female competition. Thus, male traits could be expected to receive greater attention during assessment of potential mates and competitors (Trivers 1972).

In addition, symmetry may be attractive because it can be processed more fluently than asymmetry because of the redundancy of information. For adults, the detection of mirror symmetry emerges automatically and effortlessly in a wide variety of conditions, and symmetric stimuli are detected more quickly, are better discriminated, and are often remembered better than less symmetric stimuli (Garner and Sutliff 1974; Pomerantz 1977; Wagemans 1995). Moreover, the perception of vertical symmetry, as is present in human faces and bodies, appears to have a processing advantage over other orientations of symmetry, as adults detect vertically symmetric patterns more quickly and accurately than they detect symmetric patterns centred around other axis orientations (Wenderoth 1994). According to the processing-fluency hypothesis, stimuli that are processed more quickly and easily are preferred (Reber et al 2004). Studies of non-face objects and random-dot patterns provide support for this hypothesis (Halberstadt and Rhodes 2000; Winkielman et al 2006). The processing advantage for vertical symmetry may then be the cognitive mechanism that leads us to prefer bilateral symmetry in faces and bodies. Evolution may have selected for these cognitive mechanisms; the salience of vertical symmetry in our environment and its value in our mate choice decisions may have favoured symmetry over asymmetry. Additionally, the presence of vertical symmetry in our environment may have favoured it over symmetry centred around other axis orientations.

By adolescence, bilateral symmetry influences attractiveness judgments of same-age faces. When younger adolescents (around the age of 11 or 12 years), and older adolescents (around the age of 13 or 14 years) are shown pairs of own-aged faces, in which one version of each face was made perfectly symmetric and the other version had the asymmetries increased by 50%, both groups selected the symmetric versions to be more attractive (Saxton et al 2009, 2011). The influence of symmetry on attractiveness judgments was stronger among older than younger adolescents when viewing male, but not female, faces, with no change in either group on a retest 10–13 months later (Saxton et al 2011). In another comparison of younger (12-year-olds) and older (13-to 14-year-olds) adolescents, children found symmetry to be attractive in faces of both their own and the other age, and older adolescents selected the more symmetric faces more frequently than younger adolescents (Saxton et al 2010). Both groups had a stronger preference for symmetry in the older than younger male faces. In sum, it appears that symmetry influences attractiveness judgments among adolescents, and that there is a change in the strength of its influence from early-adolescence to mid-adolescence. Because there was no adult comparison group, we do not know if the influence of symmetry is adult-like by mid-adolescence.

To our knowledge, there are no published data on when the influence of symmetry on judgments of attractiveness emerges during development. Infants do not show a looking preference for perfectly symmetric faces over original faces at 4 to 15 months (Samuels et al

1994) or over faces in which the asymmetries were exaggerated by 50% at 5 to 8 months (Rhodes et al 2002). In fact, in the study of 5-to 8-month-old infants, first and longest looks were marginally longer toward the less symmetric faces, opposite of the direction predicted. Nevertheless, studies with patterns indicate that infants can perceive vertical symmetry. 4-month-old infants can discriminate vertically symmetric from asymmetric and horizontally symmetric patterns, and process vertically symmetric patterns more efficiently than asymmetric or obliquely symmetric patterns, as measured by time to habituation (Bornstein and Krinsky 1985; Bornstein et al 1981; Fisher et al 1981). At 12 months of age, but not at 4 months of age, infants look longer at vertically symmetric patterns than asymmetric patterns, while there is no looking preference for horizontally symmetric patterns at either age (Bornstein et al 1981). Infants thus are sensitive to vertical symmetry, which may have a special status early in perceptual development (Bornstein and Krisky 1985). It is unclear, however, whether this is also the case for symmetry in faces.

The purpose of our study was to explore the influence of bilateral symmetry on children's judgments of facial attractiveness in the period between infancy and adolescence. As there is no evidence of an influence of symmetry on attractiveness judgments prior to early adolescence, we tested 5-year-olds, an age when children can complete enough trials to generate reliable individual data, and 9-year-olds, a prepubescent age when most aspects of basic visual sensitivity are adult-like (Adams and Courage 2002; Ellemberg et al 1999; Lewis et al 2004). We presented children and adults with two versions of individual faces, in which one version was transformed 75% toward perfect symmetry, while the other version was transformed by exaggerating its asymmetries by 75%. Participants chose which face in each pair they found more attractive, a method that is easier for young children than rating scales. We used both child and adult faces as stimuli because children may have more experience with the faces of same-age peers than of adults, and because both children and adults have an own-age bias in processing faces (Anastasi and Rhodes 2005; Hills and Lewis 2011; however, see Macchi Cassia 2011 for evidence of a processing advantage for adult faces even in children). We used faces of adults, 4-to 5-year old children (matching the recent experience of the 5-year-olds), and 8-to 9-year old faces (matching the recent experience of the 9-year-olds). Because Saxton and colleagues (2009, 2010, 2011) found changes during adolescence for male but not female faces, we included blocks with faces of both genders at all three ages. This also allowed us to examine whether the influence of symmetry is greater for male than female faces, as predicted by some evolutionary accounts.

2 Experiment 1

2.1 *Participants*

Participants were twenty-four adults (aged 18 to 25 years), twenty-four 9-year-olds (± 3 months), and twenty-four 5.5-year-olds (± 3 months). All participants were white, and half at each age were male. Child participants were recruited from a database of names of mothers who had volunteered shortly after the birth of their child to be contacted about future studies. Adults were undergraduate university students. Child participants received a toy, and adults received payment or course credit for participation. Participants were visually screened and had normal or corrected-to-normal vision; adults and 9-year-olds had normal stereoacuity as tested by the Titmus test of stereoacuity, and had a Snellen acuity of 20/20 or better, measured on a Lighthouse eye chart. Criteria were relaxed for 5-year-olds to 3/3 animals and 5/9 circles correct on the Titmus test of stereoacuity, equivalent to 100 s of arc of disparity instead of the adult norm of 40 s of arc, and a Snellen acuity of 20/30 or better measured with the Cambridge Crowding Cards, as vision is still maturing at this age (Adams and Courage 2002; Ellemberg et al 1999). An additional three 9-year-olds and two 5-year-olds were run but excluded because they were inattentive (*n* = 1), were out of the age range (*n* = 1), or did not pass our visual screening criteria (*n* = 3).

2.2 *Stimuli*

Stimuli were full-face, colour digital photographs of the faces of white adult women, adult men, 8- to 9-year-old girls, 8- to 9-year-old boys, 4- to 5-year-old girls, and 4- to 5-year-old boys. Faces were photographed with the subject facing the camera, with a neutral expression, and evenly lit. Adult models, and parents of children gave permission for their photographs to be manipulated and used in research. Adobe Photoshop CS was used to remove major blemishes and other irregularities from the faces, such as food. Faces that had the reflection of two catch lights in the eyes (because two catch lights were present when the models were photographed) had the right catch light removed from each eye with the Photoshop brush tool, to make the faces look more natural. Each face was manually delineated with 189 landmark points outlining features and the face shape. Each face was then averaged with its mirror-image to create a perfectly symmetric version. The original face was then warped 75% toward its perfectly symmetric version, or had its asymmetries exaggerated by 75% [3] changing the shape of the faces, but maintaining original texture (see Tiddeman et al 2001). This was done for 16 faces from each group to create 96 pairs of faces in total. Because we did not want participants' judgments to be influenced by distortions in the hairstyle, external features and hair were removed by placing a grey background around the outline of each face. Although this change made the faces less naturalistic, it also prevented decisions based on flukes of hairstyle and encouraged judgments based on the physiognomy of the faces. Faces within each group were standardised for size based

[3] As in previous studies, this procedure manipulates all types of asymmetries concurrently, both those that are directional and those that are fluctuating.

on interpupilary distance. Images were scaled to be approximately life-size for each age; from a viewing distance of 70 cm, adult faces subtended a visual angle of approximately 15 deg in height and 11 deg in width; 9-year-old faces subtended a visual angle of approximately 14 deg in height and 10.5 deg in width; and 5-year-old faces subtended a visual angle of approximately 13 deg in height and 10.5 deg in width (see figure 1). Images were 751 horizontal by 993 vertical pixel resolution (adults), 738 horizontal by 978 vertical pixel resolution (9-year-olds), 681 horizontal by 965 vertical pixel resolution (5-year-olds). The faces were presented on a HP 20555 SH249, 22 inch LCD Monitor with screen resolution set to 1024 pixels × 768 pixels. Although the original faces came from different sets of faces taken under different photographic conditions, participants made choices between a pair of faces that originated from the same original face. Thus, the two versions of each face always had the same resolution and lighting.

Figure 1. [In colour online, see http://dx.doi.org/10.1068/p7371] Low-symmetry (left) and high-symmetry (right) versions of an 8-year-old girl's face.

2.3 *Design*

We used a blocked within-subject design, with faces blocked by age and gender (16 for each group of faces) and the order of stimulus pairs within each block randomised for a total of 96 trials per participant. The side on which the more symmetric face appeared was randomised within each block for each participant. Blocks were counterbalanced with a Latin-square design. Adults and 9-year-olds were tested in one session, and 5-year-olds were tested in two separate sessions with identical counterbalancing, except divided across the two sessions.

2.4 *Procedure*

This study received ethics clearance from the institutional Research Ethics Board, and was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). After explaining the procedure, we obtained written consent from adult participants and parents of child participants, and verbal consent from the children. We then gave participants the following instructions in a game-like format:

> "An evil monster snuck into the lab and made copies of all my friends! Now I need your help to figure out who is my real friend and who is a copy. The monster didn't do a perfect job, so the only way to tell the difference between my real friends and the copies is that the real person looks nicer, prettier, or more attractive. Can you help me pick out the real person? Every time you see two faces on the screen, help find my real friends by choosing the face that is better looking, more handsome, or cuter."

We used a number of words throughout the experiment to describe the concept of attractiveness including *prettier, more handsome, nicer looking, better looking*, *cuter*, and *more* *attractive.* We used multiple words to be sure that the children understood the choice we were asking them to make. Children as young as 3 years give reliable attractiveness judgments in the same direction as those of adults for girls', boys', and adults' faces when instructed using the words *pretty and cute*, or the word *handsome* (Cooper et al 2006; Dion 1973; Langlois and Stephan 1977). Additionally, pre-schoolers are able to give detailed descriptions of the concept of attractiveness, a result suggesting that young children have an understanding of the concept (Dion 1973). After asking participants if they understood the procedure, they were given 10 criterion trials in which they were presented with pairs of objects the monster had copied. On each trial, one of the two objects was more faded, broken, or tattered than the other. On each trial, participants selected the "real" object, which was the object that looked better, or nicer. All participants successfully completed criterion trials with 100% accuracy and moved onto the main experiment. Trials were self-paced, and responses were made by clicking on the image with a mouse, which initiated the next trial. 5-year-old participants took a break after each block, and completed the first 3 blocks on the first testing day, and the second 3 blocks on the second testing day. Visual screening occurred after the first block in conjunction with the first break. 9-year-old participants completed 3 blocks, were then visually screened, then returned to the experiment to complete the remaining 3 blocks. Adult participants were visually screened, then completed all 6 blocks. All participants were allowed to take additional breaks as needed. Participants were debriefed with information about the purpose of the study and with information about the "Beauty is Good" stereotype following completion of the experiment.

2.5 *Results*

For each participant, we calculated the mean proportion of trials on which the more symmetric face was selected for each group of faces.[4] There were no outliers in any age group defined as being greater than 3 standard deviations from the mean.

To assess whether participants of each age selected the more symmetric faces more frequently than expected by chance, we performed a one-tailed one-sample *t*-test comparing the means of each face set to chance (0.5) for each age group, controlling for multiple comparisons with Bonferroni correction at $a = 0.008$. Adult and 9-year-old participants selected the more symmetric face more frequently than chance for all face sets (all *p*s < 0.001; see figure 2). 5-year-old participants, by contrast, did not select the more symmetric face more frequently than chance (all *p*s > 0.033). Without Bonferroni correction, 5-year-olds selected the more symmetric adult male ($t_{23} = 1.935$, $p = 0.033$) and 9-year-old girl faces ($t_{23} = 2.567$, $p = 0.009$), significantly more often than expected by chance (all other *p*s > 0.066).

To compare the strength of the effects of symmetry across age and face sets, we performed a repeated-measures ANOVA with the within-subject factors of face age (5 years, 9 years, adult) and face sex, and between-subject factors of participant age (5 years, 9 years, adult), and participant sex. The ANOVA revealed main effects of participant age ($F_{2, 66} = 32.82$, $p < 0.001$, $\eta_p^2 = 0.499$), face age ($F_{2, 132} = 4.29$, $p = 0.016$, $\eta_p^2 = 0.061$), face sex ($F_{1, 66} = 8.76$, $p = 0.004$, $\eta_p^2 = 0.117$), and an interaction between participant age and face age (*F*4, 66 = 2.49, $p = 0.046$, $\eta_p^2 = 0.070$). The effect of face sex reflected a stronger effect of symmetry on choices for male than female faces (see figure 2). To analyse the interaction, we split the ANOVA data

[4] The means for the 5-year-old female face set were calculated based on 15 rather than 16 face pairs because of a coding error.

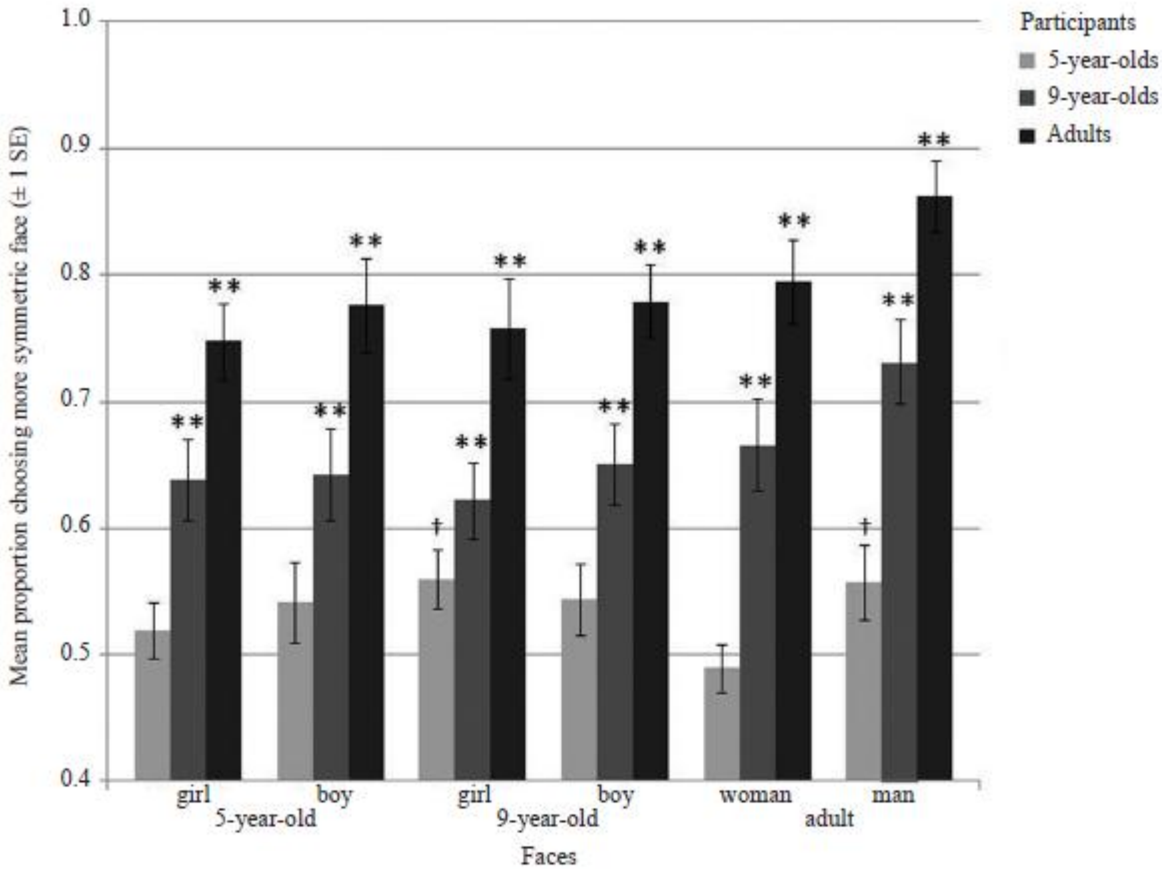


Figure 2. Mean proportion of trials on which the more symmetric face was selected by 5-year-old, 9-year-old, and adult participants for each face category. Note: † $p < 0.05$, * $p < 0.008$, ** $p < 0.001$.

by participant age, and performed separate repeated-measures ANOVAs for 5-year-old, 9-year-old, and adult participants with the within-subject factor of face age (5 years, 9 years, adult). The analysis revealed no significant effects among 5-year-old participants, and a main effect of face age among 9-year-old participants ($F_{2, 46} = 4.20$, $p = 0.021$, $\eta_p^2 = 0.154$), and among adult participants ($F_{2, 46} = 6.73$, $p = 0.003$, $\eta_p^2 = 0.226$). We followed up the effect of face age for 9-year-old and adult participants with paired samples *t*-tests comparing means for the faces of 5-year-olds, 9-year-olds, and adults, adjusting for multiple comparisons with Bonferroni correction at $a = 0.017$. In 9-year-old participants, there were no differences in the selection of more symmetric faces between 5-year-old and 9-year-old faces (t_{23} = 0.17, p = 0.866), or between 5-year-old and adult faces (t_{23} = – 2.35, p = 0.028). However, 9-year-olds selected more symmetric faces more frequently in adult (M = 0.70, SD = 0.16), than 9-year-old faces (M = 0.64, SD = 0.13; t_{23} = – 2.86, p = 0.009). In adult participants, there were no differences between 5-year-old and 9-year-old faces (t_{23} = – 0.31, p = 0.763); however, adults selected the more symmetric faces more frequently in adult (M = 0.83, SD = 0.13) than 5-year-old faces (M = 0.76, SD = 0.15; t_{23} = – 3.16, p = 0.004), and in adult than 9-year-old faces (M = 0.77, SD = 0.14; t_{23} = – 3.54, p = 0.002).

We performed a complementary item analysis across faces rather than across participants by calculating the proportion of participants of each age (5 years, 9 years, and adult) selecting the more symmetric face for each group of faces (16 face pairs × 6 groups of faces). For every age of participant, this produced 16 preference scores for each of the 6 groups of faces.[5] The null hypothesis states that the mean of the preference scores should be 50%, with half the raters selecting the more symmetric face. To assess whether more participants than expected by chance selected the more symmetric faces, for each age of participant we calculated 6 one-tailed one-sample t-tests comparing the mean preference score for each age and sex of face to chance (0.5), controlling for multiple comparisons with Bonferroni correction at a = 0.008. None of the mean preference scores across face pairs was significantly different from chance for 5-year-old participants with Bonferroni correction. Without Bonferroni correction, mean preference scores were greater than chance for 9-year-old girl faces (M = 0.56, SD = 0.109; t_{15} = 1.98, p = 0.022), 9-year-old boy faces (M = 0.544, SD = 0.089; t_{15} = 1.98, p = 0.033), and men's faces (M = 0.556, SD = 0.101; t_{15} = 2.27, p = 0.019) (all other ps > 0.091). The mean preference scores across

[5] The calculations in the 5-year-old female face set were based on the same 15 faces used for the analysis in experiment 1.

stimuli for each of the 6 groups of faces were significantly above chance for 9-year-old and adult participants (all *p*s < 0.001). When we took the mean preference score across all faces for each age of participant and calculated a one-sample *t*-test comparing the mean preference score to chance, we found that 5-year-olds' ($M = 0.534$, SD = 0.100; $t_{94} = 3.47$, $p < 0.001$), 9-year-olds' ($M = 0.659$, SD = 0.111; $t_{94} = 13.99$, $p < 0.001$), and adults' ($M = 0.786$, SD = 0.108; $t_{94} = 25.91$, $p < 0.001$) preference scores were above chance.

We additionally performed a repeated-measures ANOVA on the item scores with the within-subject factors of face age (5 years, 9 years, adult) and face sex, and between-subject factors of participant age (5 years, 9 years, adult) and participant sex. We found main effects of participant age ($F_{2, 90} = 145.77$, $p < 0.001$, $\eta_p^2 = 0.764$), of face age ($F_{2, 180} = 5.97$, $p = 0.003$, $\eta_p^2 = 0.062$), and face sex, with more raters choosing the more symmetric faces among male than female faces ($F_{1, 90} = 11.73$, $p = 0.001$, $\eta_p^2 = 0.115$). A-posteriori comparisons using the Tukey HSD test indicated that more 9-year-olds ($M = 0.659$, SD = 0.111) selected more symmetric faces than 5-year-olds ($M = 0.536$, SD = 0.010) ($p < 0.001$), and more adults ($M = 0.786$, SD = 0.108) selected more symmetric faces than 9-year-olds ($p < 0.001$) or 5-year-olds ($p < 0.001$). We followed up with paired-samples *t*-tests comparing means for 5-year-old, 9-year-old, and adult faces, controlling for multiple comparisons with Bonferroni correction at $a = 0.017$. We found that more participants selected the more symmetric faces in adult ($M = 0.684$, SD = 0.160) than 5-year-old faces ($M = 0.625$, SD = 0.163; $t_{95} = -3.52$, $p < 0.001$). Without Bonferroni correction, marginally more participants selected the more symmetric faces in adult than 9-year-old faces ($M = 0.652$, SD = 0.134; $t_{95} = -1.91$, $p = 0.060$).

2.6 *Discussion*

Our results indicate that both 9-year-olds and adults found symmetry to be attractive in faces. There was little evidence of an influence of symmetry on 5-year-olds' attractiveness judgments and its influence increased between the age of 9 years and adulthood. We additionally found that symmetry was a stronger influence on attractiveness judgments in adult than child faces, and in male than female faces.

This is the first study, to our knowledge, that has explored the influence of symmetry on attractiveness judgments between infancy and adolescence. Our results indicate that symmetry begins to influence facial attractiveness judgments reliably after the age of 5 years, and its influence reaches adult levels after the age of 9 years, a pattern suggesting a long developmental trajectory. It is possible that 5-year-olds could not even see the differences between the pairs of faces, a possibility that will be taken up in the general discussion. As the differences between face pairs in this study were exaggerated to likely be larger on average than the symmetry differences between faces in the real world, our results suggest that bilateral symmetry is unlikely to influence the attractiveness judgments of 5-year-olds in the real world.

The greater influence of symmetry on attractiveness judgments in male than female faces is consistent with findings that adolescents selected the symmetric face over the more asymmetric companion face more frequently for male than female faces when shown mid-adolescent (but not young adolescent) faces (Saxton et al 2009, 2010, 2011). From the standpoint of cognitive fluency, the greater influence of symmetry on attractiveness judgments in male faces is difficult to explain, because infants already show evidence of easier processing of female than male faces (see Ramsey et al 2005; Ramsey-Rennels and Langlois 2006), likely because of greater experience with female faces (Rennels and Simmons 2008). The stronger influence of symmetry on attractiveness judgments in male faces is less surprising from the standpoint of evolutionary explanations based on sexual selection (see introduction). Relatedly, it is possible that fluctuating asymmetry is larger, and hence more salient in male faces. However, the evidence is at best mixed. Manning (1995) found no differences in mean levels of FA between the bodies of males and females in a sample of 70 adults, or 100 children aged 5–12 years. However, in another group of 60 adults, Manning et al (1997) found higher levels of FA in the bodies of males than females. In a study of mandibular symmetry, Melnik (1992) found greater asymmetry in boys than girls at younger ages, but no sex difference by the age of 14 years. By contrast, a large study of school children in rural Jamaica found lower levels of asymmetry in boys than girls, which was mainly driven by asymmetries in elbow width (Trivers et al 1999). In sum, while our finding that symmetry had a greater influence on attractiveness judgments in male faces than female faces is not unique, it is unclear whether there may be peculiarities in our specific face sets, whether male faces vary more or less than female faces in fluctuating asymmetry in the general population, or whether fluctuating asymmetries are expressed more in males than females only in stressful environmental conditions, as seen in the slum districts of Ankara, Turkey (Özener 2010; Özener and Fink 2010).

The stronger influence of symmetry on attractiveness judgments in adult than child faces is unexpected, as Livshitz and Kobylianski (1989) found decreasing levels of fluctuating asymmetry from infancy to adulthood, and Melnik (1992) found decreasing levels of mandibular asymmetry from young childhood to early adulthood. A large-scale study examining fluctuating asymmetries of British children aged 2–18 years found that asymmetries decreased from 2 to 10 years, increased in adolescents at 11–15 years, and decreased again after the age of 15 years, a decrease that was maintained to the age of 18 years (Wilson and Manning 1996). Children’s faces may then be more asymmetric than adult faces, possibly caused by differential rates of growth on the two sides of the body (Melnik 1992). Our finding of a greater influence of symmetry on adult than child faces could arise if we are more forgiving of asymmetries in children's faces because they tend to be more prevalent and/or it may reflect a processing advantage for adult faces because of the early and continuous exposure to adults' faces throughout development (see Macchi Cassia 2011).

In experiment 2, we compared the amount of asymmetry in our 6 face sets to see if differences based on sex or age of face could account for the stronger influence of symmetry on judgments of male faces and of faces of adults. Specifically, we examined whether our face sets match the differences reported in the literature (less asymmetry in adult faces). These data will help to distinguish whether our results could be caused by an unusual pattern of asymmetries in our face sets (greater asymmetries in our adult than child faces that are not typical of the population), or whether our stimuli are typical and symmetry may be a stronger influence on attractiveness judgments in older than younger faces and in male than female faces, as fluctuating asymmetries may be more informative for adult male faces.

3 Experiment 2

To test whether the effects of age and sex of face on attractiveness judgments in experiment 1 could be caused by mean differences in symmetry across our specific face sets, we measured the amount of asymmetry in the original unwarped faces in each set, and had adults rate the symmetry of those faces. Rhodes et al (1998) found that adults accurately rated symmetry differences among adult faces that had been manipulated to create low, medium, high, and perfectly symmetric versions of each face. Because in Scheib et al (1999), women did not accurately rate the symmetry of men's faces (despite finding symmetry to be attractive in men's faces), we also compared these ratings to actual measurements of symmetry in the original faces.

3.1 *Participants*

Participants were twenty-four white adults (aged 18 to 35 years; half male). All were students at McMaster University and met the same visual screening criteria as described in experiment 1. Participants volunteered, or participated in exchange for course credit.

3.2 *Stimuli*

Stimuli were the original, unwarped images that were used to create the symmetry stimuli in experiment 1. As in experiment 1, the images had been created by using Adobe Photoshop CS to remove major blemishes and the second catch light from each eye. External features and hair were removed by placing a grey background around the outline of each face. Faces subtended the same visual angle as in experiment 1.

3.3 *Procedure*

After obtaining consent, participants viewed the faces individually and were asked to rate how symmetric each face looked on a 5-point scale. Each face appeared individually in the centre of the computer screen, and the anchors (1) *very asymmetric*, and (5) *very symmetric* appeared in the top left and right corners of the screen. The instructions "How symmetric is this face?" were centred at the top of the screen. Faces appeared in random order within blocks counterbalanced by age and sex of face with a Latin-square design. There were 16 faces within each of the 6 face categories, for a total of 96 trials. Participants were told the age and sex of the group of faces they would be viewing prior to rating each block. Faces appeared on the screen until participants made a response with the keyboard, which then initiated the next trial.

3.4 *Results*

For each participant, we calculated the mean symmetry rating for each group of faces (see footnote 5). A repeated-measures ANOVA with the within-subject factors of face age (5 years, 9 years, adult) and face sex, and the between-subject factor of participant sex revealed main effects of face age ($F_{2, 44} = 5.99$, $p = 0.004$, $\eta_p^2 = 0.214$), face sex ($F_{1, 22} = 16.06$, $p = 0.001$, $\eta_p^2 = 0.422$), qualified by an interaction between face sex and face age ($F_{2, 44} = 5.79$, $p = 0.006$, $\eta_p^2 = 0.208$). Non-significant effects included the main effect participant sex ($F_{1, 22} = 3.69$, $p = 0.068$, $\eta_p^2 = 0.144$), and interactions between face age and participant sex ($F_{2, 22} = 1.81$, $p = 0.835$, $\eta_p^2 = 0.008$), and between face age, face sex, and participant sex ($F_{2, 22} = 1.42$, $p = 0.252$, $\eta_p^2 = 0.061$). To break down the face sex by face age interaction, we did separate paired-samples *t*-tests comparing male and female faces for each age of face, correcting for multiple comparisons with Bonferroni correction at $a = 0.017$. The analysis revealed that participants rated adult male faces to be less symmetric than adult female faces ($t_{23} = 4.98$, $p < 0.001$), but there were no differences between male and female 9-year-old faces ($t_{23} = 2.28$, $p = 0.032$) or 5-year-old faces ($t_{23} = 0.989$, $p = 0.333$). Paired-samples *t*-tests comparing the different ages of faces for each sex of face, correcting for multiple comparisons with Bonferroni correction at $a = 0.017$, revealed no significant differences among female faces of different ages (all *p*s > 0.13). In male faces, participants perceived adult faces to be less symmetric than 5-year-old faces ($t_{23} = 4.29$, $p < 0.001$) and 9-year-old faces ($t_{23} = 4.21$, $p < 0.001$). In a-posteriori analysis, paired-samples *t*-tests adjusting for multiple comparisons with Bonferroni correction at $a = 0.008$, revealed that adult male faces were rated to be less symmetric than all other groups of faces (all *p*s < 0.005; see figure 3).

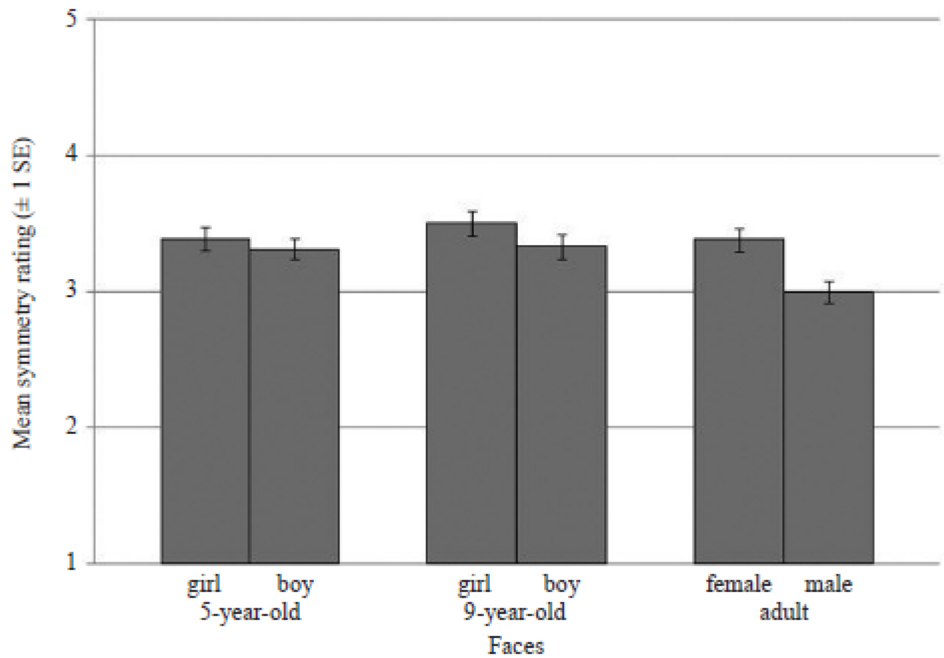


Figure 3. Mean symmetry ratings on a 5-point scale by adults of the original, untransformed faces (1 = *very asymmetric*, 5 = *very symmetric*).

3.5 *Symmetry measurements*

The procedure was similar to that described by Scheib et al (1999) and Penton Voak et al (2001). We used 6 pairs of corresponding bilateral points on each face to calculate measures of horizontal and vertical asymmetry. Calculations were based on bilaterally paired points at the outer corner of the eyes, the inner corner of the eyes, the outer edge of the cheekbones, the outer edge of the nostrils, the outer corner of the lips, and the outer edge of the jaw. Horizontal asymmetry refers to the difference for two corresponding points in the distance from the vertical midline. As points farther from the vertical midline exert a greater influence on an overall horizontal asymmetry measurement for the face than points closer to the midline, we took *z*-scores for each pair of points across all face sets. We then took the sum of the absolute value of the *z*-scores for the 6 pairs of horizontal asymmetry measurements to gain an overall measure of horizontal asymmetry for each face. Vertical asymmetry refers to the deviation of corresponding points from a level horizontal plane. The measurement for each face was based on the sum of the vertical differences, converted to *z*-scores for consistency. We additionally calculated a measurement of total asymmetry for each face by adding the absolute values of the *z*-scored vertical asymmetry and horizontal asymmetry measurements for each face. We performed separate repeated-measures ANOVAs for vertical asymmetry, horizontal asymmetry, and total asymmetry with the factors of face sex (male, female), and face age (5 years, 9 years, adult; see footnote 5), and found no main effect of face sex ($F_{1, 14} = 0.718$, $p = 0.411$) or of face age ($F_{2, 28} = 0.758$, $p = 0.478$), and no interaction between face sex and face age ($F_{2, 28} = 0.402$, $p = 0.673$; figure 4).

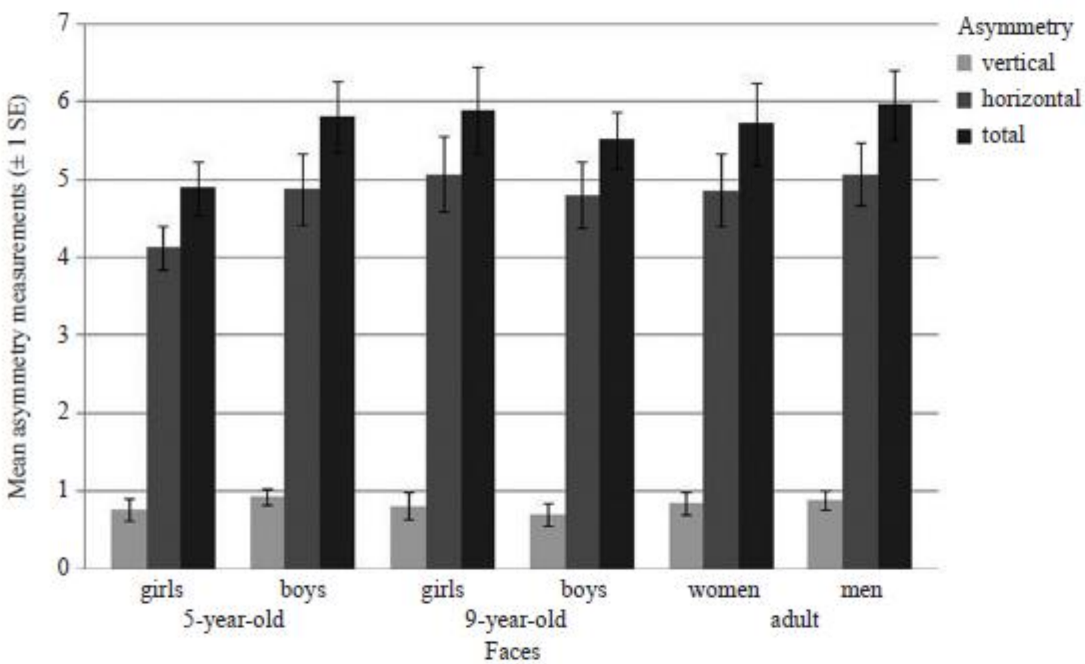


Figure 4. Mean asymmetry measurements for each group of faces. Higher numbers refer to higher levels of asymmetry.

3.6 *Discussion*

One result of experiment 1 was that symmetry exerted a stronger influence on adults' and 9-year-olds' attractiveness judgments for adult than child faces. In experiment 2, age of face did not affect adults' ratings of symmetry or our measurements. Combined, the data indicate that symmetry has more influence on judgments of attractiveness for adult than child faces, even though the face sets of different ages did not differ in average symmetry. In the general discussion, we consider the possible explanations for this effect.

Another result of experiment 1 was a stronger influence of symmetry on judgments of attractiveness for male than for female faces, regardless of age. In experiment 2, adults rated adult male faces to be less symmetric than all other groups of faces. There were no differences, however, in mean levels of asymmetry among the groups of faces according to our symmetry measurements. Thus, symmetry exerted a greater influence on the attractiveness judgments of children and adults when viewing male faces of adults or children, but our measurements indicated no sex differences in asymmetry, and adults' ratings did not differ except for rating adult male faces to be less symmetric. The discrepancy could reflect inaccurate measurement or ratings, and/or adults could have greater sensitivity to small variations in symmetry in male than in female faces.

It is possible that our symmetry measurements are inaccurate, as 2-D measurements of 3-D stimuli are inaccurate if the face is rotated even to a small degree away from a front-face view, making one side of the face appear to be larger than the other (Penton-Voak et al 2001). Adult raters, who take viewpoint into account when processing faces, might have been less affected by such hypothetical rotations. It is unlikely, however, that adult male models would have been more likely to rotate their heads than would other groups. Alternately, it is possible that adults were inaccurate when rating the symmetry of the faces. Although they can accurately rate symmetry differences in faces that have been manipulated to have low, medium, high, or perfect symmetry (Rhodes et al 1998), they may not be able to explicitly pick out subtle variations in symmetry in original faces of the type we used here, despite being affected by exaggerations of those asymmetries when making judgments of attractiveness. Our results are similar to those of Scheib et al (1999) who had women rate the symmetry of men's faces, and found only weak correlations between the symmetry ratings and actual measurements of symmetry.

Finally, it is possible that humans are more sensitive to asymmetries in adult male faces than in other groups of faces. Among most human populations, more males are available to reproduce than females (Low 2001). This creates stronger male–male competition over females compared to female–female competition over males and, as a consequence, male traits are expected to receive greater attention during assessment of potential mates and competitors (Trivers 1972). Indeed, the ratio of males to females to be judged alters the strength of the preference for symmetry, so that, when there is a higher proportion of males than females, symmetry has a stronger influence on female's judgments of attractiveness. (Watkins et al 2012). Our research suggests that these effects may carry over between the sexes, such that both sexes respond more strongly to the symmetry of men's than women's faces, and do so even in children's faces.

4 General discussion

We found that symmetry has clear influence on attractiveness judgments in 9-year-olds and adults, but only a weak, if any, influence on the judgments of 5-year-olds. This is the first evidence, to our knowledge, of the influence of symmetry on attractiveness judgments in pre-adolescent children. It is unlikely that the largely random performance of 5-year-olds was caused by children's poor understanding of the task, weak attention, or poor motivation, as all participants completed the criterion trials successfully, and averageness influenced the attractiveness judgments of children of the same age when they were tested with a similar procedure (Vingilis-Jaremko and Maurer, in press).

Combined with previous evidence, our results suggest a very long developmental trajectory for the influence of symmetry on judgments of attractiveness: a preference appears to be just emerging about the age of 5 years (this study), to strengthen by the age of 9 years (this study), and to increase further during adolescence (Saxton et al 2009, 2010, 2011). This pattern contrasts with the influences of feature height and of averageness on children's judgments of attractiveness that are already evident at or by 5 years of age (Cooper et al 2006; Vingilis-Jaremko and Maurer, in press). Nevertheless, those influences, like symmetry, are weaker throughout middle childhood than they are in adults (Cooper et al 2006; Vingilis-Jaremko and Maurer, in press).

There are several reasons the developmental trajectory for the influence of symmetry might be so long. First, the differences in symmetry between the two members of each pair were subtle and hence may have been difficult for children to detect. There is evidence that infants can distinguish asymmetric from vertically symmetric patterns as early as at 4 months of age [Bornstein et al 1981; see Bornstein and Stiles-Davis (1984) for evidence of discrimination in children aged 4 to 6 years] and that by the age of 1 year they have a looking preference for vertically symmetric patterns. However, it may take longer for them to become adept at detecting small differences in the degree of symmetry in a vertically symmetric pattern, such as the subtle differences present in faces. Indeed, children's sensitivity to the global structure present in dot patterns, moving dots, or biological motion continues to improve until the age of 9–12 years

(Hadad et al 2011; Lewis et al 2004). So does their sensitivity to small differences in the location of internal facial features (Baudouin et al 2010; Mondloch et al 2002). Other immaturities of the visual system could have made it difficult for 5-year-olds to perceive the differences between faces. Contrast sensitivity does not become adult-like until the ages of 7 to 9 years, and grating acuity is not adult-like until the age of 6 years (Adams and Courage 2002; Ellemberg et al 1999). The 5-year-old age group may then have had greater difficulties perceiving the differences between the faces, which could limit or remove the influence of symmetry on their attractiveness judgments. Nevertheless, there was evidence that 5-year-olds could at least detect the asymmetries in some of the faces, as there was an influence of symmetry on their judgments of attractiveness when we collapsed the data across all faces to maximise power. As our stimuli vary more in symmetry than faces in a typical population, our findings suggest that, in everyday social interactions, symmetry has no, or at best minimal, influence on 5-year-olds' perceptions of attractiveness.

A second and related possibility is that poorer visual sensitivity in children prevents any processing advantage for symmetry. It has been hypothesised that adults may prefer symmetrical patterns because the redundancy of information leads to faster and more efficient processing, associated with a general tendency to find stimuli that are processed more easily to be attractive (Reber et al 2004). One can quantify differences between groups (or conditions) in processing efficiency by using a procedure that distinguishes differences in internal noise from differences in efficiency. In this procedure, the limits on processing of external stimuli are estimated by superimposing external noise (random variations in pixel luminance) on the stimuli and then estimating internal noise and efficiency from the shape of a function relating performance to level of external noise in log-log coordinates (Lu and Dosher 1999). Internal noise limits performance only at high levels of external noise and can result from stochastic fluctuations of neural responses, receptor sampling errors, and information loss during neural transmission (Lu and Dosher 1999). Inefficiency in processing the signal limits performance at all levels of external noise. Either higher levels of internal noise or less efficiency could limit children's preferences based on processing fluency, particularly for stimuli with very subtle differences, such as the faces differing in symmetry used in this study. Jeon et al (2012) recently used this approach with children aged 5, 7, and 9 years and adults in a paradigm in which subjects had to detect low-contrast gratings embedded in noise. Sensitivity improved between the ages 5 and 9 years, and again from the age of 9 years to adulthood. Computer modelling suggested that the improvements resulted from decreases in internal noise and increased efficiency. These visual limitations at the ages of 5 and 9 years are likely to reduce processing fluency, and thereby limit processing-based preferences when differences between stimuli are subtle.

A third possible explanation for the long developmental trajectory is that symmetry begins to strongly influence judgments of facial attractiveness only when children become old enough to think about mating, at which point its influence should be stronger for adult than children's faces. As reviewed in the introduction, symmetry may be an honest signal of phenotypic quality, and hence it is adaptive for symmetry to influence mate choice (see discussion of experiment 1). If this hypothesis is correct, there might be a sharp increase in the influence of symmetry after puberty, with a milder or no influence before then. Indeed there is an increase in the influence of symmetry on attractiveness judgments within adolescence, although the rate of increase at puberty is unknown, as prepubescent children were not tested in these studies (Saxton et al 2009, 2010, 2011).

A final possible explanation is that the gradual accumulation of experience in differentiating among faces from childhood to adulthood increases sensitivity to differences in symmetry when making judgments of attractiveness. There is evidence that the development of many aspects of face processing, including attractiveness judgments, is influenced by experience with faces (eg Cooper et al 2006; De Heering et al 2010; Hills and Lewis 2011; Macchi Cassia et al 2009; Mondloch et al 2006). For example, 3-year-old children with high levels of interaction with peers, like adults, judged faces with low feature height, as is present in children's faces, as more attractive than faces with high feature height. By contrast, 3-year-olds with low levels of peer interaction exhibited no preference between faces with low, average, and high feature height. Experience with peer faces may then have tuned children's attractiveness judgments toward the proportions of those faces (Cooper et al 2006). Additional evidence for a role of experience comes from the findings that the influence of symmetry on adults' judgments of attractiveness is greater for upright than inverted faces, and that their ability to detect small variations in symmetry is better for unaltered than contrast-reversed faces, and possibly better for upright than inverted faces (Little and Jones 2006; Rhodes et al 2005). Even brief periods of biased experience can change attractiveness judgments in both children and adults. Adapting 8-year-olds and adults to faces with either compressed or expanded features leads them to increase their attractiveness ratings of faces in the distorted direction, compared to before adaptation (Anzures et al 2009). These brief periods of biased experience probably affect attractiveness judgments by biasing a norm, or prototype face. When the biased input ends, exposure to the normal range of human faces will reset the norm to near the population average. Experiential refinement of the norm and the dimensions of the face space in which it is centred (Rhodes and Leopold 2011) may contribute to developmental improvements in detecting subtle differences among faces, including symmetry. Through this process, children may adapt to directional asymmetries that are common across human faces (eg the right side of the prototype face may become larger than the left: Rhodes et al 2009), and become more sensitive to fluctuating asymmetries. However, the finding of a strong influence of symmetry on judgments of attractiveness in Hadza adults, a hunter-gather group in Tanzania, that was equivalent for the Hadza faces of the type they had experienced and the European faces they had rarely seen (Little et al 2007) suggests that the preference may not arise from experience and/or that by adulthood it generalises to all types of adult faces.

These four explanations are not mutually exclusive. Increased visual sensitivity could allow children to extract more information from faces, and thereby allow them to form more useful dimensions in a multi-dimensional face space and a more veridical norm, both of which would promote processing fluency. This improved sensitivity could have more impact on judgments of attractiveness after puberty. All of these proximal mechanisms could, in turn, underlie the evolutionary advantage afforded by the influence of symmetry on mate choice.

Future studies could evaluate these explanations by assessing changes in the influence of symmetry at the transition to puberty by testing prepubertal, pubertal, and postpubertal children with adult same and opposite-sex faces. It would also be useful to compare these groups to young and older adults. If postpubertal interest in mating is critical, the effects should be stronger in postpubertal adolescents and young adults than in the other groups. Another future direction would be to assess developmental changes in symmetry discrimination among faces and patterns, an approach that would elucidate the role of changes in visual sensitivity in the increasing influence of symmetry on judgments of facial attractiveness during childhood.

Acknowledgments. We thank Renata Samigullina, Dana Shen, and Megan Hophing for help with the collection of data, and David Feinberg for contributing a subset of the face photographs that we used to create stimuli, for advice on creating stimuli, and for comments on an earlier draft of the manuscript. We thank Cathy Mondloch for contributing a subset of the face photographs that we used to create stimuli. This research was supported by a grant from the Canadian Natural Sciences and Engineering Council (9797) to Daphne Maurer. Larissa Vingillis-Jaremko was supported by an NSERC CGS D.

References

Adams R A, Courage M L, 2002 "Using a single test to measure human contrast sensitivity from early childhood to maturity" *Vision Research* **42** 1205–1210

Anastasi J S, Rhodes M G, 2005 "An own-age bias in face recognition for children and older adults" *Psychonomic Bulletin & Review* **12** 1043–1047

Anzures G, Mondloch C J, Lackner C, 2009 "Face adaptation and attractiveness aftereffects in 8-year-olds and adults" *Child Development* **80** 178–191

Baudouin J, Gallay M, Durand K, Robichon F, 2010 "The development of perceptual sensitivity to second-order facial relations in children" *Journal of Experimental Child Psychology* **107** 195–206

Bernstein I H, Lin T, McClellan P, 1982 "Cross-vs. within-racial judgments of attractiveness" *Perception* & *Psychophysics* **32** 495–503

Bornstein M H, Ferdinandsen K, Gross C G, 1981 "Perception of symmetry in infancy" *Developmental Psychology* **17** 82–86

Bornstein M H, Krinsky S J, 1985 "Perception of symmetry in infancy: The salience of vertical symmetry and the perception of pattern wholes" *Journal of Experimental Child Psychology* **39** 1–19

Bornstein M H, Stiles-Davis J, 1984 "Discrimination and memory for symmetry in young children" *Developmental Psychology* **20** 637–649

Cooper P A, Geldart S S, Mondloch C J, Maurer D, 2006 "Developmental changes in perceptions of attractiveness: a role of experience?" *Developmental Science* **9** 530–543

Cunningham M R, Roberts A R, Barbee A P, Druen P B, 1995 “Their ideas of beauty are, on the whole, the same as ours: Consistency and variability in the cross-cultural perception of female physical attractiveness” *Journal of Personality and Social Psychology* **68** 261–279

De Heering A, De Liedekerke C, Deboni M, Rossion B, 2010 “The role of experience during childhood in shaping the other-race effect” *Developmental Science* **13** 181–187

Dion K K, 1973 “Young children’s stereotyping of facial attractiveness” *Developmental Psychology* **9** 183–188

Dion K, Berscheid E, Walster E, 1972 “What is beautiful is good” *Journal of Personality and Social Psychology* **24** 285–290

Ellemberg D, Lewis T L, Liu C H, Maurer D, 1999 “Development of spatial and temporal vision during childhood” *Vision Research* **39** 2325–2333

Fisher C B, Ferdinandsen K, Bornstein M H, 1981 “The role of symmetry in infant form discrimination” *Child Development* **52** 457–462

Gangestad S W, Merriman L A, Thompson M E, 2010 “Men’s oxidative stress, fluctuating asymmetry and physical attractiveness” *Animal Behaviour* **80** 1005–1013

Garner W R, Sutliff D, 1974 “The effect of goodness on encoding time in visual pattern discrimination” *Perception & Psychophysics* **16** 426–430

Grammar K, Thornhill R, 1994 “Human (*Homo sapiens*) facial attractiveness and sexual selection: The role of symmetry and averageness” *Journal of Comparative Psychology* **108** 233–242

Hadad B, Maurer D, Lewis T L, 2011 “Long trajectory for the development of sensitivity to global and biological motion” *Developmental Science* **14** 1330–1339

Halberstadt J, Rhodes G, 2000 “The attractiveness of nonface averages: implications for an evolutionary explanation of the attractiveness of average faces” *Psychological Science* **11** 285–289

Hills P J, Lewis M B, 2011 “The own-age face recognition bias in children and adults” *Quarterly Journal of Experimental Psychology* **64** 17–23

Jeon S T, Maurer D, Lewis T L, 2012 “Characterizing the mechanisms behind improvements in visual sensitivity during childhood” [Abstract] *Journal of Vision* in press

Johnson R W, Dannenbring G L, Anderson N R, Villa R E, 1983 “How different cultural and geographic groups perceive the attractiveness of active and inactive feminists” *Journal of Social Psychology* **119** 111–117

Kowner R, 1996 “Facial asymmetry and attractiveness judgment in developmental perspective” *Journal of Experimental Psychology: Human Perception and Performance* **22** 662–675

Langlois J H, Kalakanis L, Rubenstein A J, Larson A, Hallam M, Smoot M, 2000 “Maxims or myths of beauty? A meta-analytic and theoretical review” *Psychological Bulletin* **126** 390–423

Langlois J H, Roggman L A, Casey R J, Ritter J M, Rieser-Danner L A, Jenkins V Y, 1987 “Infant preferences for attractive faces: Rudiments of a stereotype?” *Developmental Psychology* **23** 363–369

Langlois J H, Roggman L A, Musselman L, 1994 “What is average and what is not average about attractive faces?” *Psychological Science* **5** 214–220

Langlois J H, Stephan C, 1977 “The effects of physical attractiveness and ethnicity on children’s behavioral attributions and peer preferences” *Child Development* **48** 1694–1698

Lewis T, Ellemberg D, Maurer D, Dirks M, Wilkinson F, Wilson H, 2004 "A window on the normal development of sensitivity to global form in Glass patterns" *Perception* **33** 409–418

Little A C, Apicella C L, Marlowe F W, 2007 "Preferences for symmetry in human faces in two cultures: data from the UK and the Hadza, an isolated group of hunter-gatherers" *Proceedings of the Royal Society of London B* **274** 3113–3117

Little A C, Jones B C, 2006 "Attraction independent of detection suggests special mechanisms for symmetry preferences in human face perception" *Proceedings of the Royal Society B* **273** 3093–3099

Livshitz G, Kobylianski E, 1989 "Study of genetic variance in the fluctuating asymmetry of anthropometrical traits" *Annals of Human Biology* **16** 121–129

Low B, 2001 *Why Sex Matters: A Darwinian Look at Human Behavior* (Princeton, NJ: Princeton University Press)

Lu Z, Dosher B A, 1999 "Characterizing human perceptual inefficiencies with equivalent internal noise" *Journal of the Optical Society of America* **16** 764–778

Macchi Cassia V, 2011 "Age biases in face processing: The effects of experience across development" *British Journal of Psychology* **102** 816–829

Macchi Cassia V, Kuefner D, Picozzi M, Vescovo E, 2009 "Early experience predicts later plasticity for face processing" *Psychological Science* **20** 853–859

Manning J T, 1995 "Fluctuating asymmetry and body weight in men and women: implications for sexual selection" *Ethology & Sociobiology* **16** 145–163

Manning J T, Koukourakis K, Brodie D A, 1997 "Fluctuating asymmetry, metabolic rate and sexual selection in human males" *Evolution & Human Behavior* **18** 15–21

Mealey L, Bridgestock R, Townsend G C, 1999 “Symmetry and perceived facial attractiveness: A monozygotic co-twin comparison” *Journal of Personality and Social Psychology* **76** 151–158

Melnik A K, 1992 “A cephalometric study of mandibular asymmetry in a longitudinally followed sample of growing children” *American Journal of Orthodontics and Dentofacial Orthopedics* **101** 355–366

Møller A P, 1990 “Fluctuating asymmetry in male sexual ornaments may reliably reveal male quality” *Animal Behaviour* **40** 1185–1187

Møller A P, 1997 “Developmental stability and fitness: a review” *The American Naturalist* **149** 916–932

Møller A P, Pomiankowski A, 1993 “Fluctuating asymmetry and sexual selection” *Genetica* **89** 267–279

Møller A P, Swaddle J P, 1997 *Developmental Stability and Evolution* (Oxford: Oxford University Press)

Møller A P, Thornhill R, 1998 “Bilateral symmetry and sexual selection: A meta-analysis” *The American Naturalist* **151** 174–192

Mondloch C, Le Grand R, Maurer D, 2002 “Configural face processing develops more slowly than featural face processing” *Perception* **31** 553–566

Mondloch C J, Maurer D, Ahola S, 2006 “Becoming a face expert” *Psychological Science* **17** 930–934

Özener B, 2010 “Brief communication: Facial fluctuating asymmetry as a marker of sex differences of the response to phenotypic stresses” *American Journal of Physical Anthropology* **143** 321–324

Özener B, Fink B, 2010 "Facial symmetry in young girls and boys from a slum and a control area of Ankara, Turkey" *Evolution and Human Behavior* **31** 436–441

Penton-Voak I S, Jones B C, Little A C, Baker S, Tiddeman B, Burt D M, Perrett D I, 2001 "Symmetry, sexual dimorphism in facial proportions and male facial attractiveness" *Proceedings of the Royal Society of London B* **268** 1617–1623

Perrett D I, Burt M B, Penton-Voak I S, Lee K J, Rowland D A, Edwards R, 1999 "Symmetry and human facial attractiveness" *Evolution and Human Behavior* **20** 295–307

Perrett D I, May K A, Yoshikawa S, 1994 "Facial shape and judgments of female attractiveness" *Nature* **368** 239–242

Pomerantz J R, 1977 "Pattern goodness and speed of encoding" *Memory & Cognition* **5** 235–241

Ramsey J L, Langlois J H, Marti C N, 2005 "Infant categorization of faces: Ladies first" *Developmental Review* **25** 212–246

Ramsey-Rennels J L, Langlois J H, 2006 "Infants' differential processing of female and male faces" *Current Directions in Psychological Science* **15** 59–62

Reber R, Schwartz N, Winkielman P, 2004 "Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience?" *Personality and Social Psychology Review* **8** 364–382

Rennels J L, Simmons R E, 2008 "Facial experience during the first year" Infant Behavior and Development **31** 665–678

Rhodes G, 2006 "The evolutionary psychology of facial beauty" Annual Review of Psychology **57** 199–226

Rhodes G, Geddes K, Jeffery L, Dziurawiek S, Clark A, 2002 "Are average and symmetric faces attractive to infants? Discrimination and looking preferences" *Perception* **31** 315–321

Rhodes G, Leopold D A, 2011 “Adaptive norm-based coding of face identity”, in *The Oxford Handbook of Face Perception* Eds A J Calder, G Rhodes, M H Johnson, J V Haxby (Oxford: Oxford University Press) pp 263–286

Rhodes G, Louw K, Evangelista E, 2009 “Perceptual adaptation to facial asymmetries” *Psychonomic Bulletin & Review* **16** 503–508

Rhodes G, Peters M, Lee K, Concetta Morrone M, Burr D, 2005 “Higher-level mechanisms detect facial symmetry” *Proceedings of the Royal Society of London B* **272** 1379–1384

Rhodes G, Proffitt F, Grady J M, Sumich A, 1998 “Facial symmetry and the perception of beauty” *Psychonomic Bulletin & Review* **5** 659–669

Rhodes G, Yoshikawa S, Clark A, Lee K, McKay R, Akamatsu S, 2001 “Attractiveness of facial averageness and symmetry in non-Western cultures: in search of biologically based standards of beauty” *Perception* **30** 611–625

Samuels C A, Butterworth G, Roberts T, Graupner L, Hole G, 1994 “Facial aesthetics: babies prefer attractiveness to symmetry” *Perception* **23** 823–831

Saxton T K, Debruine L M, Jones B C, Little A C, Roberts S C, 2009 “Face and voice attractiveness judgments change during adolescence” *Evolution and Human Behavior* **30** 398–408

Saxton T K, Debruine L M, Jones B C, Little A C, Roberts S C, 2011 “A longitudinal study of adolescents’ judgments of the attractiveness of facial symmetry, averageness and sexual dimorphism” *Journal of Evolutionary Psychology* **9** 43–55

Saxton T K, Kohoutova D, Roberts S C, Jones B C, DeBruine L M, Havlicek J, 2010 “Age, puberty and attractiveness judgments in adolescents” *Personality and Individual Differences* **49** 857–862

Scheib J E, Gangestad S W, Thornhill R, 1999 “Facial attractiveness, symmetry and cues of good genes” *Proceedings of the Royal Society of London A* **66** 1913–1917

Simmons L W, Rhodes G, Peters M, Koehler N, 2004 “Are human preferences for facial symmetry focused on signals of developmental instability?” *Behavioral Ecology* **15** 864–871

Slater A, Quinn P C, Hayes R, Brown E, 2000 “The role of facial orientation in newborn infants’ preference for attractive faces” *Developmental Science* **3** 181–185

Slater A, Von der Schulenburg C, Brown E, Badenoch M, Butterworth G, Parsons S, Samuels C, 1998 “Newborn infants prefer attractive faces” *Infant Behavior and Development* **21** 345–354

Thornhill R, Gangestad S W, 1994 “Human fluctuating asymmetry and sexual behavior” *Psychological Science* **5** 297–302

Thornhill R, Møller A P, 1997 “Developmental stability, disease and medicine” *Biological Reviews* **72** 497–548

Thornhill R, Sauer P, 1992 “Genetic sire effects on the fighting ability of sons and daughters and mating success of sons in a scorpionfly” *Animal Behaviour* **43** 255–264

Tiddeman B, Burt D M, Perrett D, 2001 “Computer graphics in facial perception research” *IEEE Computer Graphics and Applications* **21** 42–50

Trivers, R L, 1972 “Parental investment and sexual selection”, in *Sexual Selection and the Descent of Man, 1871–1971* Ed. B Campbell (Chicago, IL: Aldine-Atherton) pp 136–179

Trivers R L, Manning J T, Thornhill R, Singh D, McGuire M, 1999 “Jamaican Symmetry Project: Long-term study of fluctuating asymmetry in rural Jamaican children” *Human Biology* **71** 417–430

Vingilis-Jaremko L, Maurer D, in press, “The influence of averageness on children’s judgments of facial attractiveness” *Journal of Experimental Child Psychology*

Wade 2010 “The relationships between symmetry and attractiveness and mating relevant decisions and behavior: A review” *Symmetry* **2** 1081–1098

Wagemans J, 1995 “Detection of visual symmetries” *Spatial Vision* **9** 9–32

Watkins C D, Jones B C, Little A C, DeBruine L M, Feinberg D R, 2012 “Cues to the sex ratio of the local population influence women’s preferences for facial symmetry” *Animal Behaviour* **83** 545–55

Waynforth D, 1998 “Fluctuating asymmetry and human male life-history traits in rural Belize” *Proceedings of the Royal Society of London B* **265** 1497–1501

Wenderoth P, 1994 “The salience of vertical symmetry” *Perception* **23** 221–236

Wilson J M, Manning J T, 1996 “Fluctuating asymmetry and age in children: evolutionary implications for the control of developmental stability” *Journal of Human Evolution* **30** 529–537

Winkielman P, Halberstadt J, Fazendeiro T, Catty S, 2006 “Prototypes are attractive because they are easy on the mind” *Psychological Science* **17** 799–806

CHAPTER 3: The Influence of Averageness on Children's Judgments of Facial Attractiveness

Vingilis-Jaremko, L., Maurer, D. (in press). The Influence of Averageness on Children's Judgments of Facial Attractiveness. *Journal of Experimental Child Psychology*. http://dx.doi.org/10.1016/j.jecp.2013.03.014

Preface

Adults find faces approximating the population average to be more attractive than most other faces (Langlois & Roggman, 1990). In the work presented in chapter 3, I explored whether averageness also influences children's judgments of attractiveness. To do so I tested 5-year-olds, 9-year-olds, and adults with pairs of faces in which one version of the face had been transformed toward its group average, while the other version of the face had been transformed away from its group average. On each trial participants selected which face they found to be more attractive. I found that averageness influenced 5-year-olds' attractiveness judgments to a lesser extent than 9-year-olds' attractiveness judgments, and 9-year-olds were not adult-like in the strength of their preference. These are the first findings, to our knowledge, demonstrating that averageness influences attractiveness judgments prior to adolescence.

I additionally used faces of 5-year-olds, 9-year-olds, and adults in different blocks to assess whether averageness influences attractiveness judgments in children's faces, and whether experience influences judgments of attractiveness, as children and adults have an own age bias in processing faces (Anastasi & Rhodes, 2005; Hills & Lewis, 2011; but see Macchi Cassia, 2011 for evidence of a processing bias for adult faces among children). I found that averageness influenced judgments of attractiveness in both children's and adults' faces, which is the first demonstration to our knowledge that averageness influences attractiveness judgments in children's faces. Although there were a complex set of interactions between age and sex of face, they were not consistent with an own-age bias or a processing bias for adult faces. Overall, the results demonstrate that the influence of averageness on attractiveness judgments emerges before age 5, matures after age 9, and is present for both adult's and children's faces.

Abstract

We examined developmental changes in the influence of averageness on judgments of facial attractiveness by showing adults and children pairs of individual faces in which one face was transformed 50% toward its group average, while the other face was transformed 50% away from that average. In one comparison, adults and 5-year-olds rated the more average faces as more attractive whether the faces were of adult females, 5-year-old boys, or 5-year-old girls. The influence of averageness, however, was weaker in 5-year-olds than in adults. In another comparison, a new group of adults and 9-year-olds rated the more average faces as more attractive for male and female faces of adults, 9-year-olds, and 5-year-olds. The influence of averageness was again weaker for children than for adults, although the strength of 9-year-olds' preference was greater than that in 5-year-olds. Developmental changes may reflect the refinement of an average face prototype as the child is exposed to more faces, increased sensitivity as visual perception develops, and/or the greater salience of attractiveness after puberty.

Keywords: Face processing, attractiveness, face space, averageness, development, children

Contrary to popular belief, there is high agreement among adults across cultures in the relative attractiveness of different faces (Bernstein, Lin, & McClellan, 1982; Cunningham, Roberts, Barbee, & Druen, 1995; Johnson, Dannenbring, Anderson, & Villa, 1983; Langlois et al., 2000; Perrett, May, & Yoshikawa, 1994), and developmentally, infants look longer at faces judged by adults to be attractive than those judged to be unattractive (Langlois et al., 1987; Samuels, Butterworth, Roberts, Graupner, Hole, 1994; Slater et al., 1998; Slater, Quinn, Hayes, & Brown, 2000). Adults can appraise the attractiveness of a face in as little as a glance (Olsen & Marshuetz, 2005), and these quick judgments can influence social interactions, as attractive people are judged to have more positive traits than those judged as unattractive (the "what is beautiful is good" stereotype; Dion, Berscheid & Walster, 1972). One influence on facial attractiveness judgments in adults is a face's proximity to the population average.

In 1878, Sir Francis Galton published the observation that averaged composite faces are attractive. Using composite photography, Galton exposed the portraits of several individuals consecutively onto the same photographic plate, creating an average of the individual faces. He noted that the "composites are better looking than their components" (Galton, 1878, p.98). Similarly, Langlois and Roggman (1990) found that averaged faces are attractive when they created averaged composites of digital images using 2, 4, 8, 16, and 32 faces by mathematically averaging the luminance values of individual pixels across the images. Adults rated the 16 and 32 face composites as more attractive than the mean rating of the original faces used in their creation. Moreover, composites created from greater numbers of original faces were rated as more attractive than those created from fewer original faces. These findings suggested that faces approximating the population mean are attractive. Additionally, as the 16 and 32 face composites looked very similar to one another regardless of which original faces were used (Langlois & Roggman, 1990), and both were more attractive than the mean of their component faces, the average of 16 faces may be a good approximation of a population mean.

Although Langlois & Roggman's (1990) averaging method artificially smoothed skin texture, which could have led to the enhanced attractiveness of the composite over the component faces (Alley & Cunningham, 1991; Benson & Perrett, 1992), others have replicated the finding when they manipulated shape and texture separately. They did so by outlining the features and external contour of each face with landmark points, which can then be used to calculate an average face shape (Rowland & Perrett, 1995; Tiddeman et al., 2001). Individual faces can then be transformed relative to the average, such that the spatial configuration and shape changes, while the texture remains that of the original face. Using male faces, Little & Hancock (2002) found that separate manipulations that averaged texture or shape each increased attractiveness independently. Moreover, adults judge line drawings of faces, the shape of which have been transformed closer to their group average, to be more attractive than line drawings that have been transformed away from their group average, despite the fact that line drawings remove the influence of skin tone and texture completely (Rhodes & Tremewan, 1996). These findings provide evidence that average face shape is attractive independent of average skin texture.

While averageness and symmetry are confounded, as faces nearer to average are also more symmetrical, averageness remains attractive when the effects of symmetry and averageness are examined separately. For example, faces photographed in profile, in which direct cues to bilateral symmetry are absent, are judged by adults to be more attractive after having been transformed toward their group average rather than away from their group average (Valentine, Darling, & Donnelly, 2004). Additionally, faces that are nearer their group average are judged by adults to be more attractive than faces that are farther from their group average, even when all faces have been made bilaterally symmetrical by blending each face with its mirror image (Rhodes, Sumich, & Byatt, 1999). Thus, averageness influences attractiveness judgments independently from symmetry. These studies, along with evidence that averaged faces are attractive across cultures (see Rhodes, Harwood, Yoshikawa, Nishitani, & McLean, 2002 for a review), and that faces naturally sitting closer to the population average are judged to be more attractive than more distinctive faces (Light, Hollander, & Kayra-Stuart, 1981), provide strong evidence that facial averageness is attractive.

From an evolutionary perspective, facial averageness may be attractive because of stabilizing selection, in which evolutionary pressures act against extremes of a trait in favour of average faces, or the most common or average features (Dobzhansky, 1982). For many heritable traits, the average signals heterozygosity, or having dissimilar gene pairs for heritable characteristics (Fink & Penton-Voak, 2002; Thornhill & Gangestad, 1993). Heterozygosity can signal an outbred individual with greater genetic diversity and resistance to parasites (Thornhill & Gangestad, 1993; 1999), and such individuals may carry fewer harmful mutations, all of which could lead to a mate preference (Dobzhansky, 1982).

Evolution may have additionally selected for cognitive mechanisms that facilitate processing of faces near the population average. It is hypothesized that faces are represented within a multidimensional face-space centered on a norm, or average face, formed based on our accumulated experience with faces (Rhodes, 2006; Valentine, 1991). In this system of norm-based coding, individual faces are represented as unique, multi-dimensional vectors defined by their differences and distances from the prototype; faces near the prototype may be processed more fluently, with greater speed and efficiency, and consequently preferred (Valentine, 1991;

Winkielman, Halberstadt, Fazendeiro, & Catty, 2006). Indeed, random-dot patterns closer to a prototype of random-dots presented to adults in a training phase are processed more fluently, and rated as more attractive than less prototypical patterns (Winkielman, et al. 2006). Additionally, dogs, wristwatches, and birds rated by adults as more prototypical are also rated as more attractive (Halberstadt & Rhodes, 2000). Prototypical patterns, objects, and faces may be processed more fluently, leading to a preference.

Developmentally, there is evidence that infants can form cognitive prototypes of faces by 3 months of age, as 3-month-olds (but not 1-month-olds) show evidence of recognizing a composite of four faces after being familiarized to the four faces individually (de Haan, Johnson, Maurer, Perrett, 2001; see Rubenstein, Kalakanis, & Langlois, 1999 for evidence in 6-month-olds). In that experiment, even without familiarization, female 3-month-olds also showed a looking preference for the composite face over the individual component faces (de Haan et al., 2001). By 5 years of age, children show evidence of norm-based coding for processing facial identity: adaptation to a face identity leads to a shift in the recognition of other faces, and by 8 years of age (youngest age tested), the shift is specific to faces that lie on a trajectory passing through an average face (Jeffery et al., 2011; 8-year-olds, Nishimura, Maurer, Jeffery, Pellicano, & Rhodes, 2008; Pimperton, Pellicano, Jeffery, & Rhodes, 2009). By age 7, these identity aftereffects are stronger for adaptors that lie farther from the average (Jeffery et al. 2011), consistent with the predictions of norm-based coding. There is similar evidence at a younger age for figural distortions: by age 4-6, adaptation to faces that have been contracted or expanded (or have had the eyes moved up/down) leads to a shift in children's perception of an average face, and the shift is greater for distortions farther from the norm (Jeffery et al., 2010). Such distortions also shift children's judgments of attractiveness as early as 5 years of age (Short, Hatry, & Mondloch, 2011; for similar evidence in 8-year-olds, see Anzures, Mondloch, & Lackner, 2009): their attractiveness judgments shift in the adapted direction, a result suggesting that, like adults (Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003), their judgments of attractiveness are based on a prototype that is constantly being updated as they encounter new faces. Children's accuracy at recognizing faces improves from ages 6-10 (Diamond & Carey, 1977), presumably as the prototype becomes more refined.

However, there have been no studies of whether averageness affects attractiveness judgments in children to the same extent as in adults. At 6 months, infants look longer at average faces than at faces rated by adults to be unattractive (Rubenstein et al., 1999). At 5-8 months, infants do not look longer at faces transformed toward average, than those transformed away from average; indeed the longest look was toward the less average face (Rhodes, Geddes, Jeffery, Dziurawiek, & Clark, 2002). By adolescence, children do select faces that have been transformed toward their group average to be more attractive than the original versions of the faces (Saxton, Debruine, Jones, Little, Roberts, 2009; 2011; Saxton et al., 2010). However since these studies did not have adult comparison groups, it is not known when during development averageness becomes as strong an influence as in adults. The purpose of this study was to explore the influence of averageness on judgments of facial attractiveness in mid-childhood, as we are aware of no published data between 8 months and adolescence. We tested 5-year-olds, an age at which norm-based coding is used for processing of facial identity (Jeffery et al., 2010), and the youngest age able to complete enough trials to calculate reliable individual data. We also tested 9-year-olds, a pre-adolescent age at which most aspects of basic vision are adult-like (Adams & Courage, 2002; Ellemberg, Lewis, Liu, & Maurer, 1999; Lewis et al., 2004). Adults were tested for comparison. We showed children and adults pairs of individual faces that had been warped 50% toward and away from their group averages. Participants selected which face from each pair they found to be more attractive. We used faces of children and adults because children may have more experience with faces of their own age, than of adults, and because children and adults have own-age biases in processing faces (Anastasi & Rhodes, 2005; Hills & Lewis, 2011; but see Macchi Cassia, 2011 for evidence that children have a processing advantage for adult faces). We used photographs of young adults, 4- to 5-year-olds, and 8- to 9-year-olds, reflecting the recent experience of the participants. To shorten the task, we presented 5-year-olds and the first group of adult participants with the three face categories with which they should have most experience; faces of 5-year-old girls, 5-year-old boys, and women because the full set of six face categories would have been challenging for 5-year-olds to complete in a single test session and because any experience-based influence of averageness should be most likely to be manifest for these face categories. Nine-year-olds and another group of adults saw, in addition, faces of 9-year-old girls and boys (their age mates) and faces of men. This allowed us to evaluate whether the influence of averageness on children's judgments of attractiveness is weaker for men's than women's faces, which they experience most beginning in infancy (Rennels & Davis, 2008), and which could continue into childhood. Use of all six face categories in the second comparison allowed us to evaluate the extent to which the influence of averageness on attractive judgments is invariant across face age and sex, at least for adults and 9-year-old children. The six face categories were presented in separate counterbalanced blocks.

Methods

Participants

There were two subgroups of participants. Subgroup A consisted of 36 5.5-year-olds (±3 months), and 36 adults (aged 17-28). Subgroup B, which completed a longer procedure, consisted of a second group of 36 adults (aged 18-33), and 36 9-year-olds (±3 months). All participants were White[1], and half at each age were male. Adults were undergraduate psychology students at McMaster University, and participated in exchange for course credit. Children were recruited from the names of mothers who volunteered shortly after the birth of their child to be contacted about future studies, and received a toy or book for participation. All participants had normal or corrected-to-normal vision, and met age-appropriate visual screening criteria; adults and 9-year-olds had normal stereoacuity of 40 arc seconds of disparity on the Titmus test of Stereoacuity, and a Snellen acuity of 20/20 or better in each eye, measured on a Lighthouse eye chart. Five-year-olds had normal stereoacuity, of 100 arc seconds of disparity on the Titmus test of Stereoacuity, and a Snellen acuity of 20/30 or better in each eye measured with the Cambridge Crowding Cards, as vision is still immature at this age (Adams & Courage, 2002; Ellemberg, Lewis, Liu, & Maurer, 1999).

An additional 5 adults, 12 9-year-olds, and 9 5-year-olds were tested but excluded from the data because they failed our visual screening requirements (3 adults, 7 9-year-olds, and 3 5-year-olds), were outside of our age range (2 adults and 1 5-year-old), had their identical twin tested (1 9-year -old and 1 5-year-old), were inattentive (2 9-year-olds and 2 5-year-olds), had corrupted data (1 5-year-old), or were not White (2 9-year-olds and 1 5-year-old).

[1] McMaster University is a very multicultural university. Because others have reported better recognition and discrimination of faces of one's own than other races in adults (see Meissner & Brigham, 2001 for a meta-analysis), and children (Chance, Turner & Goldstein, 1982; Corenblum & Meissner, 2006; Goldstein & Chance, 1980; Sangrigoli & de Schonen, 2004) we wanted to ensure that participants in all age groups had a similar type of face experience. As such, we used White participants and White face stimuli.

Stimuli

Stimuli were colour, full face photographs with neutral expressions of young adult women, young adult men, 8- to 9-year-old girls, 8- to 9-year-old boys, 4- to 5-year-old girls, and 4- to 5-year-old boys. There were 16 faces in each of the six face categories for a total of 96 faces. Adult models, and parents of children, gave consent for their photographs to be used and manipulated in research. Faces were evenly lit and directly faced the camera. The brush tool in Adobe Photoshop CS was used to remove major blemishes. Each face was manually delineated with 189 landmark points, outlining the face shape and features, using PsychoMorph. An average face was then created for each face category (woman, man, 8- to 9-year-old girl, 8- to 9-year-old boy, 4- to 5-year-old girl, and 4- to 5-year-old boy), by moving the points on each of the 16 faces to their mean location. Each original face was then transformed 50% toward and away from its group average by moving each of its delineated points halfway toward the group average, and the same distance away from the group average (see Tiddeman, Burt, & Perrett, 2001), creating pairs of faces that differed in averageness based on shape, but maintained the texture of the original face.

Because faces become more symmetrical when they are moved closer to average, all faces were made perfectly symmetrical by averaging each face with its mirror image, to remove the influence of symmetry. We symmetrized both the shape and texture of the faces because bilateral differences in shadow and skin pigmentation can provide cues to symmetry, another influence on judgments of attractiveness (Perrett et al., 1999). As this symmetrizing procedure leads to the reflection of two flashes in each eye, one of the reflections was removed from each eye with the brush tool in Adobe Photoshop CS. Because both faces from each pair were symmetrised, there were no major textural differences between the two versions of the face. In order to remove any influence from distortions in the hairstyle, external features and hair were removed by placing a black background outside the outline of each face while maintaining the original face shape (Figure 1). Although it is not typical to view faces without hair, this precaution maximized the salience of internal physiognomic cues and hence made it less likely that we would underestimate children's sensitivity to the cue of averageness. Faces were standardized for size based on interpupilary distance. Subgroup A (5-year-olds and one group of adults) viewed the faces on a Dell Trinitron P1330, 21 inch CRT monitor. Subgroup B (9-year-olds and the other group of adults) viewed the faces on an HP 20555 SH249, 22 inch LCD Monitor. Images had 2048 horizontal by 3072 vertical pixel resolution. From a viewing distance of 50 cm, faces subtended a visual angle of approximately 12 degrees in height and 7 degrees in width.

To ensure that the six face categories were equivalent in normality, a separate group of 24 White adults (aged 17-27; 12 male), rated how normal each of the unmanipulated faces looked on a 5-point scale (1=very normal and 5=very unusual). Each face was presented on a grey background without hair but retaining face shape. Faces were presented individually, in blocks counterbalanced for age and sex of face. Participants viewed the faces on an HP 20555 SH249, 22 inch LCD Monitor and responses were made on a keyboard. A Cronbach's α of .873 indicated internal consistency in the ratings. The mean normality ratings did not differ among the six face categories (no main effect of category, $F(5,115)=1.625$, $p=.159$, $\eta p2=.066$).

Design

We used a within subject design, with the 5-year-olds and the corresponding adults in Subgroup A viewing the three face categories (16 face pairs per face category) blocked for a total of 48 trials per participant. Nine-year-olds and the corresponding adults in Subgroup B viewed the six face categories for a total of 96 trials per participant. Stimulus presentation was randomized within each block, and the side of the more average face was randomized across trials. The order of blocks was counterbalanced across participants in each age group.

Procedure

This study received ethics clearance from the institutional Research Ethics Board. After explaining the procedure, we obtained verbal consent from child participants, and written consent from their parents, and from adult participants. We then explained the instructions in a game-like format:

> I'm having a birthday party and I have invited all of my friends! Among my friends, pairs of brothers and pairs of sisters will be attending the party. These brothers and sisters have been trying very hard to look their very best. They are trying to make themselves look nice because a clown at the party will be giving a red balloon to the brother or sister from each pair who looks cuter, prettier, or more handsome today. Every time you see two faces on the screen, they are either sisters or brothers, and it will be your job to figure out who looks better, nicer, or more attractive today, and will receive the red balloon from the clown!

A number of words were used to describe the concept of attractiveness including *prettier*, *more handsome, nicer looking, better looking, cuter, and more attractive*. Children as young as age 3 can provide reliable attractive judgments in the same direction as those of adults for children's and adults' faces using the words *pretty*, *cute*, or *handsome* (Cooper, Geldart, Mondloch, & Maurer, 2006; Dion, 1973; Langlois & Stephan, 1977). Participants were asked if they understood the procedure, and were then presented with criterion trials containing nine pairs of non-face stimuli that differed in attractiveness (such as a new book and an old tattered book), and were asked to select which object looked better or nicer. All participants completed the criterion trials with 100% accuracy and moved onto the main experiment. Trials were self paced, and participants made selections by clicking on the image with a mouse, which initiated the next trial. Five-year-old participants were visually screened after the first block of faces, and took a break after the second block of faces. Nine-year-old participants were visually screened after the third block of faces, and adult participants were visually screened at the beginning of the experiment. All groups took additional breaks as needed. Following the experiment, participants were debriefed with information about the purpose of the experiment, and about the "what is beautiful is good" stereotype (Dion, et al. 1972).

Results

Data analysis.

For each participant and group of faces, we calculated the mean proportion of trials on which the more average face was selected. We replaced outliers greater than 3 standard deviations from the mean with new participants (Subgroup A: two adult males; one 5-year-old boy; Subgroup B: one adult male; four adult females; two 9-year-old boys; two 9-year-old girls). To assess whether participants of each age selected the more average faces more frequently than chance, we performed one-tailed one sample t-tests comparing the mean for each face category to chance (0.5), for each age group, controlling for multiple comparisons with Bonferroni correction at α=.017 for Subgroup A and α=.008 for Subgroup B. To assess whether attention declined during the experiment, we did a preliminary analysis with the within subjects factor of block order (blocks 1-3 for subgroup A and blocks 1-6 for subgroup B) and the between subjects factor of participant age. We followed up with paired samples t-tests, controlling for multiple comparisons with Bonferroni correction at α=.017 for Subgroup A and α=.008 for Subgroup B.

To compare the strength of the influence of averageness across face categories and participant groups, we performed repeated measures ANOVAs. For subgroup A we used the between subject factors of participant age (5 and adult) and participant sex, and the within subject factor of face category (5-year-old girl; 5-year-old boy; woman). For subgroup B we used the between subject factors of participant age (9 and adult) and participant sex, and the within subject factors of face age (5, 9, adult) and face sex. We performed an additional ANOVA comparing 5- and 9-year-old participants on the three face categories on which they were both tested with the between subject factors of participant age and participant sex, and within subject factor of face category (5-year-old girl; 5-year-old boy; woman).

We additionally conducted complementary item analyses across faces rather than across participants by calculating the proportion of participants of each age (5, 9, and adult) selecting the more average face for each group of faces (16 face pairs x 3 face categories for subgroup A; 6 face categories for subgroup B). For every age of participant, this produced 16 preference scores for each of the groups of faces. The null hypothesis states that the mean of the preference scores should be 50%, with half the raters selecting the more average face. Each item analysis followed the same sequence as the main analyses, as described above.

Subgroup A: 5-year-olds and corresponding adults.

Adult and 5-year-old participants selected the more average face more frequently than chance for all face categories (all *p*s<.001; see figure 2). A preliminary analysis indicated a main effect of block order, $F(2,140)=3.54$, $p=.032$, $\eta p2=.048$, and no interaction between block order and participant age, $F(2,70)=.050$, $p=.952$, $\eta p2=.001$. Paired samples t-tests indicated that averageness influenced attractiveness judgments more strongly in the third block ($M=.875$, $SD=.132$) than the second block ($M=.832$, $SD=.171$), $t(71)=-2.48$, $p=.016$, $d=.282$, and without Bonferroni correction, more strongly in the third block than the first block ($M=.844$, $SD=.140$), $t(71)=-2.02$, $p=.047$, $d=.228$, suggesting that attention did not decline from the first to the last block.

Mauchly's test indicated that the assumption of sphericity had been violated, $\chi 2(2)=7.382$, $p=.025$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon=0.906$). The ANOVA revealed main effects of face category, $F(1.81,123.15)=3.55$, $p=.036$, $\eta p2=.050$, and participant age $F(1,68)= 67.96$, $p<.001$, $\eta p2=.500$, with adults selecting the more average faces more frequently than 5-year-olds. None of the interactions were significant (all ps>.063). We followed up the main effect of face category with two-tailed paired samples t-tests comparing the means for the three face categories, controlling for multiple comparisons with Bonferroni correction at $\alpha=.017$. Participants selected the more average faces marginally more frequently among 5-year-old girl faces ($M=.867$, $SD=.139$) than 5-year-old boy faces ($M=.826$, $SD=.162$), $t(71)=2.42$, $p=.018$, $d=0.272$. No other comparisons were significant (both ps>.095).

The item analysis indicated that for every face category, more 5-year-old and adult participants than expected by chance selected the more average faces for all three face categories (all ps<.001). The ANOVA on the item analysis revealed main effects of participant age, $F(1,60)=139.036$, $p<.001$, $\eta p2=.699$, and of face category $F(2,120)=3.218$, $p=.043$, $\eta p2=.051$, with more adults selecting the more average faces than 5-year-olds. We followed up with two-tailed paired samples t-tests comparing means for the 5-year-old girl, 5-year-old boy, and woman faces, controlling for multiple comparisons with Bonferroni correction at α=.017. There were no differences in the proportion of participants selecting the more average faces between face categories. Without Bonferroni correction, more participants selected the more average faces in 5-year-old girl (*M*=.867, *SD*=.052) than 5-year-old boy faces (*M*=.826, *SD*=.06), $t(15)=2.37$, $p=.032$, $d=0.730$.

Subgroup B: 9-year-olds and corresponding adults.

Adult and 9-year-old participants selected the more average face more frequently than chance for all face categories (all *p*s<.001; see figure 3). A preliminary analysis indicated a main effect of block order, $F(5,350)=4.60$, $p<.001$, ηp2=.062, and no interaction between block order and participant age, $F(5,70)=1.65$, $p=.146$, ηp2=.023. Paired samples t-tests indicated that averageness influenced attractiveness judgments less strongly in the first block (*M*=.898, *SD*=.095) than the fifth block (*M*=.944, *SD*=.070), $t(71)=-4.22$, p<.001, *d*=.551, or sixth block (*M*=.948, *SD*=.083), $t(71)=-2.64$, $p<.001$, *d*=.561. Without Bonferroni correction, averageness influenced attractiveness judgments less strongly in the first block than all other blocks (all *p*s<.035). Averageness also influenced attractiveness judgments less strongly in the second block (*M*=.924, *SD*=.088) than the sixth block, $t(71)=-2.59$, $p=.012$, *d*=.281. These results indicate that attention did not decline during the experiment, and that averageness influenced attractiveness judgments more strongly in later than earlier blocks. As with Subgroup A, the increasing effect of averageness over blocks did not interact with age and hence cannot explain the age differences in the strength of the influence.

The ANOVA revealed a main effect of participant age, $F(1,68)=25.96$, $p<.001$, $\eta p2=.276$, with adults selecting the more average faces more frequently than 9-year-olds, and a face sex by face age interaction, $F(2,136)=25.65$, $p<.001$, $\eta p2=.274$. To understand whether there are differences between the different ages of face because of possible processing advantages for same age (Anastasi & Rhodes, 2005; Hills & Lewis, 2011) or adult faces (Macchi Cassia, 2011), we followed up the interactions with separate ANOVAs for male and female faces with the within subjects factor of face age (5, 9, adult), and found a main effect of face age for male faces $F(2,142)=10.71$, p<.001, $\eta p2=.131$. Mauchly's test indicated that the assumption of sphericity had been violated in the female face ANOVA, $\chi 2(2)=8.71$, $p=.013$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon=0.90$). The analysis revealed a main effect of face age, $F(1.79, 127.13)=18.48$, $p<.001$, $\eta p2=.207$. We followed up for each sex of face with two-tailed paired samples t-tests comparing each age of face, controlling for multiple comparisons with Bonferroni correction ($\alpha=.017$). The interaction arose because participants selected the more average faces less frequently for 9-year-old girl ($M=.892$, $SD=.097$) than 5-year-old girl faces ($M=.939$, $SD=.090$), $t(71)=3.72$, $p<.001$, $d=0.502$, or women's faces ($M=.958$, $SD=.054$), $t(71)=-7.01$, $p<.001$, $d=0.840$. The reverse was true in male faces, as participants selected the more average faces more frequently for 9-year-old boy ($M=.958$, $SD=.069$) than 5-year-old boy faces ($M=.911$, $SD=.104$), $t(71)=-4.36$, $p<.001$, $d=0.533$, and men's faces ($M=.912$, $SD=.105$), $t(71)=4.21$, $p<.001$, $d=0.518$. There were no differences between adult and 5-year-old faces for either sex (both ps>.102).

It is also of interest to understand whether there is an influence of face sex for each age of face because of a potential processing advantage for female faces (Quinn, Yahr, & Kuhn, 2002; Ramsey, Langlois & Marti, 2005; Ramsey-Rennels & Langlois, 2006); therefore, we broke down the interaction a second way by doing two-tailed paired-samples t-tests comparing male and female faces at each face age, controlling for multiple comparisons with Bonferroni correction, α=.017. Participants selected the more average faces more frequently in the faces of adult females (*M*=.958, *SD*=.054) than adult males (*M*=.912, *SD*=.105), *t*(71)=4.56, *p*<.001, d=0.551, and more frequently in the faces of 9-year-old boys (*M*=.958, *SD*=.069) than 9-year-old girls (*M*=.892, *SD*=.097), *t*(71)=-6.10, *p*<.001, *d*=0.784. Participants selected the more average faces marginally more frequently without Bonferroni correction in the faces of 5-year-old girls (*M*=.939, *SD*=.090) than of 5-year-old boys (*M*=.911, *SD*=.104), *t*(71)=1.97, *p*=.052, *d*=0.288.

In the complementary analysis by item, more 9-year-old and adult participants than expected by chance selected the more average faces for each of the six face categories (all *p*s<.001). Mauchly's test indicated that the assumption of sphericity had been violated, $\chi 2(2)$=8.68, *p*=.013, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε=0.88). The ANOVA revealed a main effect of participant age, *F*(1,60)=46.89, *p*<.001, $\eta p2$=.439, and a face sex by face age interaction, *F*(2,120)=15.48, *p*<.001, $\eta p2$=.205. Separate ANOVAs for male and female faces with the within subjects factor of face age (5, 9, adult), revealed a main effect of face age for male faces *F*(2,126)=7.89, *p*=.001, $\eta p2$=.111. Mauchly's test indicated that the assumption of sphericity had been violated in the female face ANOVA, $\chi 2(2)$=20.53, *p*< .001, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε=0.78). The analysis revealed a main effect of face age, *F*(2,126)=9.22, *p*=.001, $\eta p2$=.128, among female faces. We followed up for each sex of face with two-tailed paired samples t-tests comparing each age of face, controlling for multiple comparisons with Bonferroni correction (α=.017). More participants selected the more average faces for 9-year-old boy (*M*=.958, *SD*=.03) than 5-year-old boy faces (*M*=.911, *SD*=.059), *t*(15)=-2.94, *p*=.01, *d*=1.00, or without Bonferroni correction, men's faces (*M*=.912, *SD*=.065) *t*(15)=2.37, *p*=.032, *d*=0.908. No other comparisons were significant (all *p*s>.067). To get a more complete picture of the interaction, we also did two-tailed paired-samples t-tests comparing male and female faces at each face age, controlling for multiple comparisons with Bonferroni correction, α=.017. More participants selected the more average faces in 5-year-old girl (*M*=.939, *SD*=.042) than 5-year-old boy (*M*=.911, *SD*=.059) faces, *t*(15)=2.81, *p*=.013, *d*=0.547. Without Bonferroni correction, more participants selected the more average faces in adult female (*M*=.958, *SD*=.041) than adult male (*M*=.912, *SD*=.065) faces, *t*(15)=2.47, *p*=.026, *d*=0.846, and marginally more participants selected the more average faces in 9-year-old boy (*M*=.958, *SD*=.030) than 9-year-old girl (*M*=.892, *SD*=.112) faces, *t*(15)=-2.07, *p*=.056, *d*=0.805.

Comparison of 5-year-old and 9-year-old data for overlapping face categories.

Mauchly's test indicated that the assumption of sphericity had been violated, χ2(2)=7.10, *p*=.029, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε=0.91). The ANOVA revealed main effects of face category, *F*(2,136)=6.39, *p*=.003, ηp2=.086, and of participant age, *F*(1,68)=43.208, *p*<.001, ηp2=.389, with 9-year-olds selecting the more average faces more frequently than 5-year-olds. We followed up with paired samples t-tests comparing the three face categories, controlling for multiple comparisons with Bonferroni correction, α=.016. Participants selected the more average faces more frequently for 5-year-old girl (*M*=.855, *SD*=.140) than 5-year-old boy faces (*M*=.800, *SD*=.158), *t*(71)=2.94, *p*=.004, *d*=0.368, and adult female (*M*=.854, *SD*=.145) than 5-year-old boy faces, *t*(71)=-2.89, *p*=.005, *d*=0.356. There were no differences between 5-year-old girl and adult female faces, *t*(71)=.061, *p*=.952, *d*=0.356.

Discussion

We found that averageness influences 5-year-olds', 9-year-olds', and adults' judgments of facial attractiveness of both children's and adults' faces. This is the first evidence, to our knowledge, of the influence of averageness on children's judgments of facial attractiveness between infancy and adolescence, and it suggests a long developmental trajectory with the influence emerging before age 5, and maturing after age 9. Other studies have found that infants as young as 3 months of age can recognize an average of faces to which they were familiarized (de Haan et al., 2001). By 6 months, infants look longer at average than unattractive faces (Rubenstein, et al., 1999); however, when presented with stimuli like those in the current study, infants look equally long at the two faces, and the longest look was to the less average face (Rhodes, Geddes, et al., 2002). Our results indicate that by 5 years, averageness has clearly emerged as an influence on children's judgments of attractiveness. This pattern is consistent with the influence of average feature height on children's facial attractiveness judgments, which is present by age 5, and not yet adult-like at age 9 (Cooper, et al., 2006). Averageness, however, influences children's judgements of attractiveness earlier than bilateral symmetry, which has little to no influence in infancy (Rhodes, Geddes, et al., 2002), or even at age 5 (Vingilis-Jaremko, & Maurer, 2013). When the influence becomes adult-like is unknown because the studies that documented that adolescents find averageness to be attractive did not have adult comparison groups (Saxton, et al., 2009; 2011; Saxton et al., 2010). This study is also the first demonstration that averageness influences attractiveness judgments of children's faces, a result suggesting that both adults and children have enough experience with children's faces to form a prototype[2], or that a prototype of adult faces is sufficiently similar to a prototype of children's faces to exert an influence on judgments of attractiveness. Our results suggest that averageness affects children's judgments of attractiveness in everyday life by age 5, at least for categories with which they have had the most experience, namely own age and adult female faces. Of course, it is possible that the influence is weaker at age 5 for less familiar categories not tested here, such as adult male faces. In any event, the influence for even familiar categories was weaker than in 9-year-olds and adults.

As with any study in developmental psychology, we cannot rule out differences in attention and motivation. However, all participants passed the nine criterion trials with 100% accuracy, suggesting that the children understood the task and that they are capable of adult-like performance when examples are sufficiently dissimilar. Additionally, performance did not decline for any age group from the first to the last block. There are several possible visual and cognitive explanations for the weaker influence of averageness on children's than adults' judgments of facial attractiveness. First, children have had less experience with faces than adults, a difference that could lead to a less stable prototype, and hence more variability in judgments of attractiveness based on averageness. Differences in exposure in the real world have been shown to alter judgments of attractiveness in both adults (Apicella, Little, & Marlowe, 2007; Geldart, 2008) and children (Cooper et al., 2006). For example, the Hadza, an isolated hunter-gatherer society in Africa, do not find averageness attractive in British faces, a group with whom they have little to no experience, while they do find averageness attractive in faces of the

[2] Although some believe that an exemplar-based model better accounts for preferential responses near the average, recent evidence more strongly favours a prototype-based model for face perception in adults (Rhodes & Jeffery, 2006; Robbins et al., 2007; Leopold et al., 2001;Webster & MacLin, 1999) and children (Jeffery et al. 2010; Jeffery & Rhodes, 2011; Jeffery et al. 2011; Nishimura et al., 2008). However, it should be noted that the interpretation of the preferences found here remains the same whether based on prototype or exemplar-based models.

Hadza. Conversely, Western individuals who presumably have more experience with faces from diverse cultures, find averageness attractive in both British and Hadza faces (Apicella, et al., 2007). Additional evidence comes from studies of the influence of feature height on judgments of attractiveness in adults (Geldart, 2008) and children (Cooper et al., 2006). Shorter adults, who typically look up at faces, prefer faces with a larger chin and smaller forehead, matching the foreshortening with which they typically see faces (Geldart, 2008). That preference is present in infancy (Geldart, Maurer, & Henderson, 1999), and changes to a preference for faces with a smaller chin, like those of peers, when children begin to interact more with their peers at eye level after entering preschool (Cooper et al., 2006).

Short-term shifts of a similar type can be created in the lab by biased exposure to faces with distorted feature height (Cooper & Maurer, 2008) or distorted shape (Anzures et al., 2009). For example, showing adults faces with features at a high (or low) height shifts their subsequent judgements of the ideal feature height in the adapted direction (Cooper & Maurer, 2008). Showing adults faces that are expanded or compressed shifts their attractiveness judgments in that direction (Rhodes et al., 2003). Similar attractiveness aftereffects have been shown in children (Anzures et al., 2009) and occur even after exposure to very bizarre faces that have no effect on adults' judgments of oddness or attractiveness (Hills, Holland, & Lewis, 2010). Such shifts raise the possibility that the prototype may not be as refined in children as in adults, and that might explain why averageness has a weaker influence on their judgments of attractiveness.

A second possible explanation for the increase in the influence of averageness on judgments of attractiveness from childhood to adulthood is the immaturity of the visual system. Although both 5-year-olds and 9-year-olds could discriminate between the faces, they may have had greater difficulty perceiving some of the finer differences that were visible to adults.

Children's sensitivity to subtle differences in the location of faces' internal features improves from age 6 to age 10-11 (Baudouin, Gallay, Durand, & Robichon, 2010; Mondloch, Le Grand, & Maurer, 2002), and their ability to detect global structure from dot patterns, moving dots, and biological motion improves after age 6 until as late as age 12-14 for moving patterns (Hadad, Maurer, & Lewis, 2011; Lewis et al., 2004). Additionally, acuity and contrast sensitivity become adult-like around age 6 and ages 7-9, respectively (Adams & Courage, 2002; Ellemberg, et al. 1999). These visual immaturities could affect children's ability to detect as many subtleties between the faces as adults and thereby limit the influence of averageness on their judgments of attractiveness.

A related possibility is that a less stable norm and/or worse visual sensitivity could limit the processing advantage for faces nearer the prototype. It is hypothesized that adults prefer faces closer to the population average because those faces are processed more quickly and easily than faces that are farther from the average (Winkielman, et al., 2006). If children have higher levels of internal noise, which can originate from random fluctuations in neural response, information loss during neural transmission, and receptor sampling errors, and/or if children have less efficient processing, defined as a lesser ability to detect the signal despite the internal noise (see Lu & Dosher, 1999), than do adults, judgments based on processing fluency could be affected. It is possible to estimate processing efficiency and levels of internal noise by superimposing external noise (i.e., random variations in luminance across pixels) onto stimuli to be detected (see Levi, 2005). Jeon, Maurer, & Lewis (2012) did so by measuring contrast sensitivity for gratings embedded in external noise. They found improvements in the ability to detect the signal in the noise from ages 5 to 9, and from 9 to adulthood. Computer modelling suggested the improvements were caused by both decreases in internal noise and increases in efficiency. These developmental differences in internal noise and efficiency could reduce children's preferences based on processing fluency, including the influence of averageness on judgments of facial attractiveness.

Finally, it is possible that the influence of averageness on judgments of facial attractiveness is not adult-like by age 9 because pre-pubescent children may not be attuned to decisions relevant to mate choice. Averageness could be attractive to adults because of stabilizing selection (Dobzhansky, 1982), and/or because it is a signal of heterozygosity (Fink & Penton-Voak, 2002; Thornhill & Gangestad, 1993). The influence of averageness on judgments of attractiveness may not mature to adult levels until after puberty, when mate-choice decisions are more relevant. Although averageness influences adolescents' judgments of attractiveness (Saxton et al., 2009; 2011; Saxton et al., 2010), and the strength of the influence does not change from early to mid adolescence (Saxton, et al., 2009; 2011), we do not know whether the influence strengthens after adolescence as there were no adult comparison groups in these studies or whether it changes between age 9 and the onset of puberty.

We found no evidence of an own-age bias, as there was no interaction between age of face and age of participant. Such a bias might be expected based on differential experience, which could lead to a more well-defined and stable prototype for own-age faces. Indeed, adults and children are better at recognizing faces of their own age than of other ages, consistent with an experiential account (Anastasi & Rhodes, 2005; 2006; Harrison & Hole, 2009; Hills, 2012; Hills and Lewis, 2011; Kuefner, Macchi Cassia, Picozzi, & Bricolo, 2008). Additionally, differential experience appears to affect attractiveness judgments in some cases (e.g., Anzures, et al., 2009; Apicella et al., 2007; Cooper et al., 2006). Such experiential differences might affect attractiveness through the formation of prototypes for different categories of faces that are somewhat distinct. Evidence for at least partially distinct prototypes comes from studies using contingent adaptation with adults. For example, adults can be adapted in opposite directions by male and female faces distorted in opposite ways (Little, DeBruine, & Jones, 2005), or by own and other race faces manipulated in opposite ways (Jacquet, Rhodes, & Hayward, 2008). Since such opposite aftereffects have not been tested with child and adult faces, we do not know if distinct prototypes exist for faces of different ages. However, when adults are adapted to one sex of child face, the adaptation partially transfers to adult faces, a result suggesting a partially shared representation of sex across ages of face (Barrett & O'Toole, 2009). In the current study there was no evidence of an influence of an own-age effect on children's judgments of attractiveness: the influence of averageness was not consistently strongest for faces matching the participant's age (5-year-old faces viewed by 5-year-olds; 9-year-old faces viewed by 9-year-olds; adult faces viewed by adults). However, it has been suggested recently that children actually get more exposure to adult than child faces throughout development and hence may be best at processing adult faces (Macchi Cassia, 2011). The predicted effect of a stronger influence of averageness on children's judgments of adult faces than of children's faces also was not observed. We speculate that the influence of the well-formed face prototype from familiar categories may affect the reaction to less familiar categories because there may be similarities in the average face shape across categories. Alternatively, some minimal level of exposure may be sufficient to form a prototype that resembles an average face for that category.

We found interactions between age and sex of face: for 5-year-old and adult faces, the influence of averageness was generally stronger for female than male faces. It was not the case, however, that participants had a stronger preference for averageness in female faces in general, as 9-year-olds and adults selected the more average faces more frequently for 9-year-old boy than 9-year-old girl faces (5-year-old participants were not tested with this face category). Others have reported a processing advantage for female over male faces in infants (see Ramsey et al., 2005; Ramsey-Rennels & Langlois, 2006), possibly because infants typically have more experience with female than male faces (Rennels & Davis, 2008). This advantage for processing female faces could persist if children continue to see more female than male faces and/or if early experience contributes to later face processing (see Macchi Cassia et al., 2009). Although this could explain our findings of a greater influence of averageness on women's than men's faces, it does not account for why averageness affected attractiveness judgments more strongly in 9-year-old boy than girl faces. Alternately, it is possible that the interaction resulted from differences in the typicality of the particular 16 faces we chose for each category, although we note that there were no differences in the mean normality ratings for the original unmanipulated faces among the six categories, as rated by a separate group of adults.

While averageness is attractive, it is not the peak of attractiveness; an averaged composite face created only from faces rated by adults as attractive is judged to be more attractive than a composite created from a wider selection of faces (Perrett, May, & Yoshikawa, 1994). Exaggerating the differences between the two composites can lead to faces judged to be even more attractive (DeBruine, Jones, Unger, Little, Feinberg, 2007; Perrett et al., 1994). Future directions include exploring whether children similarly find these faces along the "attractiveness dimension" attractive, and testing the influence of averageness on attractiveness judgments with older children and adolescents with adult comparison groups to determine the age at which these preferences mature.

In summary, averageness influences judgments of attractiveness as early as age 5 and does so reliably enough that it is likely to influence everyday social interactions. After age 5, its influence increases as children build more stable face prototypes and become sensitive to more subtle differences among faces, both of which may allow a stronger effect of processing fluency. By the time children begin to think about mate-choice after puberty, the preference is well-established.

Acknowledgements

We thank Kathleen Lee, Sarah Lyon, and Julian Ghloum for help with the collection of data, and David Feinberg for contributing a subset of the face photographs that we used to create stimuli, for advice on creating stimuli and for comments on an earlier draft of the manuscript. We thank Cathy Mondloch for contributing another subset of the face photographs that were used to create stimuli. This research was supported by a grant from the Canadian Natural Sciences and Engineering Council (9797) to Daphne Maurer. Larissa Vingilis-Jaremko was supported by an NSERC CGS D.

References

Adams, R. A., & Courage, M. L. (2002). Using a single test to measure human contrast sensitivity from early childhood to maturity. *Vision Research*, 42, 1205–1210.

Alley, T.R., & Cunningham, M.R. (1991). Averaged Faces are Attractive, but Very Attractive Faces are Not Average. *Pyschological Science*, 2(2), 123-125.

Anastasi, J.S., & Rhodes, M.G. (2005). An own-age bias in face recognition for children and older adults. *Psychonomic Bulletin & Review*, 12(6), 1043-1047.

Anastasi, J.S., & Rhodes, M.G. (2006). Evidence for an own-age bias in face recognition. *North American Journal of Psychology*, 8(2), 237-252.

Anzures, G., Mondloch, C.J., & Lackner, C. (2009). Face Adaptation and Attractiveness Aftereffects in 8-Year-Olds and Adults. *Child Development*, 80(1), 178-191.

Apicella, C.L., Little, A.C., & Marlowe, F.W. (2007). Facial averageness and attractiveness in an isolated population of hunter-gatherers. *Perception*, 36, 1813-1820.

Barrett, S.E., & O'Toole, A.J. (2009). Face adaptation to gender: Does adaptation transfer across age categories? *Visual Cognition*, 17(5), 700-715.

Baudouin, J., Gallay, M., Durand, K., & Robichon, F. (2010). The development of perceptual sensitivity to second-order facial relations in children. *Journal of Experimental Child Psychology*, 107, 195–206.

Bernstein, I.H., Lin, T., & McClellan, P. (1982). Cross- vs. within-racial judgments of attractiveness. *Perception* & *Psychophysics*, 32(6), 495-503.

Benson P, Perrett D. (1992). Face to face with the perfect image. *New Scientist*, 1809:32–35.

Chance, J.E., Turner, A.L., & Goldstein, A.G. (1982). Development of differential recognition for own- and other-race faces. *Journal of Psychology*, 112, 29–37.

Cooper, P.A., Geldart, S.S., Mondloch, C.J., & Maurer, D. (2006). Developmental changes in perceptions of attractiveness: a role of experience? *Developmental Science*, 9(5), 530–543.

Cooper, P.A., & Maurer, D.M. (2008). The influence of recent experience on perceptions of attractiveness. *Perception*, 37, 1216-1226.

Corenblum, B., & Meissner, C.A. (2006). Recognition of faces of ingroup and outgroup children and adults. *Journal of Experimental Child Psychology*, 93, 187–206.

Cunningham, M.R, Roberts, A.R., Barbee, A.P., & Druen, P.B. (1995). "Their Ideas of Beauty Are, on the Whole, the Same as Ours": Consistency and Variability in the Cross-Cultural Perception of Female Physical Attractiveness. *Journal of Personality and Social Psychology*, 68(2), 261-279.

DeBruine, L.M., Jones, B.C., Unger, L., Little, A.C., & Feinberg, D.R. (2007). Dissociating averageness and attractiveness: Attractive faces are not always average. *Journal of Experimental Psychology: Human Perception and Performance*, 33(6), 1420-1430.

de Haan, M., Johnson, M.H., Maurer, D., Perrett, D. (2001). Recognition of individual faces and average face prototypes by 1-and 3-month-old infants. *Cognitive Development*, 16(2), 659-678.

Diamond, R., & Carey, S. (1977). Developmental Changes in the Representation of Faces. *Journal of Experimental Child Psychology*, 23, 1-22.

Dion, K.K. (1973). Young Children’s Stereotyping of Facial Attractiveness. *Developmental Psychology*, 9(2), 193-188.

Dion, K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personality and Social Psychology*, 24(3), 285-290.

Dobzhansky, T. (1982). *Genetics and the Origin of Species*. Columbia University Press, New York.

Ellemberg, D., Lewis, T. L., Liu, C. H., & Maurer, D. (1999). Development of spatial and temporal vision during childhood. *Vision Research*, 39, 2325–2333.

Fink, B., & Penton-Voak, I. (2002). Evolutionary Psychology of Facial Attractiveness. *Current Directions in Psychological Science*, 11(5), 154-158.

Galton, F.J. (1878). Composite portraits. *Nature*, 18, 97-100.

Geldart, S. (2008). Tall and Good-Looking? The Relationship Between Raters' Height and Perceptions of Attractiveness. *Journal of Individual Differences*, 29(3), 148–156.

Geldart, S., Maurer, D., Henderson, H. (1999). Effects of the height of the internal features of faces on adults' aesthetic ratings and 5-month-olds' looking times. *Perception*, 28, 839-850.

Goldstein, A.G., & Chance, J.E. (1980). Memory for faces and schema theory. *Journal of Psychology*, 105, 47–59.

Hadad, B., Maurer, D., & Lewis, T.L. (2011). Long trajectory for the development of sensitivity to global and biological motion. *Developmental Science*, 14, 1330-1339.

Halberstadt, J. & Rhodes, G. (2000). The Attractiveness of Nonface Averages: Implications for an Evolutionary Explanation of the Attractiveness of Average Faces. *Psychological Science*, 11(4), 285-289.

Harrison, V., & Hole, G.J. (2009). Evidence for a contact-based explanation of the own-age bias in face recognition. *Psychonomic Bulletin & Review*, 16(2), 264-269.

Hills, P.J. (2012). A Developmental Study of the Own-Age Face Recognition Bias in Children. *Developmental Psychology*, 48(2), 499–508.

Hills, P. J., Holland, A.M., & Lewis, M.B. (2010). Aftereffects for face attributes with different natural variability: Children are more adaptable than adolescents. *Cognitive*

Development, 25(3), 278–289.

Hills, P.J., & Lewis, M.B. (2011). The own-age face recognition bias in children and adults. *The Quarterly Journal of Experimental Psychology*, 64(1), 17–23.

Jacquet, E., Rhodes, G., & Hayward, W.G. (2008). Race-contingent aftereffects suggest distinct perceptual norms for different race faces. *Visual Cognition*, 16(6), 734-753.

Jeffery, L., McKone, E., Haynes, R., Firth, E., Pellicano, E., & Rhodes, G. (2010). Four-to-six-year-old children use norm-based coding in face-space. *Journal of Vision*, 10(5):18, 1–19.

Jeffery, L., & Rhodes, G. (2011). Insights into the development of face recognition mechanisms revealed by face aftereffects. British Journal of Psychology, 102, 799-815.

Jeffery, L., Rhodes, G., McKone, E., Pellicano, E., Crookes, K., Taylor, E. (2011). Distinguishing Norm-Based From Exemplar-Based Coding of Identity in Children: Evidence From Face Identity Aftereffects, *Journal of Experimental Psychology: Human Perception and Performance*, 37(6), 1824-1840.

Jeon, S.T., Maurer, D., & Lewis, T.L. (2012). Characterizing the mechanisms behind improvements in visual sensitivity during childhood [Abstract]. *Journal of Vision*, 12, art. 1366

Johnson, R.W., Dannenbring. G,L., Anderson. N,R.. & Villa. R.E. (1983). How different cultural and geographic groups perceive the attractiveness of active and inactive feminists. *The Journal of Social Psychology*, 119, 111-117.

Jones, B.C., DeBruine, L.M. & Little, A.C. (2007). The role of symmetry in attraction to average faces. *Perception & Psychophysics*, 2007, 69(8), 1273-1277.

Kuefner, D., Macchi Cassia, V., Picozzi, M., & Bricolo, E. (2008). Do All Kids Look Alike? Evidence for an Other-Age Effect in Adults. *Journal of Experimental Psychology: Human Perception and Performance*, 34(4), 811–817.

Langlois, J.H., Kalakanis, L., Rubenstein, A.J., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or Myths of Beauty ? A Meta-Analytic and Theoretical Review. *Psychological Bulletin*, 126(3), 390-423.

Langlois, J.H., & Roggman, L.A. (1990). Attractive faces are only average. *Psychological Science*, 1, 115-121.

Langlois, J.H., Roggman, L.A., Casey, R.J, Ritter, J.M., Rieser-Danner, L.A., & Jenkins, V.Y. (1987). Infant preferences for attractive faces: Rudiments of a stereotype? *Developmental Psychology*, 23, 363-369.

Langlois, J.H., Roggman, L.A., Casey, R.J., Ritter, J.M., Rieser-Danner, L.A., & Jenkins V.Y. (1987). Infant Preferences for Attractive Faces: Rudiments of a Stereotype? *Developmental Psychology*, 23(3), 363-369.

Langlois, J.H., & Stephan, C. (1977). The effects of physical attractiveness and ethnicity on children's behavioral attributions and peer preferences. *Child Development*, 48, 1694–1698.

Leopold, D. A., O'Toole, A. J., Vetter, T. & Blanz, V. (2001). Prototype-referenced shape encoding revealed by highlevel aftereffects. *Nature Neuroscience*, 4, 89–94.

Levi, D.M. (2005). Perceptual Learning in Adults with Amblyopia: A Reevaluation of Critical Periods in Human Vision. *Developmental Psychobiology*, 46(3), 222-232.

Lewis, T., Ellemberg, D., Maurer, D., Dirks, M., Wilkinson, F., & Wilson, H. (2004). A window on the normal development of sensitivity to global form in Glass patterns. *Perception*, 33, 409-418.

Light, L.L., Hollander, S., & Kayra-Stuart, F. (1981). Why attractive people are harder to remember. *Personality & Social Psychology Bulletin*, 7(2), 269-276.

Little, A.C., DeBruine, L.M., & Jones, B.C. (2005). Sex-contingent face after-effects suggest distinct neural populations code male and female faces. *Proceedings of the Royal Society B*, 272, 2283–2287.

Little, A.C., & Hancock, P.J.B. (2002). The role of masculinity and distinctiveness in judgments of human male facial attractiveness. *British Journal of Psychology*, 93, 451–64.

Macchi Cassia, V., Kuefner, D., Picozzi, M., & Vescovo, E. (2009). Early Experience Predicts Later Plasticity for Face Processing Evidence for the Reactivation of Dormant Effects. *Psychological Science*, 20(7), 853-859.

Macchi Cassia, V. (2011). Age biases in face processing: The effects of experience across development. *British Journal of Psychology*, 102, 816–829.

Meissner, C.A., & Brigham, J.C. (2001). Thirty years of investigating the own-race bias in memory for faces: a meta-analytic review. *Psychology, Public Policy and Law*, 7, 3–35.

Mondloch, C., Le Grand, R., & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception*, 31, 553-566.

Nishimura, M., Maurer, D., Jeffery, L., Pellicano, E., & Rhodes, G. (2008). Fitting the child's mind to the world: Adaptive norm-based coding of facial identity in 8-year-olds. *Developmental Science*, 11, 620–627.

Olsen, I.R., & Marshuetz, C. (2005). Facial Attractiveness Is Appraised in a Glance. *Emotion*, 5(4), 498–502.

Perrett, D.I., May, K.A., & Yoshikawa, S. (1994). Facial shape and judgments of female attractiveness. *Nature*, 368, 239-242.

Perrett, D.I., Burt, M.B., Penton-Voak, I.S., Lee, K.J, Rowland, D.A., & Edwards, R. (1999). Symmetry and Human Facial Attractiveness. *Evolution and Human Behavior*, 20: 295-307.

Pimperton, H., Pellicano, E., Jeffery, L., & Rhodes, G. (2009). The role of higher level adaptive coding, mechanisms in the development of face recognition. *Journal of Experimental Child Psychology*, 104, 229–238.

Quinn, P., Yahr, J., Kuhn, A., Slater, A.M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. Perception, 31, 1109–1121.

Ramsey, J.L., Langlois, J.H., & Marti, C.N. (2005). Infant categorization of faces: Ladies first. *Developmental Review*, 25, 212–246.

Ramsey-Rennels, J.L., & Langlois, J.H. (2006). Infants' differential processing of female and male faces. *Current Directions in Psychological Science*, 15, 59–62.

Rennels, J.L., & Davis, R.E. (2008). Facial Experience During the First Year. *Infant Behavior and Development*, 31(4): 665–678.

Rhodes, G. (2006). The Evolutionary Psychology of Facial Beauty. *Annual Review of Psychology*, 57, 199-226.

Rhodes, G., Harwood, K., Yoshikawa, S., Nishitani, M., & McLean, I. (2002). The attractiveness of average faces: cross-cultural evidence and possible biological basis. In G Rhodes, LA Zebrowitz (Eds.), *Facial Attractiveness: Evolutionary, Cognitive and Social Perspectives*, (pp. 35–58). Westport, CT: Ablex

Rhodes, G., Geddes, K., Jeffery, L., Dziurawiek, S., Clark, A. (2002). Are average and symmetric faces attractive to infants? Discrimination and looking preferences. *Perception*, 31, 315-321.

Rhodes, G., & Jeffery, L. (2006). Adaptive norm-based coding of facial identity. *Vision Research*, 46, 2977-2987.

Rhodes, G., Jeffery, L., Watson, T.L., Clifford, C.W.G., & Nakayama, K. (2003). Fitting the mind to the World: Face adaptation and attractiveness aftereffects. *Psychological Science*, 14(6), 558-556.

Rhodes, G., Sumich, A. & Byatt, G. (1999). Are Average Facial Configurations

Attractive Only Because of their Symmetry? *Psychological Science*, 10(1), 52-58.

Rhodes, G., & Tremewan, T. (1996). Averageness, Exaggeration, and Facial Attractiveness, *Psychological Science*, 7(2), 105-110.

Robbins, R.A., Maurer, D., Hatry, A., Anzures, G., & Mondloch, C.J. (2007). Effects of normal and abnormal visual experience on the development of opposing aftereffects for upright and inverted faces. *Developmental Science*, 15(2), 194–203.

Rowland, D.A., & Perrett, D.I. (1995). Manipulating Facial Appearance through Shape and Color. *IEEE Computer Graphics and Applications*. 70-76.

Rubenstein, A.J., Kalakanis, L., Langlois, J.H. (1999). Infant Preferences for Attractive Faces : A Cognitive Explanation. *Developmental Psychology*, 35(3), 848-855.

Samuels, C.A., Butterworth, G., Roberts, T., Graupner, L., & Hole, G. (1994). Facial aesthetics: babies prefer attractiveness to symmetry. *Perception*, 23, 823-831.

Sangrigoli, S., & de Schonen, S. (2004a). Effect of visual experience on face processing: a developmental study of inversion and non-native effects. Developmental *Science*, 7, 74–87

Saxton, T.K., Debruine, L.M., Jones, B.C., Little, A.C., Roberts, S.C. (2009). Face and voice attractiveness judgments change during adolescence. *Evolution and Human Behavior*, 30, 398–408.

Saxton, T.K., Debruine, L.M., Jones, B.C., Little, A.C., Roberts, S.C. (2011). A longitudinal study of adolescents' judgments of the attractiveness of facial symmetry, averageness and sexual dimorphism. *Journal of Evolutionary Psychology*, 43-55.

Saxton, T.K., Kohoutova, D., Roberts, S.C., Jones, B.C., DeBruine, L.M., & Havlicek, J. (2010). Age, puberty and attractiveness judgments in adolescents. *Personality and Individual Differences*, 49(8), 857-862.

Short, L.A., Hatry, A.J., & Mondloch, C.J. (2011). The development of norm-based coding and race-specific face prototypes: An examination of 5- and 8-year-olds' face space. *Journal of Experimental Child Psychology*, 108(2), 338–357.

Slater, A., Quinn, P.C., Hayes, R. & Brown, E. (2000). The role of facial orientation in newborn infants' preference for attractive faces. *Developmental Science*, 3(2), 181-185.

Slater, A., Von der Schulenburg, C., Brown, E., Badenoch, M., Butterworth, G., Parsons, S., & Samuels, C. (1998). Newborn infants prefer attractive faces. *Infant Behavior and Development*, 21, 345-354.

Thornhill, R., & Gangestad, S.W. (1993). Human Facial Beauty, Averageness, Symmetry, and Parasite Resistance. *Human Nature*, 4(3), 237-269.

Thornhill, R., & Gangestad, S.W. (1999). Facial Attractiveness. *Trends in Cognitive Sciences*, 3(12), 452-460.

Tiddeman, B., Burt, D.M., & Perrett, D. (2001). Computer Graphics in Facial Perception Research, *IEEE Computer Graphics and Applications*, 21(5), 42-50.

Valentine, T. (1991). A Unified Account of the Effects of distinctiveness, Inversion, and Race in Face Recognition. *The Quarterly Journal of Experimental Psychology*, 43A(2), 161-204.

Valentine, T., Darling, S., & Donnelly, M. (2004). Why are average faces attractive? The effect of view and averageness on the attractiveness of female faces, *Psychonomic Bulletin & Review*, 11(3), 482-287.

Vingilis-Jaremko, L., & Maurer, D. (2013). The Influence of Symmetry on Children's Judgments of Facial Attractiveness. *Perception*, 42, 302-320.

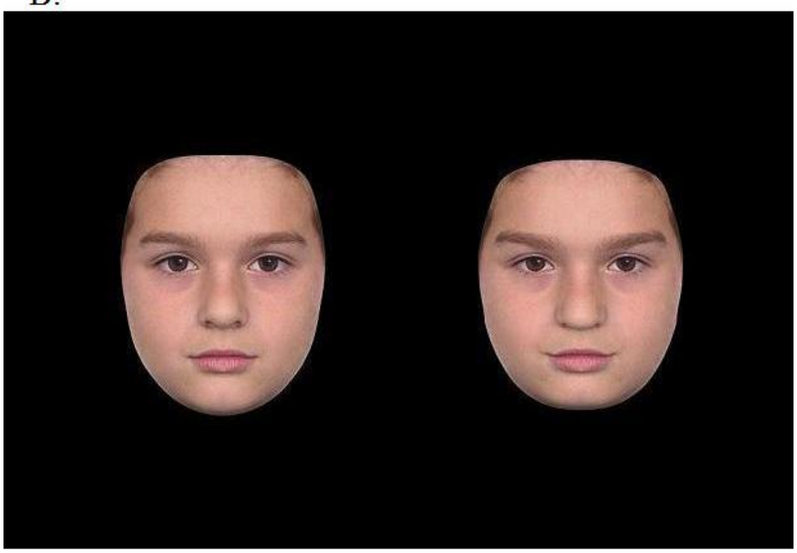
Webster, M.A., & MacLin, O.H. (1999). Figural aftereffects in the perception of faces. *Psychonomic Bulletin & Review*, 6, 647–653.

Winkielman, P., Halberstadt, J., Fazendeiro, T., & Catty, S. (2006). Prototypes Are Attractive Because They Are Easy on the Mind. *Psychological Science*, 17(9), 799-806.

Figures

A.

B.



C.

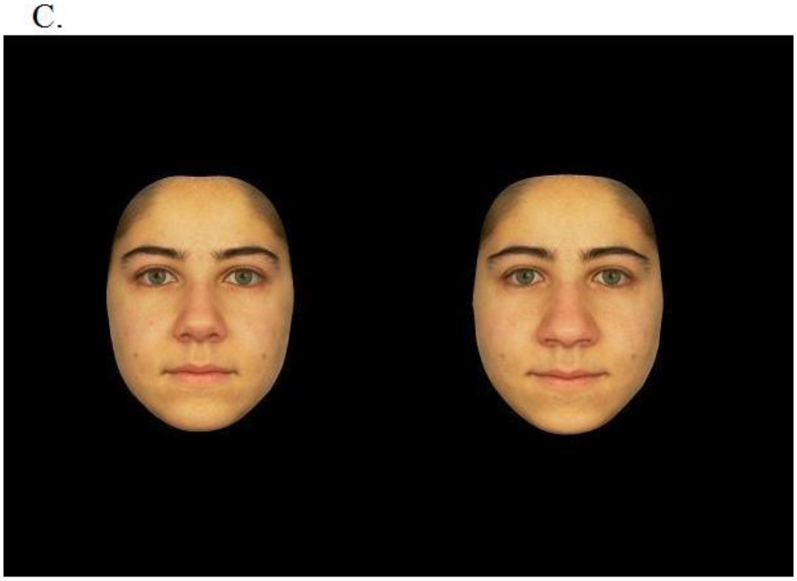


Figure 1. More average (left) and less average (right) versions of a (A) 5-year-old girl's face, (B) 9-year-old boy's face, and (C) woman's face.

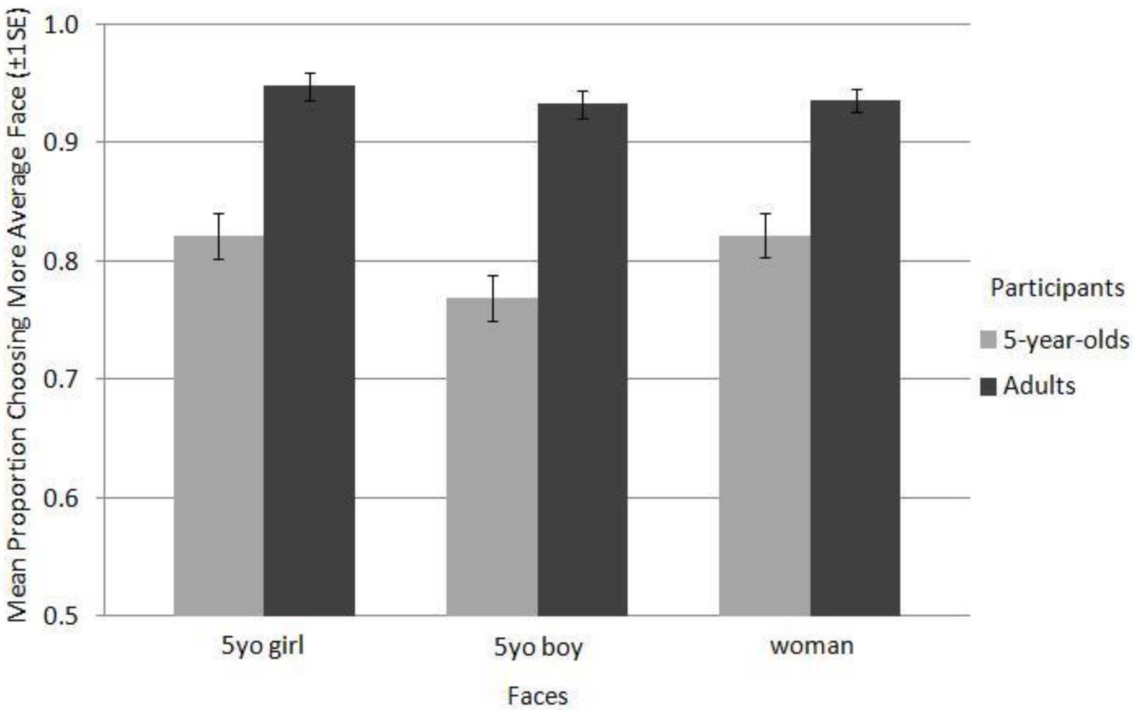


Figure 2. Mean proportion of trials on which 5-year-old (grey bars) and adult (dark bars) participants selected the more average face for each face category. Standard error bars represent the between-subject variability.

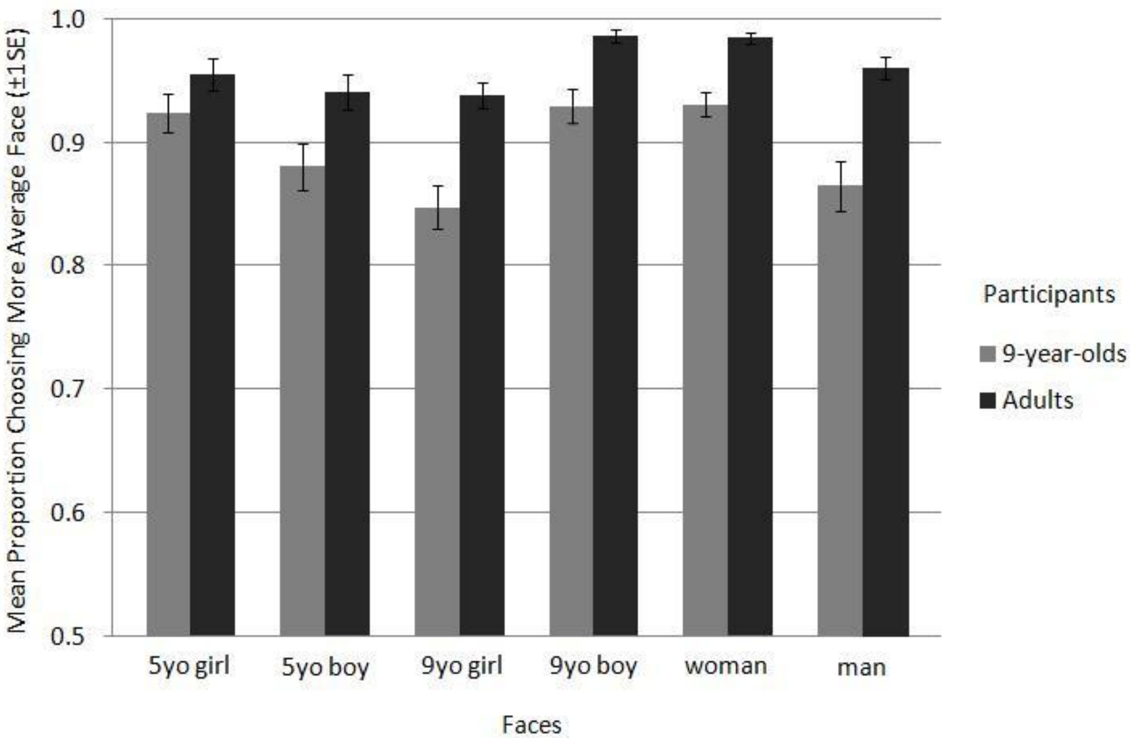


Figure 3. Mean proportion of trials on which 9-year-old (grey bars) and adult (dark bars) participants selected the more average face for each face category. Bars represent the between-subject standard error.

CHAPTER 4: The Influence of Attending a Single-Sex School on Children's Judgments of Facial Attractiveness

Vingilis-Jaremko, L., Maurer, D. & Gao, X. (submitted). The Influence of Attending a Single-Sex School on Children's Judgments of Facial Attractiveness. Manuscript has been submitted for publication.

Preface

In the work presented in chapter 3, I learned that a face's proximity to its group average influenced attractiveness judgments among both children and adults. However, there is evidence that attractiveness judgments can shift in response to differences in experience with faces (eg. Apicella et al., 2007; Anzures et al., 2009; Cooper et al., 2006; Geldart, 2008; Geldart et al., 1999; Rhodes et al., 2003) consistent with faces being processed based on a norm that is constantly being updated as new faces are encountered. To explore this question, I tested the influence of averageness on attractiveness judgments in grade 4 students attending a girls' school, a boys' school, or a mixed-sex school using the same procedure and same stimuli that were described in chapter 3 using the same stimuli. Participants viewed pairs of faces in which one version of the face had been transformed toward its group average, while the other version of the face had been transformed away from its group average, and selected which face from each pair was more attractive. In separate blocks, participants viewed faces of 5-year-old girls, 5-year-old boys, 9-year-old girls, 9-year-old boys, women, and men. I hypothesized that children attending single-sex schools would prefer averageness more strongly in same-sex, same-age faces, than faces of the opposite-sex, or other ages. I did not find that pattern of results. A separate analysis on the transformed images revealed similarities between face averages across sexes and ages.

Thus, the differences in face experience between groups may not have affected the results because of similarities between the average faces of different ages and sexes, and/or because a minimum level of experience with a particular group of faces could be adequate for the formation of a prototype and its influence on judgments of attractiveness. These results suggest that averageness affects children's attractiveness judgments regardless of the age and sex of the faces they see.

Abstract

We examined how recent biased face experience affects the influence of averageness on judgments of facial attractiveness by showing grade 4 children attending a girls' school, a boys' school, and a mixed-sex school, pairs of individual faces in which one face was transformed 50% toward its group average, while the other face was transformed 50% away from that average. Across blocks, the faces varied in age (adult, 9-year-old, 5-year-old) and sex (male, female). We expected that averageness might influence attractiveness judgments more strongly for same age faces and, for the single-sex schools, same sex faces of that age. Averageness influenced children's judgments of attractiveness, but the strength of the influence was not modulated by the age of the face, nor did the effects of sex of face differ across schools. Recent biased experience in single-sex schools may not have affected the results because of similarities between the average faces of different ages and sexes, and/or because a minimum level of experience with a particular group of faces may be adequate for prototype formation and its influence on judgments of attractiveness. The results suggest that averageness affects children's judgments of the attractiveness of the faces they encounter in everyday life, regardless of age or sex.

Keywords: face processing, attractiveness, averageness, development, children, experience

Introduction

There is a high degree of agreement across cultures (Bernstein, Lin, & McClellan, 1982; Cunningham, Roberts, Barbee, & Druen, 1995; Johnson, Dannenbring, Anderson, & Villa, 1983; Langlois et al., 2000; Perrett, May, & Yoshikawa, 1994) and across ages (Langlois et al., 1987; Samuels, Butterworth, Roberts, Graupner, Hole, 1994; Slater et al., 1998; Slater, Quinn, Hayes, & Brown, 2000) in which faces are attractive. These attractiveness judgments affect social interactions because they lead to attributions of many positive qualities to those perceived as attractive ("what is beautiful is good" stereotype; Dion, Berscheid & Walster, 1972).

One influence on judgments of facial attractiveness is the proximity of a face to the population average. Composite faces created by averaging luminance levels from 16 or 32 images are judged by adults to be more attractive than the original faces used to create the composites (Langlois & Roggman, 1990). The attractiveness of more average faces is a robust finding and control experiments have ruled out artifactual explanations based on smoothing of skin texture in the pixel-based averaging procedure (Little & Hancock, 2002; Rhodes & Tremewan, 1996), or the increasing symmetry of faces as they approach group averages (Rhodes, Sumich, & Byatt, 1999; Valentine, Darling, & Donnelly, 2004).

There is also evidence that children's judgments of attractiveness are influenced by averageness: adolescents find faces that have been transformed toward average to be more attractive than the original versions of the faces (Saxton, Debruine, Jones, Little, Roberts, 2009; 2011; Saxton et al., 2010), and children as young as 5 years select faces that have been transformed toward average to be more attractive than less average versions of the same faces, although to a lesser extent than 9-year-olds or adults (Vingilis-Jaremko & Maurer, submitted). These studies, along with evidence that averageness influences judgments of attractiveness crossculturally (see Rhodes, 2002 for a review), and that faces naturally lying closer to the population average are considered to be more attractive than more distinctive faces (Light, 1981), provide strong evidence that average faces are attractive.

Evolutionary psychologists have theorized that averageness may be attractive because of stabilizing selection, in which evolutionary pressures select against extreme phenotypes, and favour the average, or most common features or traits (Dobzhansky, 1982). Averageness can be a signal of heterozygosity (having dissimilar gene pairs) for many heritable traits (Fink & Penton-Voak, 2002; Thornhill & Gangestad, 1993). In this way, averageness could signal an outbred individual with fewer harmful mutations, and greater genetic diversity and parasitic resistance, all of which could lead to a mate preference and influences on judgments of attractiveness (Dobzhansky, 1982; Thornhill & Gangestad, 1993; 1999).

Evolutionary pressures may have selected for cognitive mechanisms that facilitate processing of averageness. Faces are hypothesized to be encoded within a multidimensional face space centered on a prototype that is formed from our accumulated experience with faces (Rhodes, 2006; Valentine, 1991). The prototype is constantly being updated as we encounter new faces, each of which is encoded as a multi-dimensional vector based on differences and distance from the prototype. As a result, more distinctive faces lie farther from the prototype. It has been theorized that faces closer to the prototype may be processed more quickly and easily than more distinctive faces, and consequently preferred (Valentine, 1991; Winkielman, Halberstadt, Fazendeiro, & Catty, 2006). Indeed, adults categorize prototypical random dot and geometric patterns more quickly than less prototypical patterns, and rate them as more attractive than less prototypical patterns (Winkielman et al. 2006). Adults also judge more prototypical dogs, wristwatches, and birds to be more attractive than more distinctive exemplars of these categories (Halberstadt & Rhodes, 2000). Similarly, adapting adults to a distorted face in which all of the features are compressed (or expanded) shifts their subsequent judgments of attractiveness in the distorted direction, as would be expected if the norm had been updated during the adaptation (Rhodes, Jeffery, Watson, Clifford, Nakayama, 2003; see Cooper & Maurer, 2008 for similar evidence with adaptation to high or low feature height in adults). Thus, adults may perceive prototypical faces, objects, and patterns as attractive because they more closely match the norm for that category and hence are processed more fluently than less prototypical exemplars.

There is evidence that children also process faces relative to a norm and that, at least by age 5, the norm influences their judgments of attractiveness (Vingilis-Jaremko & Maurer, submitted). Three-month-old infants (but not 1-month-olds) treat a four-face composite as familiar after being exposed to the four individual faces (de Haan, Johnson, Maurer, Perrett, 2001; see Rubenstein, Kalakanis, & Langlois, 1999 for similar evidence in 6-month-olds). By ages 4-6 (youngest age tested), children show evidence of processing faces relative to a prototype: after adaptation to a distorted face or a specific face identity, their recognition of other faces shifts in the expected direction (Jeffery et al., 2010; Jeffery et al., 2011; 8-year-olds, Nishimura, Maurer, Jeffery, Pellicano, & Rhodes, 2008; Pimperton, Pellicano, Jeffery, & Rhodes, 2009). By age 8-9 (youngest age tested), for recognizing identity, the shift is specific to faces on a vector going through a prototypical face (Jeffery et al., 2011). The shifts are greater the farther the adapting face is from the norm, as would be expected with norm-based coding (demonstrated for figural aftereffects at age 4-5, Jeffery et al., 2010; demonstrated for facial identity at age 7, Jeffery et al., 2011). Children’s judgments of oddness also shift in the adapted direction after adaptation to high or low feature height (as young as 6 years; Hills, Holland, &

Lewis, 2010) and their judgments of attractiveness shift in the adapted direction after adaptation to compressed or expanded faces (at age 8; Anzures, Mondloch, Lackner, 2009). For attractiveness, however, children sometimes require larger distortions than adults during the adaptation phase (Anzures et al., 2009), and can be adapted to unnatural distortions that do not affect adults' judgments of attractiveness (Hills, Holland, & Lewis, 2010). These findings suggest that children could have a less stable norm than adults, possibly caused by less accumulated experience with faces.

The updating of the norm that has been shown in adults and children as young as 4 years in laboratory experiments suggests that individuals with differences in natural face experience could differ in their perceptions of attractiveness. Indeed, shorter adults, who tend to look up at faces, find faces with a larger chin and a smaller forehead more attractive than faces with average features, consistent with the foreshortening that occurs from their viewing angle (Geldart, 2008). This is also true of the looking preferences of infants, who tend to look up at faces (Geldart, Maurer, & Henderson, 1999), but not of children who have entered preschool, where they interact with peers at eye-level; instead, they find faces with smaller chins and larger foreheads, similar to the proportions of their peers' faces, to be most attractive (Cooper, Geldart, Mondloch, & Maurer, 2006).

A complete lack of experience with a particular group of faces affects attractiveness judgments as would be expected if they are influenced by a norm built up with experience. For example, the Hadza, an isolated hunter-gatherer tribe in Africa, find averageness to be attractive in faces of the Hadza, but not in White British faces, a group with whom they have little to no experience. Westerners, however, who presumably have more experience with faces from diverse cultures, find averageness attractive in both Hadza and White British faces (Apicella, Little, Marlowe, 2007). Consistent with these findings, newborn infants show no spontaneous looking preference for same or other race faces, but by 3 months, infants look longer at same than other race faces (Bar-Haim, Ziv, Lamy & Hodes, 2006; Kelly et al., 2007; Kelly et al., 2005). Similarly, by 3 to 4 months, infants raised by a female caretaker have a looking preference for female over male faces, a preference that appears to be reversed in infants raised by a male caretaker (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002). The continued biasing of the experience of most infants in favour of female faces (Rennels & Davis, 2008) may be the foundation for infants' more advanced processing of female than male faces (Ramsey-Rennels & Langlois, 2006). The findings from infants and the Hadza suggest that as experience with a particular group of faces grows, the prototype for those faces becomes more refined, a process leading to a looking preference in infants, and attractiveness judgments based on averageness in adults.

The purpose of this study was to explore how recent biased experience affects the influence of averageness on children's judgments of attractiveness. We took advantage of a natural experiment by testing grade four students attending private schools that were limited to girls, limited to boys, or included children of both sexes. We created separate averages for the faces of 8- to 9-year-old boys and girls and transformed individual faces 50% toward and away from their group averages. Participants selected which face from each pair was more attractive. We hypothesized that averageness should influence attractiveness judgments more strongly for same-sex faces among children in single-sex schools. We made the same manipulations to faces of two other age groups (adults and 5-year-olds); we expected the influence of averageness might be greater for same-age faces as children likely have more experience with faces of their own age than younger or older ages, and because children have an own-age bias in recognizing faces

(Anastasi & Rhodes, 2005; Hills & Lewis, 2011; but see Macchi Cassia, 2011 for evidence that children have a processing advantage for adult faces).

Methods

Participants

We tested 25 girls attending a girls' school (mean age: 9 years 4.1 months; range: 8-10 years), 21 boys attending a boys' school (mean age: 9 years 4.6 months; range: 8-9 years), and 20 children attending a mixed-sex school (mean age: 9 years 4.4 months; range: 8-9 years; 8 girls). Students from each of the schools were from a variety of ethnic backgrounds. All participants had normal or corrected-to-normal vision with a Snellen acuity of 20/20 or better in each eye, as measured on a Lighthouse eye chart.

All schools were private schools in metropolitan areas of Ontario, Canada, charging similar levels of school fees. The boys' school spanned junior kindergarten through 8, and the girls' school and mixed-sex school spanned junior kindergarten through grade 12, although students from grade 9 and up are housed in a separate building. The mixed-sex school had students in both a Montessori, and regular school program. The boys' school had 304 students and 42 teachers/staff, the girls' school had 295 students and 40 teachers/staff in its Junior School, and the mixed-sex school had 334 students and 40 teachers/staff in the Montessori and Junior School. Donations were made to the school libraries in appreciation of the students' participation.

An additional 11 children were tested but excluded from the data because they failed our visual screening requirements (9 children), because of a computer error (1 child), or because they had gone through the same procedure in another study in our lab (1 child).

Stimuli

The stimuli were the same as those used in Vingilis-Jaremko & Maurer (in press). Briefly, stimuli were created from 16 colour, full front face photographs with neutral expressions from each of six categories: young adult men; young adult women, 8- to 9-year-old boys; 8- to 9-year-old girls; 4- to 5-year-old boys; 4- to 5-year-old girls. We then created an average face for each face category, and transformed the original faces 50% toward and away from their group average (see Tiddeman, Burt, & Perrett, 2001). This resulted in pairs of faces that maintained the texture of the original face, but differed in proximity to the group average based on shape. Because faces that are closer to average are also more symmetrical, we made all faces perfectly symmetrical by averaging each face with its mirror image. We removed hair and external features because we did not want participants' judgments to be influenced by distortions in the hairstyle. The external face shape, however, was retained. We standardized faces for size based on interpupilary distance and presented the faces on a black background (Figure 1). We used a BenQ ET-0027-B 24 inch widescreen LCD monitor with screen resolution set to 1024x768. From a viewing distance of 50 cm, faces subtended a visual angle of approximately 12 degrees in height and 7 degrees in width.

Design

We tested participants at three different schools, all of whom saw the six face categories (16 face pairs per face category), which were blocked, for a total of 96 trials per participant. For each participant, the side of the more average face was randomized across trials, and the presentation of stimuli was randomized within each block. The order of blocks was counterbalanced across participants from each school with a Latin Square design.

Procedure

This study received ethics clearance from the institutional Research Ethics Board. Grade 4 students at each school were given a package that included a letter from the school, a letter from our lab giving information about the study, and a consent form. Children of parents who gave consent were tested individually in a small conference room with a table and chairs. The same testing computers and identical screens were set up in each school's conference room. The rooms were reasonably quiet, except for some ambient noise from other students through the door, which was left ajar. After explaining the procedure, we obtained verbal consent from child participants. We used the same instructions as Vingilis-Jaremko & Maurer (submitted):

> I'm having a birthday party and I have invited all of my friends! Among my friends, pairs of brothers and pairs of sisters will be attending the party. These brothers and sisters have been trying very hard to look their very best. They are trying to make themselves look nice because a clown at the party will be giving a red balloon to the brother or sister from each pair who looks cuter, or prettier, or more handsome today. Every time you see two faces on the screen, they are either sisters or brothers, and it will be your job to figure out who looks better, or nicer, or more attractive today, and will receive the red balloon from the clown!

We used a number of words throughout the experiment to describe the concept of attractiveness including *prettier, more handsome, nicer looking, better looking, cuter, and more attractive*, and we told participants which age and sex of face they would be rating before beginning each block.

We asked participants if they understood the procedure, and then presented them with nine criterion trials comprising pairs of non-face objects that differed greatly in attractiveness (such as a new book and an old tattered book). We asked participants to select which object from each pair looked better or nicer. All participants met the 100% accuracy criterion required to move onto the main experiment. Trials were self-paced, and participants selected the more attractive face on each trial by clicking with a mouse, which initiated the next trial. We visually screened participants after the third block of faces, and took additional breaks as needed

Results

For each group of faces, we calculated the proportion of trials on which each participant selected the more average face. No outliers were identified as greater than three standard deviations from the mean. A preliminary analysis indicated no effect of block order $F(4.42,278.55)=1.72$, $p=.1.40$, $\eta p2=.027$, nor any interaction between block order and school, $F(10,63)=.669$, $p=.753$, $\eta p2=.021$, suggesting that children at all schools maintained attention throughout the experiment

To assess whether each group of participants selected the more average faces more frequently than chance, we performed one-tailed one sample t-tests comparing the mean of each face category to chance (0.5), for each of the schools (Bonferroni corrected $\alpha=.008$). Participants from all of the schools selected the more average face more frequently than chance for all face categories (all ps<.001; see figure 2).

A mixed model ANOVA with the between subjects factors of school, and the repeated measures of face age (5, 9, adult) and face sex, revealed a main effect of school, $F(2,63)=5.21$, $p=.008$, $\eta p2=.142$, and a main effect of face sex, $F(1,63)=8.11$, $p=.006$, $\eta p2=.114$, qualified by an interaction between face sex and face age, $F(2,126)=3.88$, $p=.023$, $\eta p2=.058$. Posthoc comparisons using the Tukey HSD test indicated that children at the girls' school ($M=.904$, $SD=.073$) selected the more average faces more frequently than children at the boys' school ($M=.823$, $SD=.111$), $p=.008$. There were no differences in selections of the more average faces between children at the mixed-sex school ($M=.887$, $SD=.077$), and the boys' school, $p=.061$, or girls' school, $p=.781$. To break down the interaction between face sex and face age, we did two-tailed paired samples t-tests comparing male and female faces for each age of face (Bonferroni corrected $\alpha=.017$). Children selected the more average faces more frequently for 5-year-old girl ($M=.885$, $SD=.123$) than 5-year-old boy ($M=.841$, $SD=.151$) faces, $t(65)=2.52$, $p=.014$, and more frequently for adult female ($M=.903$, $SD=.097$) than adult male ($M=.862$, $SD=.134$) faces, $t(65)=2.77$, $p=.008$. There were no differences in selections of the more average faces between 9-year-old girl ($M=.870$, $SD=.116$) and 9-year-old boy ($M=.877$, $SD=.119$) faces, $t(65)=-.452$, $p=.653$. Because it is also of interest to determine whether there is an influence of face age because of possible processing advantages for same age (Anastasi & Rhodes, 2005; Hills, 2012; Hills & Lewis, 2011) or adult faces (Macchi Cassia, 2011), we broke down the interaction a second way and did separate ANOVAs for male and female faces with the within subjects factor of face age (5, 9, adult). There was no main effect of face age in the female face ANOVA, $F(2,130)=2.52$, $p=.085$, $\eta p2=.037$, or in the male face ANOVA, $F(2,130)=2.49$, $p=.087$, $\eta p2=.037$.

We did several additional analyses to explore hypotheses about why we did not find the expected interaction between school and sex of face for same-age faces and to understand the origin of the main effect of school, which was caused by a difference between the girls' school and the boys' school. First, we evaluated whether there are sex differences in the strength of the influence of averageness at age 9 by comparing the responses of boys and girls from the mixed-gender school. To do so, we collapsed the data across face categories and compared the selections of the more average faces between boys and girls at the mixed-sex school with a two-tailed independent samples t-test. We found no differences in selections of the more average faces between boys (*M*=.886, *SD*=.108) and girls (*M*=.887, *SD*=.129), *t*(88.01)=.019, *p*=.985 at the mixed-sex school. Levene's test indicated unequal variances (*F*=4.50, *p*=.036), so degrees of freedom were adjusted from 118 to 88.01.

Second, we evaluated the possibility that children from the single-sex schools might have formed a prototype of the less familiar face category (opposite-sex 9-year-old faces) during the actual test. This possibility is suggested by studies showing short-term adaptation of the prototype in the lab (Hills, Holland, & Lewis, 2010; Jeffery et al., 2010; Jeffery et al., 2011; Nishimura et al., 2008; Pimperton et al., 2009). To evaluate this possibility, we calculated the mean proportion of trials on which each participant selected the more average faces for the first four and last four trials of the 9-year-old girl and 9-year-old boy face categories. We then collapsed the data across single-sex schools and reorganized it into the categories of same-sex or opposite-sex faces. If children at single-sex schools were building a prototype of opposite-sex peer faces, we should see a stronger influence of averageness in the last four trials than the first four trials in the block of opposite-sex peer faces. We did a repeated measures ANOVA with the repeated subjects factors of face type (same-sex faces; opposite sex faces), and trial set (first four trials; last four trials) and found an interaction between face type, and trial set, *F*(1,45)=7.67, *p*=.008, ηp2=.146. To follow up, we did two-tailed paired samples t-tests comparing the first four and last four trials for same-sex and opposite-sex faces (Bonferroni corrected α=.025). For same-sex faces, participants selected the more average faces more frequently in the first four

(*M*=.913, *SD*=.151) than the last four (*M*=.826, *SD*=.182) trials, $t(45)=2.97$, $p=.005$, although both of these values were well above the chance level of .50. For opposite sex faces, there were no differences in selections of the more average faces between the first four (*M*=.859, *SD*=.202) and last four (*M*=.897, *SD*=.154) trials, $t(45)=-1.27$, $p=.212$. Thus, children at the single-sex schools did not appear to be forming prototypes of opposite-sex peer faces from the beginning to the end of the face block.

Discussion

We tested the influence of averageness on attractiveness judgments in children attending a boy's school, a girl's school, and a mixed-sex school, and found that averageness influenced 8- to 9-year-olds' attractiveness judgments. These results are consistent with previous research (Vingilis-Jaremko & Maurer, submitted), and show that the influence of averageness on children's judgments of facial attractiveness is a robust finding.

This study was designed to examine how experience affects children's attractiveness judgments in two ways. First, we tested children attending single-sex schools, and hypothesized that averageness would influence attractiveness judgments more strongly in same-sex than other-sex faces of the same age. We did not find the hypothesized interaction, as averageness did not consistently influence attractiveness judgments more strongly in female faces among girls at the girls' school, nor in male faces at the boys' school. Second, we included three ages of faces to assess the influence of recent experience on attractiveness judgments, as children likely have the most experience with peers' faces (or possibly adult faces— Macchi Cassia, 2011), and children have an own age advantage when recognizing faces to which they were exposed previously in the lab, whether compared to the recognition of adults' faces or the faces of younger and older children (Anastasi & Rhodes, 2005; Hills, 2012; Hills & Lewis, 2011). We did not find any evidence of an own age bias, or processing advantage for adult faces in this study, as children did not consistently prefer averageness more strongly in same-age or adult faces, a pattern replicating findings from a previous study that tested a smaller sample of 9-year-olds (Vingilis-Jaremko & Maurer, submitted).

The lack of an influence of recent biased face experience on attractiveness judgments is a surprising result given the changes in attractiveness judgments that have been found after biased face experience in the real world, and in the lab (see introduction). One possibility, consistent with the efficacy of short-term adaptation in the lab (Hills, Holland, & Lewis, 2010; Jeffery et al., 2010; Jeffery et al., 2011; Nishimura et al., 2008; Pimperton et al., 2009) is that a minimum level of face experience is adequate to allow the formation of a prototype sufficiently well defined to influence judgments of attractiveness. In this study, although the children at single-sex schools have predominantly male or female face experience, it is likely that they have some exposure to children of the opposite sex. If children have representations of as few as 16 faces of the opposite sex, their prototype should be an accurate representation of the group average (see Langlois & Roggmann, 1990), and representations based on fewer than 16 faces will still approach the group average, allowing for attractiveness judgments based on a representative norm.

A related possibility is that experience with one face sex could facilitate processing of the other sex. The male and female averages at each age may be sufficiently similar that judgments of the attractiveness of 9-year-old boy faces based on a 9-year-old girl average might yield the same choices as judgments based on a 9-year-old boy average. To test this hypothesis, we compared the similarity of the 9-year-old boy faces that had been transformed 50% toward their

9-year-old boy average with 9-year-old boy faces that had been transformed 50% toward the 9-year-old girl average. For comparison, we also transformed each 9-year-old boy face 50% toward a randomly chosen individual face of a 9-year-old girl. We measured similarity (Pearson correlation) among the transformed faces based on the pixel-wise luminance value in matlab with custom code. We expected there to be strong correlations among all the faces because of their shared first-order face structure but, in addition, that the 9-year-old boy faces that had been transformed 50% toward their 9-year-old boy average should be more similar to the faces that had been transformed 50% toward the 9-year-old girl average than toward a randomly selected 9-year-old girl face. That pattern would be consistent with generalization across face prototypes. For the 9-year-old boys' faces, the faces that had been transformed toward the 9-year-old boy average were more similar to the faces transformed toward the 9-year-old girl average (r=.981 ± .005, (mean ± S.D.)) than toward a random 9-year-old girl's face (r=.960 ± .014, (mean ± S.D.); $p < .001$, two-tailed). The results were similar when the same analysis was done for 9-year-olds girls' faces: there was greater similarity between faces that had been transformed toward the 9-year-old girl average and 9-year-old boy average (r=.983 ± .004, (mean ± S.D.)) than toward a random 9-year-old boy's face (r=.957 ± .016, (mean ± S.D.); $p < .001$, two-tailed). These results support the possibility that children in the single-sex schools could have generated their attractiveness judgments for the faces of opposite-sex peers from a same-sex face prototype formed from their many socially salient encounters with same-sex peers.

We also did not find the expected interaction with age of face: the influence of averageness was not stronger for own-age faces than for the faces of 5-year-olds or adults. Grade 4 children may have sufficient interactions with enough adults to form a fairly accurate prototype for adult faces, despite being better at remembering own age than adult faces learned in an experiment (Anastasi & Rhodes, 2005; Hills, 2012; Hills & Lewis, 2011). They may also have remnants of the prototypes formed when they were 5 years old themselves, despite the strong own age advantage when remembering the faces of children their own age, or slightly younger (Hills, 2012). Alternatively, as with sex of face, there may be sufficient similarity among the prototypes of faces of different ages; a well-formed prototype of a 9-year-old face could be sufficient to create an effect of averageness for faces of other ages. We tested this possibility by comparing the two face ages used here that differ the most: 5-year-old and adult faces. We used the same approach as described above for sex of face. Specifically, we created additional stimulus faces by transforming each adult face 50% toward its same-age same-sex average, 50% toward a 5-year-old same-sex average, and 50% toward a random 5-year-old same-sex face identity. If there are similarities between averages of different ages, the faces that were transformed 50% toward their same-age averages should be more similar to those transformed toward the other-age averages than those transformed toward the other-age random faces. This prediction was confirmed for both male and female faces. For female faces, the correlation between face transformed to the same age and other-age average (r=.966 ± .005, (mean ± S.D.)) was higher than the correlation between the faces transformed toward the same age average and other age random face (r=.949 ± .018, (mean ± S.D.); p=.002, two-tailed). For male faces, the correlation between faces transformed toward the same age and other-age average (r=.947 ± .008, (mean ± S.D.)) was higher than the correlation between the faces transformed toward same age average and other age random face (r=.936 ± .017, (mean ± S.D.); p=.018, two-tailed)). These results suggest that there are similarities in averages across age categories, and support the possibility that the influence of averageness on children's judgments of the attractiveness of 5-year-old faces could have been generated from using, a same-age 9-

year-old prototype, or even an adult prototype. This type of generalization across age of face is also suggested by adaptation studies: adapting adults to adult female (or male) faces biases them to classify androgynous faces as being of the opposite sex, whether the test faces are of children or of adults (Barrett & O'Toole, 2009). The same is true when adults are adapted to children's female (or male) faces, and asked to judge adult androgynous faces, although the effect is slightly weaker (Barrett & O'Toole, 2009).

Although we did not find an interaction between recent biased face experience, and the influence of averageness on same or opposite-sex faces, we did find a cohort effect as children at the boys' school selected the more average faces less frequently than children at the mixed-sex, or girls' school, a result suggesting that there are individual differences in attractiveness judgments. This is not likely to be a sex difference because there was no difference between boys' and girls' judgments at the mixed-sex school and previous studies have not found a sex difference in either adults (Rhodes et al., 1999; Vingilis-Jaremko & Maurer, submitted), childen 5 to 9 (Vingilis-Jaremko & Maurer, submitted), or adolescents (Saxton et al., 2010; Saxton et al., 2011;) except for one study of that found that adolescent girls were more likely than boys to select the more average faces when judging male faces (Saxton et al., 2009). Alternately, it is possible that other differences between the schools, such as differences in the school environment or in the kind of child recruited could have influenced the findings.

We found an interaction between age and sex of face such that participants selected the more average faces more frequently in female than male faces in the 5-year-old and adult faces, but there were no differences in selections between male and female same-age faces. One possibility is that children show a stronger influence of averageness in female faces because of a history of biased exposure to female faces beginning in infancy (Rennels & Davis, 2008) and likely continuing through preschool. Faces of their own age could be the exception, for which their keen interest assures enough exposure to develop a stable prototype that exerts an influence on their judgments of attractiveness of faces of either sex. However, in a previous study we did not find this pattern in the 9-year-olds and adults we tested. Alternatively, the pattern of interactions, which are similar but not identical to those found in a previous study (Vingilis-Jaremko & Maurer, submitted) could be caused by noise in the data and/or subtle differences in the face sets from which the stimuli were formed, although no differences emerged in judgments of normality for the original faces in each set by a separate group of raters (Vingilis-Jaremko & Maurer, submitted).

In sum, we found that averageness influenced children's attractiveness judgments, but that recent biased experience with girls' or boys' faces did not strengthen its influence on attractiveness judgments. Nor were there experience-based effects of the age of the face. Other studies have found that averageness influences attractiveness judgments as early as age 5, but is not yet adult-like by age 9 (Vingilis-Jaremko & Maurer, submitted). The results of this study suggest that the differences among age groups in the strength of the influence of averageness on judgments of attractiveness does not arise mainly, if at all, from experiencing different types of faces in everyday life. The significant effect of averageness on judgments for every face category suggest that averageness will influence children's judgments of the attractiveness of the faces they encounter in everyday life, regardless of sex or age.

References

Anastasi, J.S., & Rhodes, M.G. (2005). An own-age bias in face recognition for children and older adults. *Psychonomic Bulletin & Review*, 12(6), 1043-1047.

Anzures, G., Mondloch, C.J., & Lackner, C. (2009). Face Adaptation and Attractiveness Aftereffects in 8-Year-Olds and Adults. *Child Development*, 80(1), 178-191.

Apicella, C.L., Little, A.C., Marlowe, F.W. (2007). Facial averageness and attractiveness in an isolated population of hunter-gatherers. *Perception*, 36, 1813-1820.

Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R.M. (2006). Nature and Nurture in Own-Race Face Processing. *Psychological Science*, 17(2), 159-163.

Barrett, S.E., & O'Toole, A. (2009). Face adaptation to gender: Does adaptation transfer across age categories? *Visual Cognition*, 17(5), 700-715.

Bernstein, I.H., Lin, T., & McClellan, P. (1982). Cross- vs. within-racial judgments of attractiveness. *Perception* & *Psychophysics*, 32(6), 495-503.

Cooper, P.A., Geldart, S.S., Mondloch, C.J., & Maurer, D. (2006). Developmental changes in perceptions of attractiveness: a role of experience? *Developmental Science*, 9(5), 530–543.

Cooper, P.A., & Maurer, D.M. (2008). The influence of recent experience on perceptions of attractiveness. *Perception*, 37, 1216-1226.

Cunningham, M.R, Roberts, A.R., Barbee, A.P., & Druen, P.B. (1995). "Their Ideas of Beauty Are, on the Whole, the Same as Ours": Consistency and Variability in the Cross-Cultural Perception of Female Physical Attractiveness. *Journal of Personality and Social Psychology*, 68(2), 261-279.

de Haan, M., Johnson, M.H., Maurer, D., Perrett, D. (2001). Recognition of individual faces and average face prototypes by 1-and 3-month-old infants. *Cognitive Development*, 16(2), 659-678.

Dion, K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personality and Social Psychology*, 24(3), 285-290.

Dobzhansky, T. (1982). *Genetics and the Origin of Species*. Columbia University Press, New York.

Fink, B., & Penton-Voak, I. (2002). Evolutionary Psychology of Facial Attractiveness. *Current Directions in Psychological Science*, 11(5), 154-158.

Geldart, S. (2008). Tall and Good-Looking? The Relationship Between Raters' Height and Perceptions of Attractiveness. *Journal of Individual Differences*, 29(3), 148–156.

Geldart, S., Maurer, D., Henderson, H. (1999). Effects of the height of the internal features of faces on adults' aesthetic ratings and 5-month-olds' looking times. *Perception*, 28, 839-850.

Halberstadt, J. & Rhodes, G. (2000). The Attractiveness of Nonface Averages: Implications for an Evolutionary Explanation of the Attractiveness of Average Faces. *Psychological Science*, 11(4), 285-289.

Hills, P.J. (2012). A Developmental Study of the Own-Age Face Recognition Bias in Children. *Developmental Psychology*, 48(2), 499–508.

Hills, P. J., Holland, A.M., & Lewis, M.B. (2010). Aftereffects for face attributes with different natural variability: Children are more adaptable than adolescents. *Cognitive Development*, 25(3), 278–289.

Hills, P.J., & Lewis, M.B. (2011). The own-age face recognition bias in children and adults. *The Quarterly Journal of Experimental Psychology*, 64(1), 17–23.

Jeffery, L., McKone, E., Haynes, R., Firth, E., Pellicano, E., & Rhodes, G. (2010). Four-to-six-year-old children use norm-based coding in face-space. *Journal of Vision*, 10(5):18, 1–19.

Jeffery, L., McKone, E., Haynes, R., Firth, E., Pellicano, E., & Rhodes, G. (2010). Four-to-six-year-old children use norm-based coding in face-space. *Journal of Vision*, 10(5):18, 1–19.

Jeffery, L., Rhodes, G., McKone, E., Pellicano, E., Crookes, K., Taylor, E. (2011). Distinguishing Norm-Based From Exemplar-Based Coding of Identity in Children: Evidence From Face Identity Aftereffects, *Journal of Experimental Psychology: Human Perception and Performance*, 37(6), 1824-1840.

Johnson, R.W., Dannenbring. G,L., Anderson. N,R.. & Villa. R.E. (1983). How different cultural and geographic groups perceive the attractiveness of active and inactive feminists. *The Journal of Social Psychology*, 119, 111-117.

Kelly, D.J., Liu, S., Ge, L., Quinn, P.C., Slater, A.M., Lee, K., Liu, Q., & Pascalis, O. (2007). Cross-Race Preferences for Same-Race Faces Extend Beyond the African Versus Caucasian Contrast in 3-Month-Old Infants. *Infancy*, 11(1), 87-95.

Kelly, D.J., Quinn, P.C., Slater, A.M., Lee, K., Gibson, A., Smith, M., Ge, L., & Pascalis, O. (2005). Three-month-olds, but not newborns, prefer own-race faces. *Developmental Science*, 8(6), 31–36.

Langlois, J.H., Kalakanis, L., Rubenstein, A.J., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or Myths of Beauty ? A Meta-Analytic and Theoretical Review. *Psychological Bulletin*, 126(3), 390-423.

Langlois, J.H., & Roggman, L.A. (1990). Attractive faces are only average. *Psychological*

Science, 1, 115-121.

Langlois, J.H., Roggman, L.A., Casey, R.J, Ritter, J.M., Rieser-Danner, L.A., & Jenkins, V.Y. (1987). Infant preferences for attractive faces: Rudiments of a stereotype? *Developmental Psychology*, 23, 363-369.

Light, L.L., Hollander, S., Kayra-Stuart, F. (1981) Why attractive people are harder to remember. *Personality & Social Psychology Bulletin*, 7(2), 269-276.

Little, A.C., Hancock, P.J.B. (2002). The role of masculinity and distinctiveness in judgments of human male facial attractiveness. *British Journal of Psychology*, 93, 451–64.

Macchi Cassia, V. (2011). Age biases in face processing: The effects of experience across development. *British Journal of Psychology*, 102, 816–829.

Meissner, C.A., & Brigham, J.C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy, and Law*, 7(1), 3-35.

Nishimura, M., Maurer, D., Jeffery, L., Pellicano, E., & Rhodes, G. (2008). Fitting the child's mind to the world: Adaptive norm-based coding of facial identity in 8-year-olds. *Developmental Science*, 11, 620–627.

Pimperton, H., Pellicano, E., Jeffery, L., & Rhodes, G. (2009). The role of higher level adaptive coding, mechanisms in the development of face recognition. *Journal of Experimental Child Psychology*, 104, 229–238.

Perrett, D.I., May, K.A., Yoshikawa, S. (1994). Facial shape and judgments of female attractiveness. *Nature*, 368, 239-242.

Quinn, P., Yahr, J., Kuhn, A., Slater, A.M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. *Perception*, 31, 1109–1121.

Ramsey-Rennels, J.L., & Langlois, J.H. (2006). Infants' differential processing of female and male faces. *Current Directions in Psychological Science*, 15, 59–62.

Rennels, J.L., & Davis, R.E. (2008). Facial Experience During the First Year. *Infant Behavior and Development*, 31(4): 665–678.

Rhodes, G. (2006). The Evolutionary Psychology of Facial Beauty. *Annual Review of Psychology*, 57, 199-226.

Rhodes, G., Harwood, K., Yoshikawa, S., Nishitani, M., & McLean, I. (2002). The attractiveness of average faces: cross-cultural evidence and possible biological basis. In G Rhodes, LA Zebrowitz (Eds.), *Facial Attractiveness: Evolutionary, Cognitive and Social Perspectives*, (pp. 35–58). Westport, CT: Ablex

Rhodes, G., Jeffery, L., Watson, T.L., Clifford, C.W.G., & Nakayama, K. (2003). Fitting the mind to the World: Face adaptation and attractiveness aftereffects. *Psychological Science*, 14(6), 558-556.

Rhodes, G., Sumich, A. & Byatt, G. (1999). Are Average Facial Configurations Attractive Only Because of their Symmetry? *Psychological Science*, 10(1), 52-58.

Rhodes, G., & Tremewan, T. (1996). Averageness, Exaggeration, and Facial Attractiveness, *Psychological Science*, 7(2), 105-110.

Rowland, D.A., & Perrett, D.I. (1995). Manipulating Facial Appearance through Shape and Color. *IEEE Computer Graphics and Applications*. 70-76.

Rubenstein, A.J., Kalakanis, L., Langlois, J.H. (1999). Infant Preferences for Attractive Faces : A Cognitive Explanation. *Developmental Psychology*, 35(3), 848-855.

Samuels, C.A., Butterworth, G., Roberts, T., Graupner, L., & Hole, G. (1994). Facial aesthetics: babies prefer attractiveness to symmetry. *Perception*, 23, 823-831.

Saxton, T.K., Debruine, L.M., Jones, B.C., Little, A.C., Roberts, S.C. (2009). Face and voice attractiveness judgments change during adolescence. *Evolution and Human Behavior*, 30, 398–408.

Saxton, T.K., Debruine, L.M., Jones, B.C., Little, A.C., Roberts, S.C. (2011). A longitudinal study of adolescents' judgments of the attractiveness of facial symmetry, averageness and sexual dimorphism. *Journal of Evolutionary Psychology*, 43-55.

Saxton, T.K., Kohoutova, D., Roberts, S.C., Jones, B.C., DeBruine, L.M., & Havlicek, J. (2010). Age, puberty and attractiveness judgments in adolescents. *Personality and Individual Differences*, 49(8), 857-862.

Slater, A., Quinn, P.C., Hayes, R. & Brown, E. (2000). The role of facial orientation in newborn infants' preference for attractive faces. *Developmental Science*, 3(2), 181-185.

Slater, A., Von der Schulenburg, C., Brown, E., Badenoch, M., Butterworth, G., Parsons, S., & Samuels, C. (1998). Newborn infants prefer attractive faces. *Infant Behavior and Development*, 21, 345-354.

Thornhill, R., & Gangestad, S.W. (1993). Human Facial Beauty, Averageness, Symmetry, and Parasite Resistance. *Human Nature*, 4(3), 237-269.

Thornhill, R., & Gangestad, S.W. (1999). Facial Attractiveness. *Trends in Cognitive Sciences*, 3(12), 452-460.

Tiddeman, B., Burt, D.M., & Perrett, D. (2001). Computer Graphics in Facial Perception Research, *IEEE Computer Graphics and Applications*, 21(5), 42-50.

Valentine, T. (1991). A Unified Account of the Effects of distinctiveness, Inversion, and

Race in Face Recognition. *The Quarterly Journal of Experimental Psychology*, 43A(2), 161-204.

Valentine, T., Darling, S., & Donnelly, M. (2004). Why are average faces attractive? The effect of view and averageness on the attractiveness of female faces, *Psychonomic Bulletin & Review*, 11(3), 482-287.

Winkielman, P., Halberstadt, J., Fazendeiro, T., Catty, S. (2006). Prototypes Are Attractive Because They Are Easy on the Mind. *Psychological Science*, 17(9), 799-806.

Figures

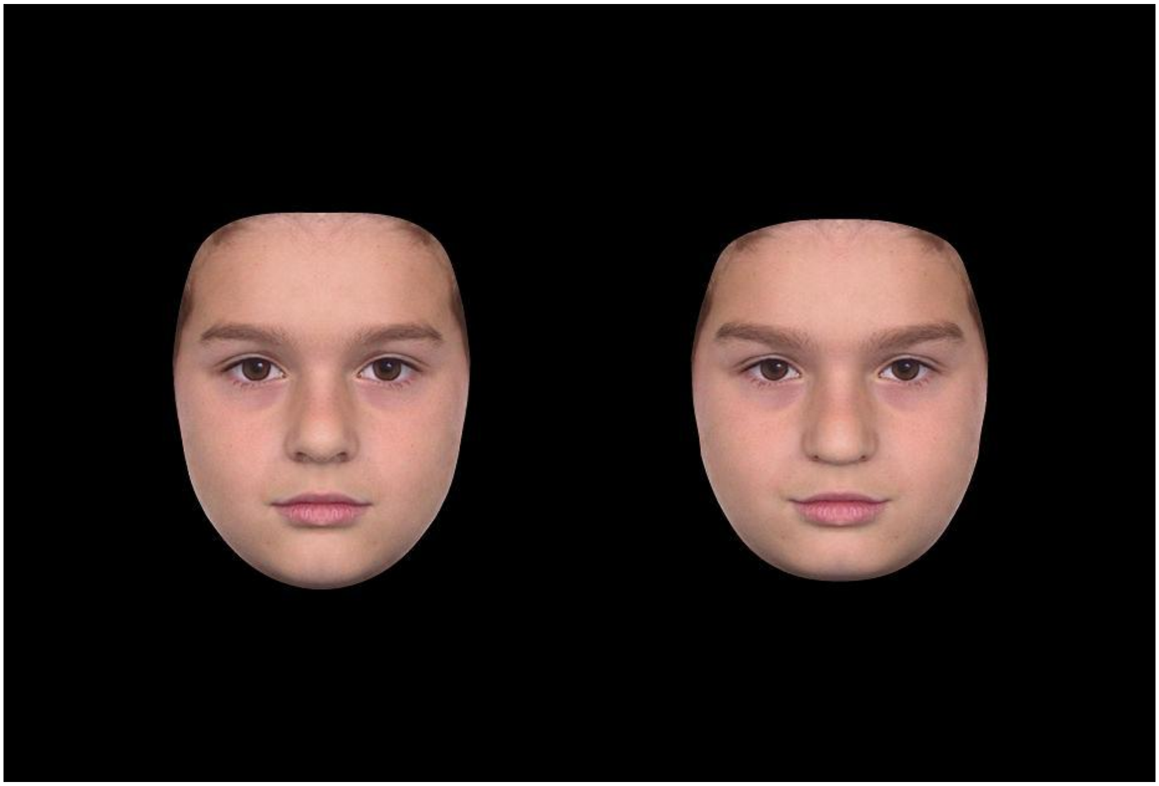


Figure 4. More average (left) and less average (right) versions of a 9-year-old boy's face.

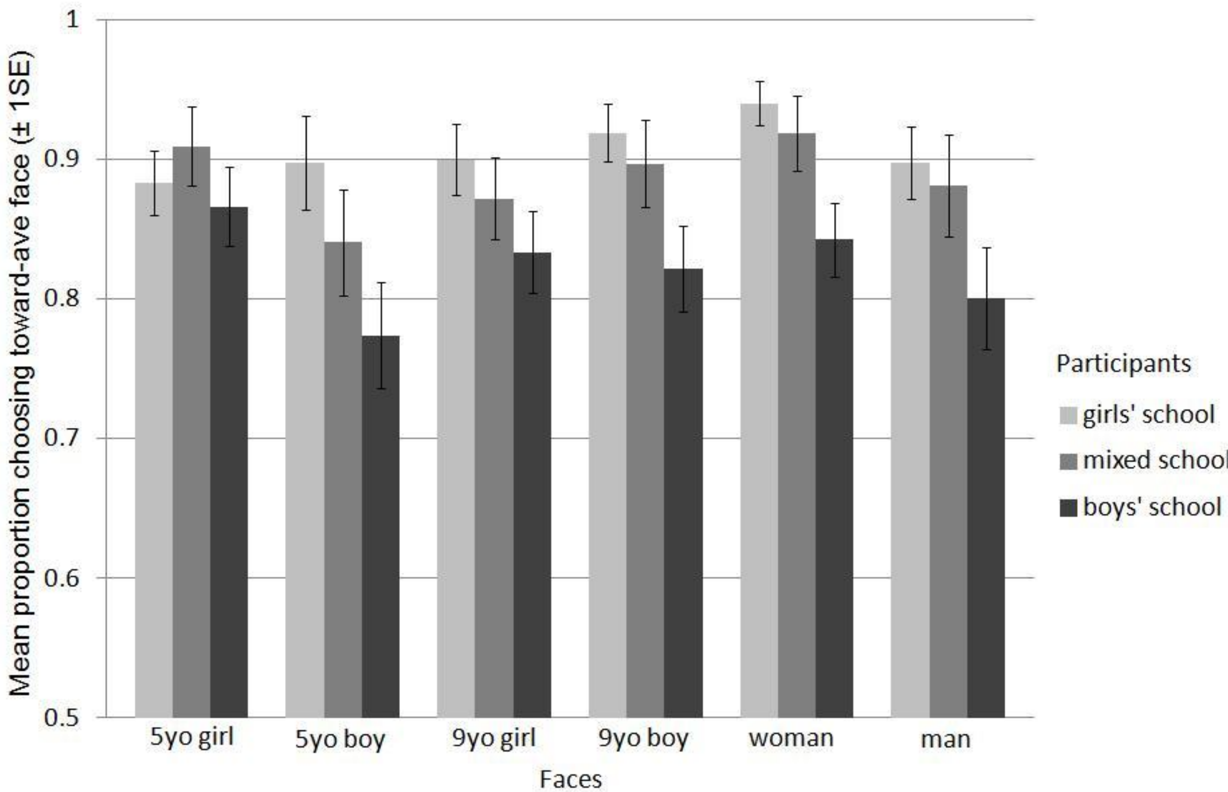


Figure 5. Mean proportion of trials on which participants at the girls' school, mixed-sex school, and boys' school selected the more average face for each face category. The Y-axis begins from the chance level of .50.

CHAPTER 5: General Discussion

Adults assess the attractiveness of those around them effortlessly and automatically. A face's attractiveness can be assessed in as little as a glance (Olsen & Marshuetz, 2005), and there is remarkable agreement in these judgments both within and across cultures (see Langlois et al., 2000 for a meta analysis). A face's symmetry (Perrett et al., 1999), its proximity to the population average (Langlois & Roggman, 1990), and its level of sexual dimorphism (Perrett et al., 1998) are known to influence adults' and adolescents' judgments of attractiveness (Saxton et al., 2009; 2011; Saxton et al., 2010). No research, however, had examined whether these influences affect children's judgments of attractiveness, or whether these influences affect judgments of attractiveness in children's faces. To fill this gap, I studied the influence of symmetry and averageness on the attractiveness judgments of 5-year-olds, 9-year-olds, and adults using the faces of children and adults. In the work described in chapter 2, I discovered that the influence of symmetry on judgments of facial attractiveness emerges after age 5, and the means approach adult levels after age 9. I additionally found that among 9-year-olds and adults, symmetry influences attractiveness judgments in male and female faces of both children and adults. In the work described in chapter 3, I discovered that averageness already influences attractiveness judgments strongly at age 5, and that the strength of the preference increases from age 5 to 9, and again from age 9 to adulthood. Additionally, averageness influences judgments of attractiveness in male and female faces of both children and adults. These findings provide the first evidence, to our knowledge, that symmetry and averageness influence judgments of attractiveness prior to adolescence, and that these influences affect attractiveness judgments in pre-adolescent children's faces.

The results presented in chapters 2 and 3 add to the existing literature on the development of perceptions of attractiveness. Infants look longer at faces judged by adults as attractive than at faces judged by adults as unattractive (Langlois et al., 1987; Samuels, Butterworth, Roberts, Graupner, Hole, 1994; Slater et al., 1998; Slater, Quinn, Hayes, & Brown, 2000), with the longer looking times considered a measure of interest in the stimulus (Fantz, 1961). However, 5- to 8-month-old infants do not look longer at faces that have been transformed to be perfectly symmetrical than at faces that have been transformed away from symmetry, despite their mothers selecting the symmetrical faces as more attractive than the less symmetrical faces (Rhodes et al., 2002). The work presented in chapter 2 demonstrate that symmetry has not yet emerged as an influence on judgments of facial attractiveness at age 5. Although there is evidence that symmetry weakly influenced 5-year-olds' attractiveness judgments when the data were collapsed across all faces to maximize power, it is unlikely that symmetry influences their attractiveness judgments in everyday life because the stimulus faces were transformed to increase asymmetries, and likely vary more in asymmetry than most faces from the general population. The results presented in chapter 2 demonstrate that symmetry influences 9-year-olds' attractiveness judgments in male and female faces of children and adults, but the means of the 9-year-old participants are not adult at adult levels. Symmetry continues to influence adolescents' attractiveness judgments, and the strength of the preference increases from early to mid adolescence (Saxton et al. 2009; 2011; Saxton et al. 2010), although it is not known whether adolescents are adult-like in the strength of their preference because these studies did not have adult comparison groups.

The influence of averageness on judgments of attractiveness emerges earlier than the influence of symmetry, possibly because the differences tended to be greater between face pairs differing in averageness than symmetry. Six-month-old infants look longer at averaged faces than at faces judged by adults as unattractive (Rubenstein et al., 1999). However, 5- to 8-month-old infants do not look longer at faces that have been transformed toward their group average than at faces that have been transformed away from their group average (Rhodes et al., 2002). The mothers of the infants, however, judge the more average faces to be more attractive than the less average faces (Rhodes et al., 2002). The results presented in chapter 3 demonstrate that averageness strongly influences attractiveness judgments at age 5, and the strength of the preference increases from age 5 to 9, and from age 9 to adulthood. These findings are consistent with the influence of average feature height on judgments of facial attractiveness, which is also present by age 5, and adult-like after age 9 (Cooper et al., 2006). Averageness influences adolescents' judgments of attractiveness (Saxton et al. 2009; 2011; Saxton et al. 2010), and the strength of the preference does not increase from early to mid adolescence when both participant groups view the same stimuli (Saxton et al., 2010). It is not known whether adolescents are adult-like in the strength of the preference for averageness as these studies did not have adult comparison groups.

Although I cannot conclude definitively that the age differences between participants were not caused by differences in attention and motivation, all participants of all ages completed all criterion trials with 100% accuracy before moving onto the main experiment, a result that suggests that children can achieve perfect performance on the task when examples are very obvious. Additionally, analyses by block order revealed that performance did not decline from the first to the last block in any age group, and an analysis by trial in chapter 4 revealed that performance did not decline among grade 4s from the first trial to the last trial within each block. These results that suggest attention did not decline throughout the experiment. Additionally, while symmetry exerted little influence on 5-year-olds' attractiveness judgments, averageness strongly influenced 5-year-olds attractiveness judgments using the same task, a pattern that suggests that averageness influences 5-year-olds' attractiveness judgments more strongly than symmetry.

Overall, the results suggest that in everyday social perceptions, averageness appears to strongly influence 5-year-olds' perceptions of attractiveness, while symmetry likely has no influence on 5-year-olds' attractiveness judgments. Both influences on attractiveness judgments, however, become adult-like after age 9. It is possible that symmetry and averageness influence adults' attractiveness judgments more strongly than children's attractiveness judgments because of immaturities of the visual system. Acuity and contrast sensitivity become adult-like around ages 6 and 7-9, respectively (Adams & Courage, 2002; Ellemberg et al. 1999), and sensitivity to global structure improves from age 6 to age 12-14 (Hadad, Maurer, & Lewis, 2011; Lewis et al., 2004). Additionally, the ability to detect subtle differences in the locations of faces' internal features improves from age 6 to 10-11 (Baudouin, Gallay, Durand, & Robichon, 2010; Mondloch, Le Grand, & Maurer, 2002). These immaturities could have led to decreased sensitivity to the differences between the face pairings among children. Another possibility for the greater influence of symmetry and averageness on adults' judgments of attractiveness is that children might be less attuned to decisions relevant to mate choice than adults. Symmetry and averageness both provide cues to phenotypic quality (see introduction), and it might be more adaptive for individuals to be sensitive to these signals after puberty when decisions related to mate choice are more relevant. A third possibility for the stronger influence of symmetry and averageness in adults than children is that adults have more experience with faces than children, which could facilitate the processing of symmetry and averageness in faces. I explored the influence of experience on judgments of attractiveness in the material presented in chapters 2, 3, and 4.

Because faces are processed in a multi-dimensional face-space centred on an average face that is constantly being updated as new faces are encountered (Valentine, 1991), biasing children's face experience can lead to changes in their judgments of attractiveness. For example, biasing face experience in the lab by adapting 8-year-olds to faces that have been compressed or expanded, shifts their attractiveness judgments in the adapted direction (Anzures, Mondloch, & Lackner, 2009). I hypothesized that natural differences in children's face experience could lead to differences in their attractiveness judgments based on averageness. To explore this question, in chapter 4 I tested the influence of averageness on the attractiveness judgments of children attending a girls' school, a boys' school, and a mixed-sex school. I hypothesized that averageness might influence attractiveness judgments more strongly for own-aged faces of the same-sex than of the opposite-sex, among children attending single-sex schools. I did not find the expected interaction, as averageness did not consistently influence attractiveness judgments more strongly in own-aged faces of the same sex than of the opposite sex as participants. Thus, biased face experience with girl or boy faces did not affect the strength of the preference for averageness in those faces.

I looked at the effect of experience a second way, by including faces of the same age as the participants, and of other ages. Others have found that children are better at recognizing faces of their own age than of other ages (Anastasi & Rhodes, 2005; Hills & Lewis, 2011; but see Macchi Cassia, 2011 for evidence that children have processing advantage for adult faces). This bias for own-age faces might arise from more exposure to own-age than other-age faces because the effect is not present in trainee teachers, who recognize children's faces as well as they recognize adult faces (Harrison & Hole, 2009). If face experience influences judgments of attractiveness, we might expect averageness to influence attractiveness judgments more strongly in own-age than other-age faces (or possibly more strongly in adult faces; Macchi Cassia, 2011). In the material presented in chapters 3 and 4, there were a complex set of interactions between age and sex of face, however, the interactions do not match an experiential account: averageness did not consistently influence attractiveness judgments more strongly in own-age than other-age faces (nor in adult than child faces). Averageness might influence attractiveness judgments regardless of the age and sex of face because a minimum level of face experience could be sufficient to form an average for unfamiliar face categories. Alternatively, or in addition, I discovered in the work presented in chapter 4, that there are strong similarities among averages of different sexes and ages. Thus, attractiveness judgments of an unfamiliar face category could lead to a similar result if the judgments are based on a prototype from the unfamiliar face category, or from a familiar face category.

Experience might also affect the influence of symmetry on judgments of facial attractiveness, as adults prefer symmetry more strongly in upright than inverted faces (Little & Jones, 2006). I tested the influence of experience on attractiveness judgments based on symmetry by including faces of the same age and sex of participants, and of the opposite sex and different ages from the participants. In work presented in chapter 2 I found that symmetry influenced attractiveness judgments more strongly in adults' than children's faces, and in men's faces than any other face category. It's possible that symmetry influenced attractiveness judgments more strongly in adults' than children's faces because of a processing advantage for adult faces caused by predominant exposure to adult faces from infancy onward (Macchi Cassia, 2011). However, if these effects were caused by face experience, one would expect that symmetry would influence attractiveness judgments more strongly in women's than men's faces because of the greater experience with women's than men's faces beginning in infancy (Rennels & Davis, 2008), and likely continuing throughout childhood. Instead, individuals may be more attuned to cues to symmetry in adult faces because it is more important to assess the phenotypic quality of adults than children for mate choice. Additionally, symmetry might be appraised more carefully in the faces of men than women because more men are available to reproduce than women in most human populations (Low, 2001), a pattern that could lead to closer assessment of cues to phenotypic quality in men than women because of the stronger male-male competition (Trivers 1972).

The results of this thesis demonstrate that children assess the attractiveness of other children and adults based on some of the same dimensions that adults use to assess facial attractiveness. However, children might be more tolerant of deviations from averageness and symmetry than adults. The results additionally demonstrate that symmetry and averageness influence perceptions of attractiveness in children's faces. Adults show strong agreement in their perceptions of attractiveness in children's faces, and these perceptions are known to affect adults' assessments of children via the 'beauty is good' stereotype (see Langlois et al., 2000 for a meta analysis). The more positive treatment of children perceived as attractive could provide an enriched environment for learning and development compared to those judged as unattractive.

Limitations

There were several limitations to the studies presented in this thesis. One concern is whether the findings can generalize to judgments of attractiveness under more naturalistic conditions. For example, I removed external features from the faces by placing a solid background around the outline of each face. Although it is not natural to view faces without external features, I wanted to eliminate any influence of distortions in hairstyle across the face pairings to ensure that I didn't under- or over-estimate the influence of averageness or symmetry on facial attractiveness judgments. I additionally wanted to maximize the salience of the internal physiognomy of the faces as internal features are particularly important for face detection (e.g. Mondloch et al., 1999; Vuilleumier, 2000), and children under 10 years of age rely more heavily on external features and paraphernalia than older children or adults for judgments of facial identity (Baenninger, 1994; Diamond & Carey, 1977; Freire & Lee, 2001).

Additionally, I presented faces as static, two-dimensional images, and dynamic images provide more information than static images (Lander, Christie, & Bruce, 1999). While some have found only weak correlations in adults' attractiveness ratings of static images of faces and videos of faces (men's faces, Lander, 2008; men's faces, Penton-Voak & Chan, 2008; Rubenstein, 2005), most have reported that adults' attractiveness ratings of static faces and videos of faces are strongly correlated (Brown, Cash, & Noles, 1986; women's faces, Lander, 2008; women's faces, Penton-Voak & Chan, 2008; Rhodes et al. 2011; Roberts et al., 2009), as are adults' attractiveness ratings of two-dimensional and three-dimensional women's faces (Tigue, Pisanski, O'Connor, Fraccaro, & Feinberg, 2012) . Additionally, attractiveness ratings of videos of faces are correlated with ratings of distinctiveness (an inverse of averageness) and symmetry, consistent with literature that has studied these influences using static images (Rhodes et al., 2011). Thus, the results of adult participants judging adult faces in this thesis may have been similar regardless of whether static, two-dimensional faces or dynamic faces with three-dimensional information were used. Although no studies to my knowledge have compared static and dynamic facial attractiveness judgments used child participants or child faces, I hypothesize that the results would be similar for child participants and child faces.

As with any developmental study, I cannot conclude that age differences between participants were not caused by differences in attention and motivation. However, in the work presented in chapters 2, 3, and 4, participants of all ages completed all criterion trials with 100% accuracy before moving onto the main experiment, a result that suggests that even the youngest participants can achieve perfect performance when the differences between pairings are very obvious. Moreover, there were no decrements in performance from the first block to the last block in any age group, a result that suggests that attention and performance did not decline during the experiment. Additionally, 5-year-olds were tested on the influence of averageness and symmetry with the same design and showed stronger effects for averageness than symmetry, a result that suggests that averageness influences 5-year-olds' judgments of attractiveness more strongly than symmetry.

In chapter 4, I hypothesized that children who attend single-sex schools would have more experience with faces of the same than opposite sex, a difference that might lead to a stronger preference for averageness in same than opposite sex faces. I did not find the hypothesized interaction. Although it is possible that recent biased experience with girl or boy faces did not influence judgments of attractiveness because a minimum number or faces could be sufficient to form an average and/or similarities among the averages (see chapter 4), it is also possible that my assumption regarding the children's experience with faces is invalid. Although I think it is quite likely that children who attend single-sex schools would have more experience with own-age faces of the same than opposite sex, I did not measure their actual face experience and do not know how many faces of the same and opposite sex the children actually see on a regular basis.

I additionally found a cohort effect in chapter 4, as children at the boys' school preferred averageness less strongly than children at the girls' school and mixed-sex school. It is unlikely that this differences reflects a sex difference in how strongly averageness influences boys' and girls' attractiveness judgments because there was no sex difference among participants at the mixed-sex school, and there was no sex difference among participants in chapter 3 who participated in the same procedure with the same stimuli in the lab. Although I made every attempt to ensure that the schools were well matched, it is possible that differences existed among the groups of students who attend the schools and/or in the learning environments across schools. These differences could have influenced the pattern of results.

Future Directions

The present collection of studies provides the first demonstrations of the influence of symmetry and averageness on children's judgments of attractiveness, and a first look at the developmental trajectories of each. I discovered that the influence of symmetry on judgments of attractiveness emerges after age 5, and reaches adult levels after age 9. Future studies could compare older children to adults to assess when the influence of symmetry on attractiveness judgments reaches adult levels. Additionally, because symmetry did not influence 5-year-olds' attractiveness judgments, future studies could examine whether 5-year-olds can even discriminate between the face pairings. If 5-year-olds cannot discriminate between the face pairings, it would suggest that symmetry does not influence their attractiveness judgments because they cannot readily perceive the differences in symmetry among faces. However, if 5-year-olds can discriminate between the face pairings, it would suggest that while they can perceive differences in symmetry between faces, it does not influence their judgments of attractiveness. Additional studies could explore the developmental trajectories of symmetry discrimination in faces and objects.

I also discovered that the influence of averageness on judgments of attractiveness emerges before age 5, and matures after age 9. Additional studies could compare older children to adults to assess when the influence of averageness on attractiveness judgments reaches adult levels. Although one study found a looking preference among 6-month-olds for an average face over faces judged by adults to be unattractive (Rubenstein et al., 1999), another study of 5- to 8-month-olds found no difference in mean looking time to pairs of faces that had been transformed toward and away from their group average (Rhodes et al., 2002). It is only at age 5 that there is clear evidence that attractiveness judgments are influenced by averageness (chapter 3 of this thesis). Future studies could study the influence of averageness in younger children to assess when averageness begins to influence attractiveness judgments.

Although averageness is attractive, creating an average composite based on faces that were rated by adults as attractive, is judged to be more attractive than a composite created from a wider selection of faces (Perrett et al., 1994; DeBruine et al., 2007). Additionally, exaggerating the differences between the average and attractive average composites can lead to faces that are judged to be even more attractive (Perrett et al., 1994; DeBruine et al., 2007). No published study has yet explored whether children also find 'more-than-average' faces attractive. Additionally, it has been hypothesized that 'more-than-average' faces are more sexually-dimorphic than average faces. As the faces of pre-adolescent children are less sexually dimorphic than the faces of adults, it would be of interest to create an 'attractiveness dimension' (see DeBruine et al., 2007) with children's faces to assess whether children's faces can also be more attractive than average, or whether the only structural influences on attractiveness judgments within children's faces are symmetry and averageness. If children's faces can be more attractive than average, the question is whether sexually dimorphic features like those of adults increase attractiveness in children's faces, or whether other traits such as infantile features form the attractiveness dimension among children's faces.

Among adults, sexual dimorphism influences judgments of attractiveness (see introduction). To my knowledge, no studies have explored whether sexually dimorphic features influence judgments of attractiveness in pre-adolescent children, a topic that can be explored in future studies.

Conclusions

The studies presented in this thesis explored whether symmetry and averageness influence children's judgments of facial attractiveness, and whether experience influences the strength of the preferences. In the work presented in chapter 2, I found that symmetry begins to influence judgments of attractiveness after age 5, and the strength of the preference reaches adult levels after age 9. I additionally found that symmetry influences judgments of attractiveness in the faces of both adults and children. In the work presented in chapter 3, I found that averageness strongly influences attractiveness judgments at age 5, and the strength of the preference grows from age 5 to 9, and again from age 9 to adulthood. Again, I found that this influence was present in both adults' and children's faces. In chapter 4 I hypothesized that groups with natural differences in experience might differ in how strongly averageness influences their attractiveness judgments for different categories of faces. I tested grade 4 children attending single-sex schools and expected averageness to influence attractiveness judgments more strongly in same-aged faces of the same sex than of the opposite sex. I did not find that pattern of results, nor did I find an own-age bias in attractiveness judgments. It is possible that recent biased experience did not affect how strongly averageness influenced attractiveness judgments because a minimum number of faces might be adequate to allow for attractiveness judgments based on averageness. I also discovered similarities among averages of different ages and sexes of face, thus attractiveness judgments of an unfamiliar face category could be based on an average from a familiar face category. The results of this thesis demonstrate that averageness and symmetry influence children's judgments of attractiveness in the faces of adults and children, and that the strength of the preferences are weaker than those of adults.

References

Adams, R. A., & Courage, M. L. (2002). Using a single test to measure human contrast sensitivity from early childhood to maturity. *Vision Research*, 42, 1205–1210.

Alley, T.R., & Cunningham, M.R. (1991). Averaged Faces are Attractive, but Very Attractive Faces are Not Average. *Pyschological Science*, 2(2), 123-125.

Anastasi, J.S., & Rhodes, M.G. (2005). An own-age bias in face recognition for children and older adults. *Psychonomic Bulletin & Review*, 12(6), 1043-1047.

Anzures, G., Mondloch, C.J., & Lackner, C. (2009). Face Adaptation and Attractiveness Aftereffects in 8-Year-Olds and Adults. *Child Development*, 80(1), 178-191.

Apicella, C.L., Little, A.C., & Marlowe, F.W. (2007). Facial averageness and attractiveness in an isolated population of hunter-gatherers. *Perception*, 36, 1813-1820.

Baenninger, M. (1994). The development of face recognition: Featural or configurational processing? *Journal of Experimental Child Psychology*, 57, 377–396.

Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. (2006). Nature and nurture in own-race face processing. *Psychological Science*, 17, 159–163.

Baudouin, J., Gallay, M., Durand, K., & Robichon, F. (2010). The development of perceptual sensitivity to second-order facial relations in children. *Journal of Experimental Child Psychology*, 107, 195–206.

Bernstein, I.H., Lin, T., & McClellan, P. (1982). Cross- vs. within-racial judgments of attractiveness. *Perception* & *Psychophysics*, 32(6), 495-503.

Benson P, Perrett D. (1992). Face to face with the perfect image. *New Scientist*, 1809, 32-35.

Boothroyd, L.G., Jones, B.C., Burt, D.M., & Perrett, D.I. (2007) Partner characteristics associated with masculinity, health and maturity in male faces. *Personality and*

Individual Differences, 43, 1161-1173.

Brown, T., Cash, T., & Noles, S. (1986). Perceptions of physical attractiveness among college students: selected determinants and methodological matters. *The Journal of Social Psychology*, 126(3), 305-316.

Bruce, V., Burton, A.M., Dench, N., Hanna, E., Healey, P., Mason, O., Coombes, A., Fright, R., & Linney, A. (1993). Sex discrimination: how do we tell the difference between male and female faces? *Perception*, 22, 131-152.

Bruce, V., Ellis, H., Gibling,F., & Young, A. (1987). Parallel processing of the sex and familiarity of Faces. *Canadian Journal of Psychology*, 41, 510-520.

Carrington, M., Nelson, G.W., Martin, M.P., Kissner,T., Vlahov, D., Goedert, J. J., Kaslow, R., Buchbinder, S., Hoots, K., & O'Brien, S. J. (1999). HLA and HIV-1: heterozygote advantage and B*35-Cw*04 disadvantage. *Science,* 283, 1748-1752.

Cooper, P.A., Geldart, S.S., Mondloch, C.J., & Maurer, D. (2006). Developmental changes in perceptions of attractiveness: a role of experience? *Developmental Science*, 9(5), 530–543.

Cooper, P.A., & Maurer, D.M. (2008). The influence of recent experience on perceptions of attractiveness. *Perception*, 37, 1216-1226.

Cunningham, M.R, Roberts, A.R., Barbee, A.P., & Druen, P.B. (1995). "Their Ideas of Beauty Are, on the Whole, the Same as Ours": Consistency and Variability in the Cross-Cultural Perception of Female Physical Attractiveness. *Journal of Personality and Social Psychology*, 68(2), 261-279.

DeBruine, L. M., Jones, B. C., Little, A. C., Boothroyd, L. G., Perrett, D. I., Penton-Voak, I. S., et al. (2006). Correlated preferences for facial masculinity and ideal or actual partner's masculinity. *Proceedings of the Royal Society of London B*, 273, 1355–1360.

DeBruine, L.M., Jones, B.C., Tybur, J.M., Lieberman, D., & Griskevicius, V. (2010). Women's preferences for masculinity in male faces are predicted by pathogen disgust, but not moral or sexual disgust. *Evolution and Human Behavior*, 31(1), 69-74.

DeBruine, L.M., Jones, B.C., Unger, L., Little, A.C., & Feinberg, D.R. (2007). Dissociating averageness and attractiveness: Attractive faces are not always average. *Journal of Experimental Psychology: Human Perception and Performance*, 33(6), 1420-1430.

de Haan, M., Johnson, M.H., Maurer, D., Perrett, D. (2001). Recognition of individual faces and average face prototypes by 1-and 3-month-old infants. *Cognitive Development*, 16(2), 659-678.

Diamond, R., & Carey, S. (1977). Developmental Changes in the Representation of Faces. *Journal of Experimental Child Psychology*, 23, 1-22.

Dion, K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personality and Social Psychology*, 24(3), 285-290.

Dobzhansky, T. (1982). *Genetics and the Origin of Species*. Columbia University Press, New York.

Dunkle, J. H., & Francis, P. L. (1990). The role of facial masculinity/femininity in the attribution of homosexuality. *Sex Roles*, 23, 157–167.

Ellemberg, D., Lewis, T. L., Liu, C. H., & Maurer, D. (1999). Development of spatial and temporal vision during childhood. *Vision Research*, 39, 2325–2333.

Erway, L., Hurley, L.S. & Fraser, A.S. (1970). Congenital ataxia and otolith defects due to manganese deficiency in mice. *Journal of Nutrition*, 100, 643-654.

Fantz, R.L. (1961). The Origin of Form Perception. *Scientific American*, 204(5), 66-72.

Feinberg, D.R., DeBruine, L.M., Jones, B.C. & Little, A.C. (2008). Correlated preferences for men's facial and vocal masculinity. *Evolution and Human Behavior*, 29(4), 233-241.

Feinberg, D.R., Jones, B.C., DeBruine, L.M., Moore, F.R., Law Smith, M.J., Cornwell, R.E., Tiddeman, B.P., Boothroyd, L.G., & Perrett, D.I. (2005). The voice and face of woman: One ornament that signals quality? *Evolution and Human Behavior*, 26(5), 398-408.

Fink, B., Grammer, K., Mittroecker, P., Gunz, P., Schaefer, K., Bookstein, F.L. & Manning, J.T. (2005). Second to fourth digit ratio and face shape. *Proceedings of the Royal Society B*, 272, 1995–2001.

Fink, B., & Penton-Voak, I. (2002). Evolutionary Psychology of Facial Attractiveness. *Current Directions in Psychological Science*, 11(5), 154-158.

Fleming, A.S., Corter, C., Stallings, J., Steiner, M. (2002). Testosterone and prolactin are associated with emotional responses to infant cries in new fathers. *Hormones & Behaviour*, 42(4), 399-413.

Freire, A., & Lee, K. (2001). Face recognition in 4- to 7-year-olds: Processing of configural, featural, and paraphernalia information. *Journal of Experimental Child Psychology*, 80, 347–371.

Galton, F.J. (1878). Composite portraits. *Nature*, 18, 97-100.

Gangestad, S.W., Merriman, L.A., Thompson, M.E. (2010). Men's oxidative stress, fluctuating asymmetry and physical attractiveness. *Animal Behaviour*, 80, 1005-1013.

Garner, W. R., & Sutliff, D. (1974). The effect of goodness on encoding time in visual pattern discrimination. *Perception & Psychophysics*, 16(3), 426-430.

Geldart, S. (2008). Tall and Good-Looking? The Relationship Between Raters' Height and Perceptions of Attractiveness. *Journal of Individual Differences*, 29(3), 148–156.

Geldart, S., Maurer, D., Henderson, H. (1999). Effects of the height of the internal features of faces on adults' aesthetic ratings and 5-month-olds' looking times. *Perception*, 28, 839-850.

Grammar, K. & Thornhill, R. (1994). Human (*Homo sapiens*) Facial Attractiveness and Sexual Selection: The Role of Symmetry and Averageness. *Journal of Comparative Psychology*, 108(3), 233-242.

Hadad, B., Maurer, D., & Lewis, T.L. (2011). Long trajectory for the development of sensitivity to global and biological motion. *Developmental Science*, 14, 1330-1339.

Halberstadt, J. & Rhodes, G. (2000). The Attractiveness of Nonface Averages: Implications for an Evolutionary Explanation of the Attractiveness of Average Faces. *Psychological Science*, 11(4), 285-289.

Harrison, V., & Hole, G.J. (2009). Evidence for a contact-based explanation of the own-age bias in face recognition. *Psychonomic Bulletin & Review*, 16(2), 264-269.

Haywood, J. S. (1989). Sexual selection by the handicap principle. *Evolution*, 43, 1387-1397.

Hills, P. J., Holland, A.M., & Lewis, M.B. (2010). Aftereffects for face attributes with different natural variability: Children are more adaptable than adolescents. *Cognitive Development*, 25(3), 278–289.

Hills, P.J. & Lewis, M.B. (2011). The own-age face recognition bias in children and adults. *The Quarterly Journal of Experimental Psychology*, 64(1), 17-23.

Horowitz, F.D. (1974). Infant Attention and Discrimination: Methodological and Substantive Issues. *Monographs of the Society for Research in Child Development*, 39, 1-15.

Hoss, R.A., Ramsey, J.L., Griffin, A.M., & Langlois, J.H. (2005). *Perception*, 34(12), 1459-1474.

Howe, E., & Jung, K. (1986). Immediate memory span for two-dimensional spatial arrays:

effects of pattern symmetry and goodness. *Acta Psychologica*, 61, 37-51.

Iwasa, Y., Pomiankowski, A. & Nee, S. (1991). The evolution of costly mate preferences. The “handicap" principle. *Evolution*, 45, 1431-1442.

Jeffery, L., McKone, E., Haynes, R., Firth, E., Pellicano, E., & Rhodes, G. (2010). Four-to-six-year-old children use norm-based coding in face-space. *Journal of Vision*, 10(5):18, 1–19.

Jeffery, L., Rhodes, G., McKone, E., Pellicano, E., Crookes, K., Taylor, E. (2011). Distinguishing Norm-Based From Exemplar-Based Coding of Identity in Children: Evidence From Face Identity Aftereffects, *Journal of Experimental Psychology: Human Perception and Performance*, 37(6), 1824-1840.

Johnson, R.W., Dannenbring. G,L., Anderson. N,R.. & Villa. R.E. (1983). How different cultural and geographic groups perceive the attractiveness of active and inactive feminists. *The Journal of Social Psychology*, 119, 111-117.

Johnston, V.S., & Franklin, M. (1993). Is Beauty in the Eye of the Beholder? *Ethology and Sociobiology*, 14, 183-199.

Johnston, V. S., Hagel, R., Franklin, M., Fink, B., & Grammer, K. (2001). Male facial attractiveness: Evidence for hormone-mediated adaptive design. *Evolution & Human Behavior*, 22, 251–267.

Jones, B.C., DeBruine, L.M. & Little, A.C. (2007). The role of symmetry in attraction to average faces. *Perception & Psychophysics*, 69(8), 1273-1277.

Jones, B.C., DeBruine, L.M., Perrett, D.I., Little, A.C., Feinberg, D.R. & Law Smith, M.J. (2008). Effects of menstrual cycle phase on face preferences. *Archives of Sexual Behavior*, 37(1), 78-84.

Jones, B.C., Feinberg, D.R., Watkins, C.D., Fincher, C.L., Little, A.C., & DeBruine, L.M. (in press). Pathogen disgust predicts women's preferences for masculinity in men's voices, faces, and bodies. *Behavioral Ecology*.

Jones, D., & Hill, K. (1993). Criteria of facial attractiveness in five populations. *Human Nature*, 4, 271-296.

Jones, B.C., Little, A.C., Penton-Voak, I.S., Tiddeman, B.P., Burt, D.M., Perrett, D.I. (2001). Facial symmetry and judgements of apparent health Support for a ''good genes'' explanation of the attractiveness–symmetry relationship. *Evolution and Human Behavior*, 22, 417–429.

Kelly, D.J., Quinn, P.C., Slater, A.M., Lee, K., Ge, L., & Pascalis, O. (2007). The other-race effect develops in infancy. *Psychological Science*, 18, 1084–1089.

Kelly, D.J., Quinn, P.C., Slater, A.M., Lee, K., Gibson, A., Smith, M., Ge, L., & Pascalis, O. (2005). Three-month-olds, but not newborns, prefer own-race faces. Developmental Science, 8, 31–36.

Koehler, N., Simmons, L.W., Rhodes, G., & Peters, M. (2004). The relationship between sexual dimorphism in human faces. *Proceedings of the Royal Society of London B*, 271, S233–S236.

Kowner, R. (1996). Facial Asymmetry and Attractiveness Judgment in Developmental Perspective. *Journal of Experimental Psychology: Human Perception and Performance*, 22(3), 662-675.

Kruger, D.J. (2006). Male facial masculinity influences attributions of personality and reproductive strategy. *Personal Relationships*, 13, 451-463.

Lander, K., Christie, F., & Bruce, V. (1999). The role of movement in the recognition of famous faces. *Memory & Cognition*, 27(6), 974-985.

Lander, K. (2008). Relating visual and vocal attractiveness for moving and static faces. *Animal Behaviour*, 75, 817-822.

Langlois, J.H., Kalakanis, L., Rubenstein, A.J., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or Myths of Beauty ? A Meta-Analytic and Theoretical Review. *Psychological Bulletin*, 126(3), 390-423.

Langlois, J.H., & Roggman, L.A. (1990). Attractive faces are only average. *Psychological Science*, 1, 115-121.

Langlois, J.H., Roggman, L.A., Casey, R.J, Ritter, J.M., Rieser-Danner, L.A., & Jenkins, V.Y. (1987). Infant preferences for attractive faces: Rudiments of a stereotype? *Developmental Psychology*, 23, 363-369.

Law Smith, M.J., Perrett, D.I., Jones, B.C., Cornwell, R.E., Moore, F.R., Feinberg, D.R., Boothroyd, L.G., Durrani, S.J., Stirrat, M.R., Whiten, S., Pitman, R.M., & Hillier, S.G. (2006). Facial appearance is a cue to oestrogen levels in women. *Proceedings of the Royal Society, B*, 273, 135–140.

Leinbach, M.D., & Fagot, B.I. (1993). Categorical Habituation to Male and Female Faces: Gender Schematic Processing in Infancy. *Infant Behavior and Development*, 16, 317-332.

Lewis, T., Ellemberg, D., Maurer, D., Dirks, M., Wilkinson, F., & Wilson, H. (2004). A window on the normal development of sensitivity to global form in Glass patterns. *Perception*, 33, 409-418.

Lie, H.C., Rhodes, G., & Simmons, L.W. (2008). Diversity Revealed in Human Faces. *Evolution*, 62(10), 2473-2486.

Little, A.C., Apicella, C.L., & Marlowe (2007). Preferences for symmetry in human faces in two cultures: data from the UK and the Hadza, an isolated group of hunter-gatherers.

Proceedings of the Royal Society B, 274, 3113-3117.

Little, A.C., Burt, D.M., Penton-Voak, I.S., & Perrett, D.I. (2001). Self-perceived attractiveness influences human female preferences for sexual dimorphism and symmetry in male faces. *Proceedings of the Royal Society of London B*, 268, 39-44.

Little, A.C., Cohen, D., Jones, B.C., & Belsky, J. (2007). Human preferences for facial masculinity change with relationship type and environmental harshness. *Behavioural Ecology and Sociobiology*, 61, 967-973.

Little, A.C., & Hancock, P.J.B. (2002). The role of masculinity and distinctiveness in judgments of human male facial attractiveness. *British Journal of Psychology*, 93, 451–64.

Little, A.C., & Jones, B.C. (2006). Attraction independent of detection suggests special mechanisms for symmetry preferences in human face perception. *Proceedings of the Royal Society B*, 273, 3093-3099.

Little, A.C., Jones, B.C., DeBruine, L.M., & Feinberg, D.R. (2008). Symmetry and sexual dimorphism in human faces: interrelated preferences suggest both signal quality. *Behavioral Ecology*, 19, 902–908.

Little, A.C., Jones, B.C., Penton-Voak, I.S., Burt, D.M., & Perrett, D.I. (2002). Partnership status and the temporal context of relationships influence human female preferences for sexual dimorphism in male face shape. *Proceedings of the Royal Society of London B*, 269, 1095-1100.

Little, A.C., Jones, B.C., Waitt, C., Tiddeman, B.P., Feinberg, D.R., Perrett, D.I., Apicella, C.L., & Marlowe, F.W. (2008). Symmetry correlates with sexually dimorphic traits in faces. *PLoS ONE*, 3(5), e2106.

Little, A.C., Paukner, A., Woodward, R.A., & Suomi, S.J. (2012). Facial asymmetry is negatively related to condition in female macaque monkeys. *Behavioral Ecology and Sociobiology*, 66, 1311–1318.

Low, B. (2001). *Why Sex Matters: A Darwinian Look at Human Behavior*. Princeton, New Jersey: Princeton University Press.

Macchi Cassia, V. (2011). Age biases in face processing: The effects of experience across development. *British Journal of Psychology*, 102, 816–829.

Mealey, L., Bridgestock, R., & Townsend, G.C. (1999). Symmetry and Perceived Facial Attractiveness: A Monozygotic Co-Twin Comparison. *Journal of Personality and Social Psychology*, 76(1), 151-158.

Møller, A. P. (1990). Fluctuating asymmetry in male sexual ornaments may reliably reveal male quality. *Animal Behaviour, 40,* 1185–1187.

Møller, A. P. (1997). Developmental Stability and Fitness: A Review. *The American Naturalist*, 149, 916–932.

Møller, A. P., & Pomiankowski, A. (1993). Fluctuating asymmetry and sexual selection. *Genetica*, 89, 267-279.

Møller, A. P., & Swaddle, J. P. (1997). *Developmental stability and evolution.* Oxford: Oxford University Press.

Møller, A.P., & Thornhill, R. (1998). Bilateral Symmetry and Sexual Selection: A Meta-Analysis. *The American Naturalist*, 151(2), 174-192.

Mondloch, C.J., Lewis, T.L., Budreau, D.R., Maurer, D., Dannemiller, J.L., Stephens, B.R. Kleiner-Gathercoal, K.A. (1999) Face perception during early infancy. *Psychological Science*, 10, 419–422.

Mondloch, C., Le Grand, R., & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception*, 31, 553-566.

Mooney, M. P., Siegel, M. I. & Gest, T.R. (1985). Prenatal stress and increased Fluctuating asymmetry in the parietal bones of neonatal rats. *American Journal of Physical Anthropology*, 68, 131-134.

Moore, F.R., Law Smith, M.J., Taylor, V., Perrett, D.I., (2011). Sexual dimorphism in the female face is a cue to health and social status but not age. *Personality and Individual Differences*, 50, 1068–1073.

Neave, N., Laing, S., Fink, B., & Manning, J.T. (2003). Second to fourth digit ratio, testosterone and perceived male dominance. *Proceedings of the Royal Society of London B*, 270, 2167–2172.

Nishimura, M., Maurer, D., Jeffery, L., Pellicano, E., & Rhodes, G. (2008). Fitting the child's mind to the world: Adaptive norm-based coding of facial identity in 8-year-olds. *Developmental Science*, 11, 620–627.

Özener, B. (2010). Brief Communication: Facial Fluctuating Asymmetry as a Marker of Sex Differences of the Response to Phenotypic Stresses. *American Journal of Physical Anthropology*, 143, 321-324.

Özener, B. & Fink, B. (2010). Facial symmetry in young girls and boys from a slum and a control area of Ankara, Turkey. *Evolution and Human Behavior*, 31, 436–441.

Olsen, I.R., & Marshuetz, C. (2005). Facial Attractiveness Is Appraised in a Glance. *Emotion*, 5(4), 498–502.

O'Toole, A.J., Deffenbacher, K.A., Valentin, D., McKee, K., Huff, D., & Abdi, H. (1998). The perception of face gender: The role of stimulus structure in recognition and classification.

Memory & Cognition, 26(1), 146-160.

Penton-Voak, I.S., & Chen, J.Y. (2004). High salivary testosterone is linked to masculine male facial appearance in humans. *Evolution and Human Behavior*, 25(4), 229-241.

Penton-Voak, I.S., Jacobson, A., & Trivers, R. (2004). Populational differences in attractiveness judgements of male and female faces: Comparing British and Jamaican samples. *Evolution and Human Behavior*, 25, 355–370.

Penton-Voak, I. S., Jones, B. C., Little, A. C., Baker, S., Tiddeman, B., Burt, D. M. & Perrett, D. I. (2001). Symmetry, sexual dimorphism in facial proportions and male facial attractiveness. *Proceedings of the Royal Society B: Biological Sciences*. 268, 1617-1623.

Penton-Voak, I.S., Little, A.C., Jones, B.C., Burt, D.M., Tiddeman, B.P., & Perrett, D.I. (2003). Female condition influences preferences for sexual dimorphism in faces of male humans (Homo sapiens). *Journal of Comparative Psychology*, 117, 264-271.

Penton-Voak, I. S., Perrett, D. I., Castles, D. L., Kobayashi, T., Burt, D. M., Murray, L. K. & Minamisawa, R. (1999). Menstrual cycle alters face preference. *Nature*, 399, 741-742.

Perrett, D.I., Burt, M.B., Penton-Voak, I.S., Lee, K.J, Rowland, D.A., & Edwards, R. (1999). Symmetry and Human Facial Attractiveness. *Evolution and Human Behavior*, 20: 295-307.

Perrett, D.I., May, K.A., & Yoshikawa, S. (1994). Facial shape and judgments of female attractiveness. *Nature*, 368, 239-242.

Perrett, D. I. , Lee, K. J., Penton-Voak, I. , Rowland, D. , Yoshikawa, S., Burt, D. M. , Henzi, S. P., Castles, D. L. , & Akamatsu, S. (1998). Effects of sexual dimorphism on facial attractiveness. *Nature*, 394, 884-887.

Peters, M., Rhodes, G., & Simmons, L. W. (2008). Does attractiveness in men provide cues to semen quality? *Journal of Evolutionary Biology*, 21, 572-579.

Peters, M., Simmons, L. W., & Rhodes, G. (2009). Preferences across the menstrual cycle for masculinity and symmetry in photographs of male faces and bodies. *PLOSOne*, 4, e4138, 1-7.

Pimperton, H., Pellicano, E., Jeffery, L., & Rhodes, G. (2009). The role of higher level adaptive coding, mechanisms in the development of face recognition. *Journal of Experimental Child Psychology*, 104, 229–238.

Pomerantz, J.R. (1977). Pattern goodness and speed of encoding. *Memory & Cognition*, 5(2), 235-241.

Pound, N., Penton-Voak, I.S., & Surridge, A.K. (2009). Testosterone responses to competition in men are related to facial masculinity. *Proceedings of the Royal Society B*, 276, 153–159.

Quinn, P., Yahr, J., Kuhn, A., Slater, A.M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. *Perception*, 31, 1109–1121.

Ramsey-Rennels, J.L., & Langlois, J.H. (2006). Infants' differential processing of female and male faces. *Current Directions in Psychological Science*, 15, 59–62.

Rantala, M.J., Moore, F.R., Skrinda, I., Krama, T., Kivleniece, I., Kecko, S., Krams, I. (2012). Evidence for the stress linked immunocompetence handicap in humans. *Nature Communications*, 3(694), 1-5.

Reber, R., Schwartz, N., & Winkielman, P. (2004). Processing Fluency and Aesthetic Pleasure: Is Beauty in the Perceiver's Processing Experience? *Personality and Social Psychology Review*, 8(4), 364-382.

Rennels, J.L., Bronstad, P.M., & Langlois, J.H. (2008). Are Attractive Men's Faces Masculine or Feminine? The Importance of Type of Facial Stimuli. *Journal of Experimental*

Psychology: Human Perception and Performance, 34(4), 884–893.

Rennels, J.L., & Davis, R.E. (2008). Facial Experience During the First Year. *Infant Behavior and Development*, 31(4): 665–678.

Rhodes, G. (2006). The Evolutionary Psychology of Facial Beauty. *Annual Review of Psychology*, 57, 199-226.

Rhodes, G., Chan, J., Zebrowitz, L. A., & Simmons, L. W. (2003). Does sexual dimorphism in human faces signal health. *Proceedings of the Royal Society of London B*, 270, S93–S95.

Rhodes, G., Geddes, K., Jeffery, L., Dziurawiek, S., Clark, A. (2002). Are average and symmetric faces attractive to infants? Discrimination and looking preferences. *Perception*, 31, 315-321.

Rhodes, G., Harwood, K., Yoshikawa, S., Nishitani, M., & McLean, I. (2002). The attractiveness of average faces: cross-cultural evidence and possible biological basis. In G Rhodes, LA Zebrowitz (Eds.), *Facial Attractiveness: Evolutionary, Cognitive and Social Perspectives*, (pp. 35–58). Westport, CT: Ablex.

Rhodes, G., Hickford, C., & Jeffery, L. (2000). Sex-typicality and attractiveness: Are supermale and superfemale faces super-attractive. *British Journal of Psychology*, 91, 125–140.

Rhodes, G., Jeffery, L., Watson, T.L., Clifford, C.W.G., & Nakayama, K. (2003). Fitting the mind to the World: Face adaptation and attractiveness aftereffects. *Psychological Science*, 14(6), 558-556.

Rhodes, G., Lie, H.C., Thevaraja, N., Taylor, L., Iredell, N., Curran, C., Tan, S., Carnemolla, P., Simmons, L.W. (2011). Facial Attractiveness Ratings from Video-Clips and Static Images Tell the Same Story. *PLoS ONE*, 6(11), e26653.

Rhodes, G., Louw, K., & Evangelista, E. (2009). Perceptual adaptation to facial asymmetries. *Psychonomic Bulletin & Review*, 16(3), 503-508.

Rhodes, G., Proffitt, F., Grady, J.M., & Sumich, A. (1998). Facial symmetry and the perception of beauty. *Psychonomic Bulletin & Review*, 5(4), 659-669.

Rhodes, G., Sumich, A. & Byatt, G. (1999). Are Average Facial Configurations Attractive Only Because of their Symmetry? *Psychological Science*, 10(1), 52-58.

Rhodes, G., & Tremewan, T. (1996). Averageness, Exaggeration, and Facial Attractiveness, *Psychological Science*, 7(2), 105-110.

Rhodes, G., Yoshikawa, S., Clark, A., Lee, K., McKay, R., & Akamatsu, S. (2001). Attractiveness of facial averageness and symmetry in nonwestern cultures: In search of biologically based standards of beauty. *Perception*, 30, 611-625.

Roberts, S.C., Saxton, T.K., Murray, A.K., Burriss, R.P., Rowland, H.M. & Little, A.C. (2009). Static and Dynamic Facial Images Cue Similar Attractiveness Judgements. *Ethology*, 115, 588–595.

Roney, J.R., Hanson, K.N., Durante, K.M., Maestripieri, D., 2006. Reading men's faces: women's mate attractiveness judgments track men's testosterone and interest in infants. *Proceedings of the Royal Society of London B*, 273, 2169–2175.

Rowland, D.A., & Perrett, D.I. (1995). Manipulating Facial Appearance through Shape and Color. *IEEE Computer Graphics and Applications*. 70-76.

Rubenstein, A.J. (2005). Variation in Perceived Attractiveness: Differences between Dynamic and Static Faces. *Psychological Science*, 16(10), 759-762.

Rubenstein, A.J., Kalakanis, L., Langlois, J.H. (1999). Infant Preferences for Attractive Faces : A Cognitive Explanation. *Developmental Psychology*, 35(3), 848-855.

Samuels, C.A., Butterworth, G., Roberts, T., Graupner, L., & Hole, G. (1994). Facial aesthetics: babies prefer attractiveness to symmetry. *Perception*, 23, 823-831.

Saxton, T.K., Debruine, L.M., Jones, B.C., Little, A.C., Roberts, S.C. (2009). Face and voice attractiveness judgments change during adolescence. *Evolution and Human Behavior*, 30, 398–408.

Saxton, T.K., Debruine, L.M., Jones, B.C., Little, A.C., Roberts, S.C. (2011). A longitudinal study of adolescents' judgments of the attractiveness of facial symmetry, averageness and sexual dimorphism. *Journal of Evolutionary Psychology*, 43-55.

Saxton, T.K., Kohoutova, D., Roberts, S.C., Jones, B.C., DeBruine, L.M., & Havlicek, J. (2010). Age, puberty and attractiveness judgments in adolescents. *Personality and Individual Differences*, 49(8), 857-862.

Scheib, J.E., Gangestad, S.W., & Thornhill R. (1999). Facial attractiveness, symmetry and cues of good genes. *Proceedings of the Royal Society: Biological Sciences*, 66, 1913–17.

Scott, I.M., Swami, V., Josephson, S.C., Penton-Voak, I.S. (2008). Context-dependent preferences for facial dimorphism in a rural Malaysian population. *Evolution and Human Behavior*, 29, 289–296.

Simmons, L.W., Rhodes, G., Peters, M., & Koehler, N. (2004). Are human preferences for facial symmetry focused on signals of developmental instability? *Behavioral Ecology*, 15(5), 864–871.

Slater, A., Quinn, P.C., Hayes, R. & Brown, E. (2000). The role of facial orientation in newborn infants' preference for attractive faces. *Developmental Science*, 3(2), 181-185.

Slater, A., Von der Schulenburg, C., Brown, E., Badenoch, M., Butterworth, G., Parsons, S., & Samuels, C. (1998). Newborn infants prefer attractive faces. *Infant*

Behavior and Development, 21, 345-354.

Smith, M.J.L., Perrett, D.I., Jones, B.C., Cornwell, R.E., Moore, F. R., Feinberg, D. R., Boothroyd, L.G., Durrani1, S. J., Stirrat, M.R., Whiten, S., Pitman, R.M., & Hillier, S.G. (2006). Facial appearance is a cue to oestrogen levels in women. *Proceedings of the Royal Society B*, 273, 135–140.

Soler, C., Kekäläinen, J., Núñez, M., Sancho, M., Núñez, J., Yaber, I., Gutiérrez, R., (2012). Male facial anthropometry and attractiveness. *Perception*, 41, 1234-1245.

Swaddle, J. P. & Riersen, G. W. (2002). Testosterone increases perceived dominance but not attractiveness in human males. *Proceedings of the Royal Society B*, 269, 2285–2289.

Thursz, M.R., Thomas, H.C., Greenwood, B.M., & Hill, A.V.S. (1997). Heterozygote advantage for HLA class-II type in hepatitis B virus infection. *Nature Genetics*, 17, 11–12.

Tiddeman, B., Burt, D.M., & Perrett, D. (2001). Computer Graphics in Facial Perception Research, *IEEE Computer Graphics and Applications*, 21(5), 42-50.

Thornhill, R., & Gangestad, S.W. (1993). Human Facial Beauty, Averageness, Symmetry, and Parasite Resistance. *Human Nature*, 4(3), 237-269.

Thornhill, R., & Gangestad, S.W. (1994). Human Fluctuating Asymmetry and Sexual Behavior. *Psychological Science*, 5(5), 297-302.

Thornhill, R., & Gangestad, S.W. (1996). The evolution of human sexuality. *Trends in Ecology and Evolution*, 11, 98–102.

Thornhill, R., & Gangestad, S.W. (1999). Facial Attractiveness. *Trends in Cognitive Sciences*, 3(12), 452-460.

Thornhill, R., & Grammer, K. (1999). The Body and Face of Woman: One Ornament that Signals Quality? *Evolution and Human Behavior*, 20, 105-120.

Thornhill, R., & Møller, A. P. (1997). Developmental stability, disease and medicine. *Biological Reviews, 72*, 497– 548.

Thornhill, R., & Sauer, P. (1992). Genetic sire effects on the fighting ability of sons and daughters and mating success of sons in a scorpionfly. *Animal Behaviour*, 43(2), 255-264.

Thursz, M.R., Thomas, H. C., Greenwood, B. M., & Hill, A.V. (1997). Heterozygote advantage for HLA class-II type in hepatitis B virus infection. Nature Genetics, 17, 11-12.

Tigue, C. C., Pisanski, K., O'Connor, J. J. M., Fraccaro, P. J., & Feinberg, D. R. (2012). Men's judgments of women's facial attractiveness from two- and three-dimensional images are similar. *Journal of Vision* 12(12):3, 1–7

Trivers, R. L. 1972. Parental investment and sexual selection. In B. Campbell, ed. Sexual Selection and the Descent of Man, 1871-1971, Aldine-Atherton, Chicago, pp. 136-179.

Valentine, T. (1991). A Unified Account of the Effects of distinctiveness, Inversion, and Race in Face Recognition. *The Quarterly Journal of Experimental Psychology*, 43A(2), 161-204.

Valentine, T., Darling, S., & Donnelly, M. (2004). Why are average faces attractive? The effect of view and averageness on the attractiveness of female faces, *Psychonomic Bulletin & Review*, 11(3), 482-287.

van Anders, S.M. (2010). Gonadal steroids and salivary IgA in healthy young women and men. *American Journal of Human Biology*, 22, 348–352.

Vuilleumier, P. (2000) Faces call for attention: evidence from patients with visual extinction. *Neuropsychologia*, 38, 693–700.

Waynforth, D. (1998). Fluctuating asymmetry and human male life-history traits in rural Belize. *Proceedings of the Royal Society of London B*, 265, 1497-1501.

Welling, L.L., Jones, B.C., DeBruine, L.M., Conway, C.A., Law Smith, M.J., Little, A.C., Feinberg, D.R., Sharp, M.A., Al-Dujaili, E.A. (2007). Raised salivary testosterone in women is associated with increased attraction to masculine faces. *Hormones and Behavior*, 52, 156–161.

Welling, L.L.M., Jones, B.C., & DeBruine, L.M. (2008). Sex drive is positively associated with women's preferences for sexual dimorphism in men's and women's faces. *Personality and Individual Differences*, 44, 161-170.

Wenderoth, P. (1994). The salience of vertical symmetry. *Perception*, 23, 221-236.

Winkielman, P., Halberstadt, J., Fazendeiro, T., & Catty, S. (2006). Prototypes Are Attractive Because They Are Easy on the Mind. *Psychological Science*, 17(9), 799-806.

World Health Organization (2013). *Adolescent development*. Retrieved May 8, 2013, from http://www.who.int/maternal_child_adolescent/topics/adolescence/dev/en/

Zuk, M., & McKean, K.A. (1999). Sex Differences in Parasite Infections: Patterns and Processes. *International Journal for Parasitology*, 26(10), 1009-1024.