This is a revised personal version of the text of:

Saxton, T. K., DeBruine, L. M., Jones, B. C., Little, A. C., & Roberts, S. C. (in press). Face and voice attractiveness judgments change during adolescence. *Evolution and Human Behavior*.

The published version can be found online at:

http://dx.doi.org/10.1016/j.evolhumbehav.2009.06.004

Face and voice attractiveness judgments change during adolescence

Tamsin K. Saxton [a,b*], Lisa M. Debruine [c], Benedict C. Jones [c], Anthony C. Little [d], S. Craig Roberts [b].

[a] School of Psychology, University of St Andrews

[b] Biological Sciences, University of Liverpool

[c] School of Psychology, University of Aberdeen

[d] Department of Psychology, University of Stirling

* Corresponding author. Tamsin Saxton, School of Psychology, University of St Andrews, St Mary's Quad, South Street, St Andrews, Fife, KY16 9JP, Scotland. tamsin.saxton@st-andrews.ac.uk

Key words: adolescence; attraction; face; facial attractiveness; mate choice; puberty; voice; vocal attractiveness

Attractiveness judgments are thought to underpin adaptive mate choice decisions. We investigated how these judgments change during adolescence when mate choice is becoming relevant. Adolescents aged 11 – 15 evaluated faces and voices manipulated along dimensions that affect adults' judgments of attractiveness and that are thought to cue mate value. Facial stimuli consisted of pairs of faces that were more or less average, more or less feminine, or more or less symmetric. The adolescents selected the more average, symmetric and feminine faces as more attractive more often than chance, but judgments of some facial traits differed significantly with rater age and sex, indicating a role of development in judgments of facial cues. Vocal stimuli consisted of pairs of voices manipulated to raise or lower perceived pitch. The older but not younger girls selected the lower-pitched male voices as more attractive at rates above chance, while the younger but not older boys selected the higher-pitched female voices as more attractive. Controlling for rater age, increased pubertal development was associated with increased selection of lower-pitched boys' voices by girls, and decreased selection of feminised male faces by boys. Our results are the first demonstration that adolescents show somewhat similar attractiveness judgments to adults in age-matched stimuli, and that age, sex and pubertal development have measurable effects on adolescents' attractiveness judgments. They suggest that attractiveness judgments in humans, at least for some traits, are facultatively calibrated to the individual's life stage, only reaching adult values upon sexual maturity when mate choice decisions become relevant.

1.0 Introduction

Many animal behaviors only emerge at the relevant point in the ontogeny and life stage of the animal, often alongside, or as an outcome of, the development of the relevant physical characters. This development of physical characters at the appropriate ontological stage is often most noticeable for characteristics associated with courtship and intrasexual competition. Indeed, whether a trait emerges at puberty is sometimes taken as an indicator that a trait is sexually selected (Andersson 1994; Cartwright 2000). This trend for capabilities to emerge as they are needed by the animal is, of course, not restricted to physical capabilities, but can extend to psychological capabilities. In humans, judgments of attractiveness are psychological capabilities that are thought to support biologically adaptive identification of high-quality partners (Fink & Penton-Voak 2002; Rhodes 2006). We hypothesized that adaptive attractiveness judgments may emerge during adolescence because the identification of partner quality is only biologically relevant when the individual becomes capable of reproducing (see also Rhodes 2006). We focussed on face and voice attractiveness because these are important cues used to judge attractiveness (Saxton et al. 2009).

In adults, averageness, symmetry and sexual dimorphism influence judgments of facial attractiveness and are thought to be used to select desirable partners (reviews in Rhodes 2006; Roberts & Little 2008). Although there are similarities between children's and adults' face preferences (Cross & Cross 1971; Dion 1973; Langlois et al. 1991), these broad similarities do not necessarily preclude systematic changes in facial preferences during ontogeny. Indeed, agreement among children in attractiveness ratings increases from age five to eight (Cavior & Lombardi 1973), and from pre-adolescence to adulthood (Saxton et al. 2006). Additionally, girls aged nine and 12 demonstrate less pronounced preferences for attractive girls' faces than adults do (Kissler & Bäuml 2000). Furthermore, while there is evidence that infants prefer faces that adults rate as attractive (Morton & Johnson 1991; Samuels et al. 1994; Slater et al. 1998), averageness and symmetry do not influence infants' face preferences in the same way as they do adults' (Rhodes et al. 2002). In light of these findings, the current study investigated preferences for facial symmetry, averageness and sexually dimorphic facial features in circum-pubertal boys and girls.

Adults' judgments of vocal attractiveness have also been the subject of a great deal of recent research. Adult men prefer higher-pitched voices in women (Collins & Missing 2003; Jones et al. 2008b) and the faces of women with higher-pitched voices (Feinberg et al. 2005a), while adult and adolescent women prefer lower-pitched voices in men (Collins 2000; Feinberg et al. 2005b; Feinberg et al. 2006; Saxton et al. 2006; Vukovic et al. 2008). The tendency for adult and adolescent females to prefer lower-pitched male voices is not apparent in girls aged 7 – 10 years (Saxton et al. 2006), and a preference for higher-pitched voices is found in preschool children (Trainor & Zacharias 1998). This preference is perhaps linked to the tendency for adults to elevate their pitch in infant-directed speech (Fernald & Kuhl 1987; Kitamura et al. 2002). While these findings suggest that preferences for voice pitch may change during development, the precise timing of this change is unknown. Thus, the current study also investigated circum-pubertal changes in preferences for voice pitch.

In addition to the above, we also investigated the proximate mechanisms that may support the emergence of preferences for cues of mate quality during puberty, focusing on two (non-mutually-exclusive) mechanisms. The first possible mechanism derives from the tenet that familiarity increases the attractiveness of visual stimuli (Zajonc, 1968). Children's facial features are positioned lower than those of adults, and so interaction with other children exposes them to faces with low facial features.

Consistent with this visual experience, pre-adolescent and younger children have stronger preferences than adults for faces manipulated so that internal features are located lower than average within the face, particularly if they have high levels of interaction with same-age peers (Cooper et al. 2006). Since children's peers will change in appearance as they go through puberty, face and voice preferences may change during puberty so as to reflect the physical attributes that are emerging in their peers. The second proximate mechanism driving preference change during adolescence could be endocrinological. Changes in the hormonal profile of the rater are linked to changes in men's and women's attractiveness judgments (Feinberg et al. 2006; Garver-Apgar et al.; Jones et al. 2005; Jones et al. 2008a; Puts 2006; Roney & Simmons 2008; Welling et al. 2007; Welling et al. 2008), and changes in hormone levels during puberty are linked to sexualised behavior (Ehrhardt & Meyer-Bahlburg 1994; Halpern et al. 1993; Thamdrup 1961; Udry et al. 1985; Udry 1988). Thus, hormonal changes during puberty may affect preferences.

Vocal pitch, and facial symmetry, averageness and sexual dimorphism are known to have systematic effects on adults' judgments of attractiveness. Consequently, we investigated judgments of these factors in children of different ages. In the age sample that we chose, reproductive choice is arguably relevant to the older but not the younger age group. Accordingly, we hypothesized that the older group of children would exhibit stronger preferences for cues to the quality of potential mates compared to the younger group of children, and that only the older group of children would respond consistently and positively to facial and vocal cues of partner quality. If the proximate mechanism of familiarity drives preference change, we would expect to see differences in preferences relative to peer age. If endocrine change drives preference change, we would expect to see individual differences in preferences relative to pubertal status.

2.0 Methods

We recruited sets of school children from two school years. The younger group was recruited from the year group that admitted children around age 11, and the older group was recruited from a school year two years senior, admitting children around the age of 13 years. The children carried out forced choice attractiveness judgments of age-matched faces that had been manipulated for symmetry, averageness and sexual dimorphism, and forced choice attractiveness judgments of age-matched opposite-sex voices that had been manipulated for pitch. Using age-matched stimuli controls for possible effects of, for example, own-age biases in perception (Anastasi & Rhodes 2005). Children also provided demographic information including details of pubertal development.

2.1 Stimuli creation

All visual stimuli were created on the basis of facial photographs of 60 Caucasian children recruited in equal numbers from four groups (male or female; 11-13 (mean ± SD = 12:1 ± 0:6 years:months) or 13-15 years old (mean ± SD = 14:11 ± 0:11 years:months)) from local social groups or schools. Written parental consent and individual acquiescence was obtained from each participant. Conventional methods were used to create the facial stimuli (e.g. Little et al. 2001; Perrett et al. 1994). Facial features were marked out with 179 points using dedicated software (Tiddeman et al. 2001) and used to create 12 sets (representing each level of: male or female; 11-13 or 13-15 years old; sexual dimorphism, symmetry, or averageness manipulations), each containing six pairs of images.

The mathematical averageness of stimuli was increased by adding 50% of the linear differences in 2D shape between individual images and the average shape for that category to six individual images from each sex and age category, allowing for a comparison pair with the original image. Faces were not symmetrized prior to manipulating averageness. Although the methods that we used to manipulate averageness in face images thus also alter facial symmetry, previous studies have demonstrated that the contribution of symmetry to preferences for average faces is, at best, slight (Jones et al. 2007; Rhodes et al. 2001). Following methods of previously published research (see e.g. Buckingham et al. 2006; Jones et al. 2005; Little et al. 2001; Little et al. 2002; Penton-Voak et al. 1999), stimuli which differed in sexual dimorphism were created by adding or subtracting 50% of the linear differences in 2D shape between the average face shape of the older boys and the average face shape of the older girls (i.e. 13 – 15 years old) to/from six photographs from each age and sex group. The face shape of the older children was used in creating both older and younger stimuli that differed in sexual dimorphism because pilot testing in adults revealed very little perceptual difference between images that had been masculinised and feminised using templates created from the younger stimuli (i.e. 11 – 13 years old). This is unsurprising given the low levels of sexual dimorphism evident in the faces of pre-pubertal individuals (Enlow 1990; Enlow & Hans 1996). Stimuli that differed in symmetry were created by first averaging six images from each of the four age and sex categories with their mirror image to produce a perfectly symmetric version, and then moving the image shape 100% towards (i.e. rendering the face perfectly symmetric) or 50% away from (to decrease symmetry) these perfectly symmetric versions. Stimuli that had been decreased in symmetry were used because pilot testing in adults indicated little perceptual difference between the original and the 100% symmetrised images, potentially reflecting relatively low levels of asymmetry in children’s faces (see e.g. Trivers et al. 1999). Symmetry manipulations created with reference to a continuum between symmetric and original faces are used in previous studies (e.g. Little et al. 2001; Little & Jones 2003). The same six faces were used for each manipulation type (averageness, symmetry, sexual dimorphism). Image colours were not adjusted from the original, and faces were not masked, leaving hair cues available. Examples of the stimuli manipulations as applied to adult faces are found in the supplementary electronic material.

Recordings from six native English-speaking children from each sex and age group were used to make the vocal stimuli. The vowel sounds /oʊ/ (as in “go”), /u/ (as in “soon”), /ɑ/ (as in “bar”) and /i/ (as in “see”) were recorded with a IM-DR420H 1-bit portable minidisc recorder (Sharp) at a sampling rate of 44.1 kHz and 16-bit quantization in a quiet room with a AT822 One point X/Y Stereo DAT microphone (Audio-Technica Limited, Leeds, UK) placed at a distance of around 20 cm from the speaker’s mouth. Vowel sounds are conventional as stimuli in voice preference tasks (e.g. Collins & Missing 2003; Feinberg et al. 2005b) and allow easy perception of pitch while reducing speaker variation associated with intonation and articulation. Voice recordings were high- and low-pass filtered at 20 Hz and 7900 Hz to reduce non-vocal noise in the sound file while retaining the audible formant frequencies of children’s vowel sounds (Jessica et al. 1999; Lee et al. 1999).

All further acoustic measurements and manipulations were carried out using Praat 4.4.24 (www.praat.org). The PSOLA (Pitch-Synchronous Overlap and Add) method was used to shorten or lengthen vowels to obtain a duration of 0.35 s and then to create two new samples, one of which was raised and one lowered by 20 Hz in fundamental frequency. Between-vowel silence was edited to occur at 0.5 s intervals, and amplitude normalised to 73 dB RMS. Finally, samples were converted from .wav to mp3 file format using the All To MP3 Converter 1.6 (LitexMedia, Inc).

2.2 Raters

Raters were recruited from a set of private schools charging similar levels of school fees. Children were sampled from the year group that admitted children around age 11 and from a year group two years their senior, for children around 13 years. There was less than a year's difference in age between the oldest children from the younger classes and the youngest children of the older classes because children were sampled at different points within the school year and because slightly different age divisions are made in Scotland and England, where schools were based. Stimuli were presented in pairs of faces or voices that were identical except for the manipulation applied (averageness, symmetry, sexual dimorphism, or pitch). Children had to indicate which of the two stimuli was more attractive and by how much (see Statistical Analysis for further details). Full written and verbal instructions in rating procedure were given.

Children rated the stimuli created from children within their age group either at an individual computer (n = 229 children; 43% of whom were in the younger age group) or provided pen-and-paper ratings of stimuli presented through an overhead projector and classroom stereo system (n = 102 children; 63% of whom were in the younger age group). Such differences in presentation type are thought not to affect adults' judgments; previous research has shown no differences in judgments dependent upon image size, presentation methods or viewing times (Ekman et al. 1979; Krantz et al. 1997; Willis & Todorov 2006). Presentation size was held constant within each set, such that each child viewed and made judgments of pairs of faces of equal sizes. The effects of presentation method on adolescents' judgments have not previously been explicitly tested; our analysis showed no significant effect of presentation type (mixed model ANOVA on proportions of feminine, average and symmetric faces chosen; within-subjects factors: manipulation type and stimulus face sex; between-subjects factors: rater sex, age group and presentation type; presentation type not significant ($F_{1,299}$ = .50, P = .480)).

To avoid overtaxing children's concentration spans, both same- and opposite-sex faces, but only opposite-sex voices (as voices took longer to evaluate), were rated. Voice rating was blocked after face rating. All three facial manipulation types were presented within a single face rating block, and were randomised with respect to presentation order and side. Following the preference task, children provided basic demographic information, and indicated whether their ethnicity was African, East Asian, West Asian, or White. The study was approved by the University of Liverpool Research Ethics Committee.

The data of any child who demonstrated extreme side bias in their judgments (choosing consistently the image presented on one side 35 times out of 36; n = 3), or who entered an unrealistic year of birth (n = 2), were excluded. Participant numbers and ethnicities following exclusions were 89 boys and 74 girls in the younger class (mean ± SD = 11:10 ± 0:5 years:months; 122 White, 16 West Asian, 8 East Asian, 1 African, 16 non-respondents) and 93 boys and 75 girls in the older class (mean ± SD = 14:00 ± 0:6 years:months; 146 White, 6 West Asian, 5 East Asian, 1 African, 10 non-respondents).

2.3 Measurement of pubertal development

Following the task, boys completed a questionnaire to indicate whether they had underarm hair (yes/no) and their voice had broken (yes/no) (indicative of levels of testosterone and other hormones; Lee & Migeon 1975). Girls rated their development in relation to their peers on the 4-point scale: 'much more developed', 'more developed', 'less developed' or 'much less developed', and indicated (yes/no) whether they used sanitary towels (i.e. had undergone menarche). Although menarche in girls not does necessarily correspond to reproductive potential, and often occurs without ovulation in adolescents (Apter 1980; Apter & Vihko 1983; Ibanez et al. 1999), it is a robust and key indicator of biological development, and corresponds significantly with height, trained raters' evaluations of physical development, and presence of other physical markers such as underarm hair and an adult female figure (Simmons et al. 1979).

2.4 Statistical analysis

Stimuli were presented in pairs of faces or voices that were identical except for the manipulation applied (averageness, symmetry, sexual dimorphism, or pitch). For each pair, the child had to state which face or voice was more attractive. Each child was presented with and judged six stimulus pairs for each of the seven manipulations (male and female facial averageness, symmetry and sexual dimorphism; opposite-sex vocal pitch), giving rise to seven scores per child, representing the proportion of average, symmetric or feminine faces, or lower-pitched opposite-sex voices, selected as more attractive. Data from 331 children were used; occasional technical problems or child lateness resulted in 308 of those providing face judgments, and 325 of those providing voice judgments. Further, children had the option of skipping a face or voice; a mean score was only calculated if data from at least five judgments had been obtained following such omissions. Number of raters for each of the six facial manipulations therefore ranges between 306 and 308, while data from 177 boys and 148 girls are used for the analysis of voice preference. Degrees of freedom are adjusted accordingly.

3.0 Results

Overall, children selected the average, symmetric and feminine versions of the male and female faces to be the more attractive significantly more often than chance (single-sample t test: all $t > 3.8$, $P < .001$). Children only rated opposite-sex voices; boys chose higher-pitched over lower-pitched girls' voices ($t_{176} = 4.85$, $P < .001$) and girls chose lower-pitched over higher-pitched boys' voices ($t_{147} = 4.91$, $P < .001$).

ANOVA (factors: Sex (male or female) and Age group (younger or older school class)) examined the proportion of times that the children selected the average over the distinctive (non-average) faces, the symmetric over the asymmetric faces, and the feminine over the masculine faces. Six analyses were carried out, separating the three manipulations and the male and female faces. Since children only rated opposite-sex voices, girls' voice pitch preferences was analysed separately from boys', with two ANOVAs that examined the effect of the factor Age group (younger or older school class) on choices. Analysis by age group is reported since it justifies the subsequent one-sample t-test analysis (section 3.3) used to determine whether the ratings of different groups of raters differed from chance. However, results are qualitatively identical if the analysis is conducted with age (years and months) as a covariate in place of age group as a factor.

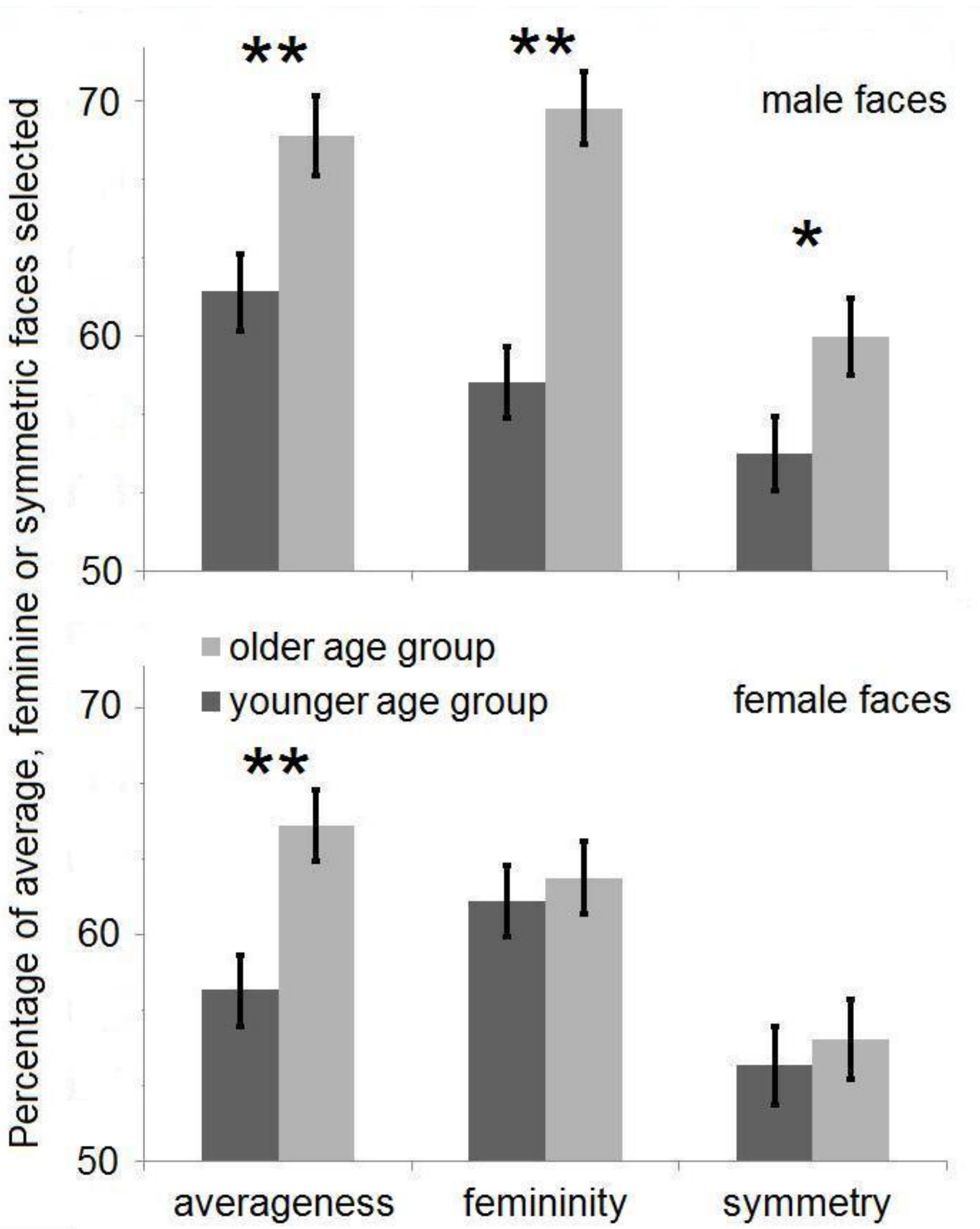

*Fig. 1. Selection of average, feminine and symmetric faces as more attractive than non-average, masculine and asymmetric faces respectively, by age group. Bars: mean +/- SE. ** P < .01, * P < .05.*

3.1 Age effects on facial and vocal attractiveness judgments

There were significant effects of age group on facial judgments (Fig. 1). When rating male faces, the older children were significantly more likely than the younger children to chose the average ($F_{1,304}$ = 8.03, P = .005), symmetric ($F_{1,302}$ = 4.76, P = .030), and feminine faces ($F_{1,302}$ = 29.69, P < .001) as more attractive, although judgments of femininity in male faces were modified by a significant interaction between sex and age group of rater ($F_{1,302}$ = 11.70, P = .001; see below). In rating female faces, the older children were significantly more likely than the younger children to select the average faces ($F_{1,302}$ = 10.83, P = .001), but not the feminine faces ($F_{1,303}$ = .21, P = .647) or the symmetric faces ($F_{1,303}$ = .21, P = .646) as more attractive.

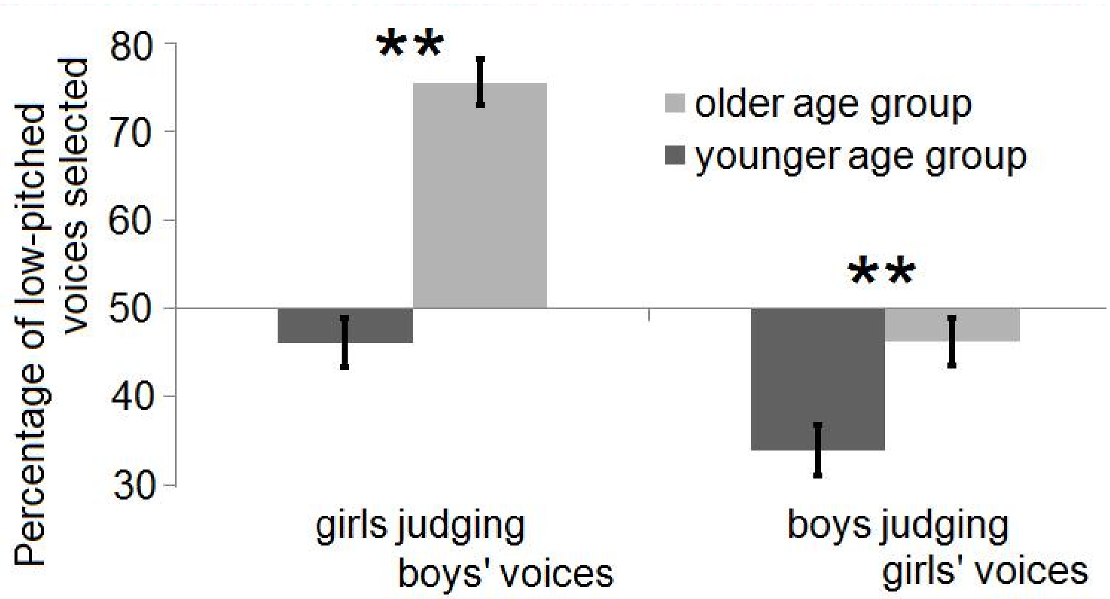

*Fig. 2. Selection of lower-pitched voices as more attractive than higher-pitched voices, by age group. Children only rated opposite-sex voices. Bars: mean +/- SE. ** P < .01, * P < .05.*

Voice pitch preference also varied with age group (Fig. 2). The older girls were significantly more likely than the younger girls to select the lower pitched boys' voices as more attractive ($F_{1,146}$ = 62.36, P < .001). The younger boys were significantly more likely than the older boys to select the higher-pitched girls' voices as more attractive ($F_{1,175}$ = 10.15, P = .002).

3.2 Sex differences in facial and vocal attractiveness judgments

When choosing the more attractive face, girls were significantly more likely than boys to select the average male faces ($F_{1,304}$ = 4.51, P = .034), and the feminised female ($F_{1,303}$ = 13.68, P < .001) and male faces ($F_{1,302}$ = 6.72, P = .010), although as noted above this last effect was modified by a significant age group by sex interaction (see below). Girls did not differ significantly from boys in their selection of the more symmetric male or female faces (symmetry in female faces: $F_{1,303}$ = .06, P = .810; symmetry in male faces: $F_{1,302}$ = .43, P = .512), or the more average female faces ($F_{1,302}$ = 2.72, P = .100) (Fig. 3).

Analysis of girls separately from boys (ANOVA: age group as factor) showed that increased age was associated with a significant increase in selection of feminised male faces as more attractive by girls ($F_{1,143}$ = 38.44, P < .001) and a non-significant increase by boys ($F_{1,159}$ = 2.12, P = .148). Separate analysis of older and younger children (ANOVA: sex of rater as factor) confirmed that girls' selection of feminised male faces was significantly greater than boys' in the older ($F_{1,147}$ = 16.68, P < .001) but not the younger ($F_{1,155}$ = .37, P = .543) age group.

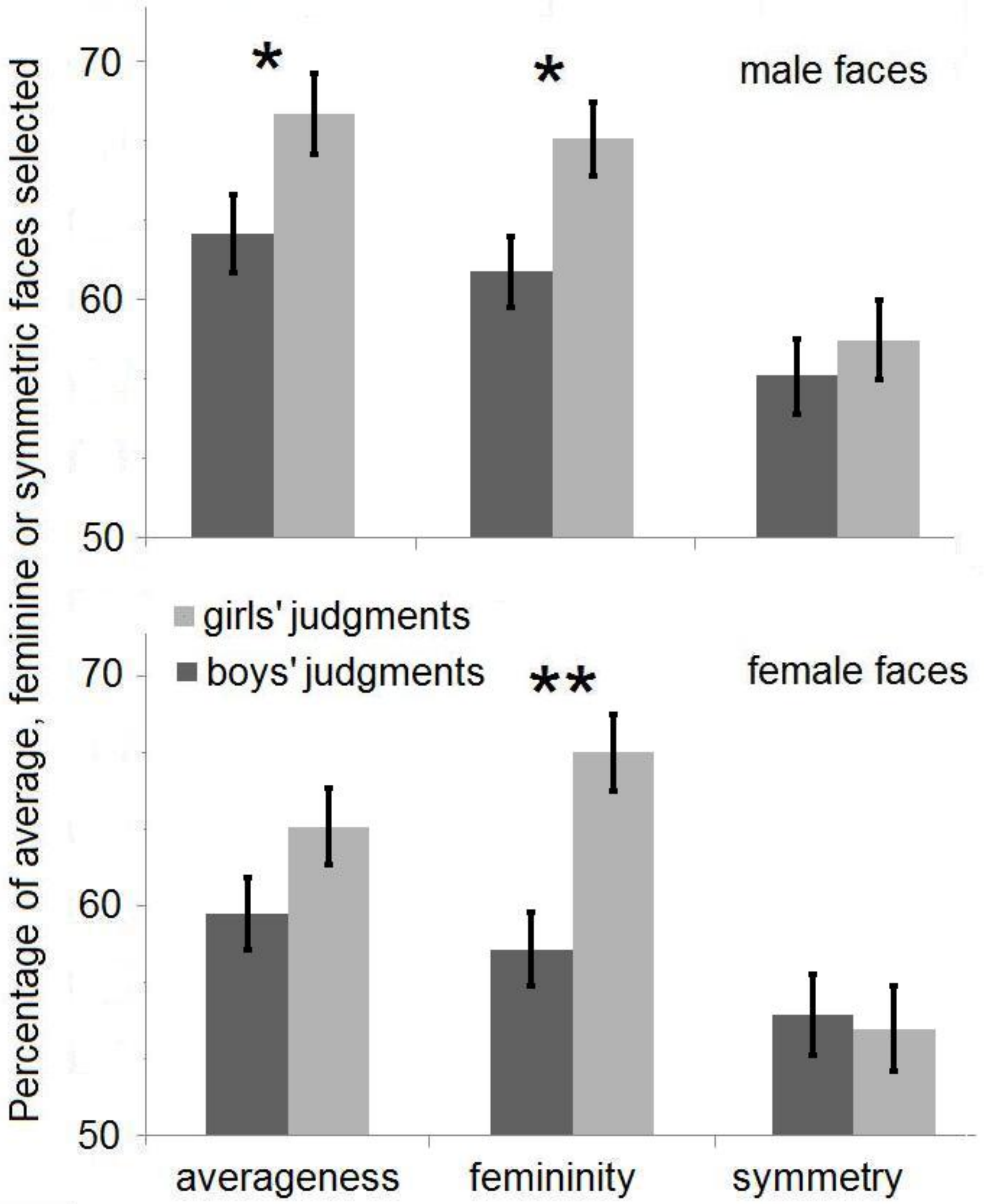

*Fig. 3. Selection of average, feminine and symmetric faces as more attractive than non-average, masculine and asymmetric faces respectively, by rater sex. Bars: mean +/- SE. ** P < .01, * P < .05.*

Table 1: Judgments of manipulated stimuli, separated by group in those cases where rater age or sex had a significant effect on judgments.

Trait judged more attractive	Group of raters	
averageness in female faces	younger children	t_{156} = 4.90, P <.001
	older children	t_{148} = 9.18, P <.001
averageness in male faces	younger children	t_{157} = 6.90, P <.001
	older children	t_{149} = 11.34, P <.001
symmetry in male faces	younger children	t_{156} = 3.21, P = .002
	older children	t_{148} = 6.00, P <.001
femininity in male faces	younger girls	t_{72} = 3.29, P = .002
	younger boys	t_{83} = 4.59, P <.001
	older girls	t_{71} = 12.13, P <.001
	older boys	t_{76}= 5.80, P <.001
low pitch in male voices	younger girls	t_{73} = -1.26, P = .211
	older girls	t_{73} = 11.78, P <.001
high pitch in female voices	younger boys	t_{83} = 5.68, P <.001
	older boys	t_{92} =1.43, P =.157

Results show one-sample t-tests against random choice between stimuli pairs. Degrees of freedom are adjusted according to number of raters (see Section 2.2 and 2.4). All significant results would survive Bonferroni correction for multiple comparisons.

3.3 Judgment of cues by different sex and age groups

Table 1 contains the results of single-sample t-tests for sex and/or age categories separately where the preceding analysis (Section 3.1 and 3.2) indicates a significant effect of those categories. With respect to the face judgments, all individual groups chose the average, symmetric and feminine faces more often than would be expected by chance. Older but not younger girls selected the lower-pitched male voices significantly more often than chance, and younger but not older boys selected the higher-pitched female voices significantly more often than chance.

3.4 Effect of pubertal development on judgments

A three-point scale was created from the two self-reported measures of pubertal development (range: 0 – 2; boys: one point if his voice had broken and one point if he had underarm hair; girls: one point if menarche had been attained and one point if she rated herself much more or more developed than her peers). One hundred and fifty boys and 111 girls completed both of these measures and were included in this analysis. ANCOVA was used to examine the effect of biological development, with the three-point scale entered as an independent variable, and Age (years and months) as a covariate. Since the scale of pubertal development was different for boys and girls, the two sexes were analysed separately (although results are qualitatively identical if the two sexes are analysed together with Sex of rater as an independent variable).

Among boys, biological development, when controlling for chronological age, only had a significant effect on judgments of femininity in male faces ($F_{2,146} = 3.71$, $P = .027$); increased pubertal development corresponded significantly to a lower proportion of feminised male faces selected as more attractive (Fig.4). Age remains significant in this analysis ($F_{2,146} = 76.65$, $P = .011$). In girls, controlling for age, overall biological development had no significant effect on any of the facial judgments, but increased pubertal development corresponded significantly to increased selection of lower-pitched male voices as more attractive ($F_{2,107} = 3.34$, $P = .039$); age remains significant in this analysis ($F_{1,107} = 10.21$, $P = .002$) (Fig.5).

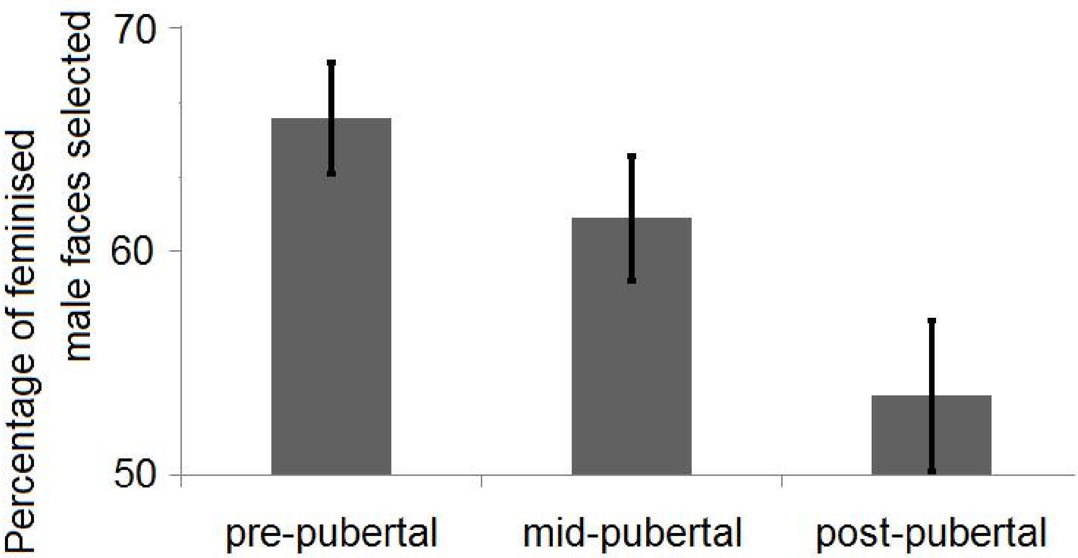

Fig. 4. Boys' selection of male feminised faces as more attractive than masculinised faces, by pubertal stage (prepubertal: voice not broken, no underarm hair; midpubertal: voice broken or underarm hair; postpubertal: voice broken and underarm hair). Bars: mean +/- SE.

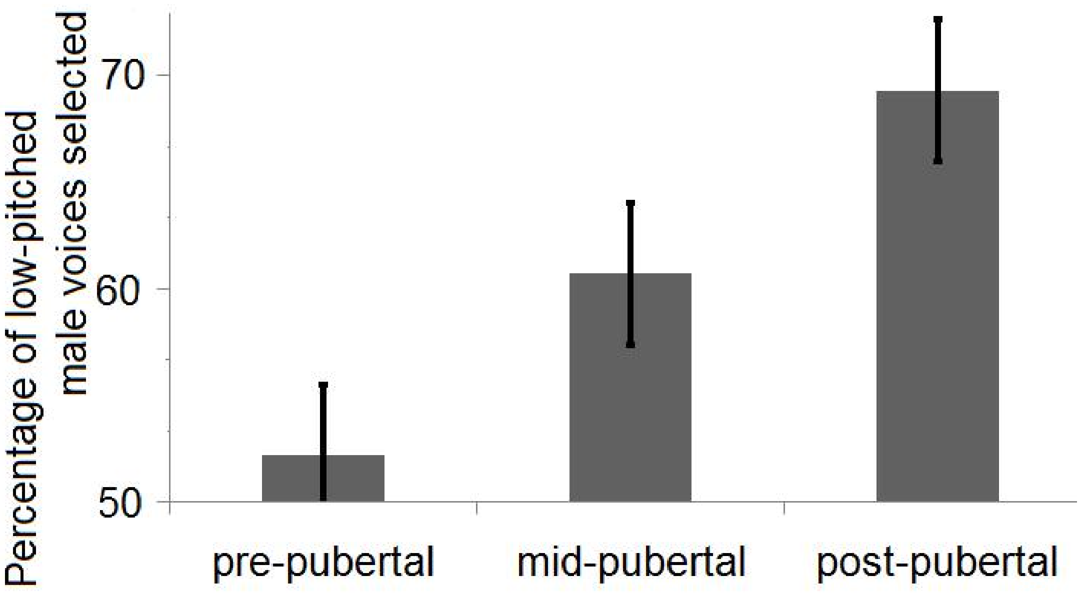

Fig. 5. Girls' selection of lower-pitched male voices as more attractive attractive than higher-pitched voices, by pubertal stage (prepubertal: pre-menarchal, less developed than peers; midpubertal: post-menarchal or more developed than peers; postpubertal: post-menarchal and more developed than peers). Bars: mean +/- SE.

4.0 Discussion

We investigated how circum-pubertal children evaluate cues of mate quality in peers' faces and voices, during the ontological stage when accurate evaluation of mate quality is becoming biologically adaptive. Raters aged 11-15 carried out forced-choice judgments of age-matched male and female faces that had been manipulated along the dimensions of symmetry, averageness and sexual dimorphism, and age-matched opposite-sex voices that had been manipulated for pitch, a sexually dimorphic vocal trait.

Both the younger and older groups of children rated the more average, more symmetric and more feminine male and female faces as the more attractive. To our knowledge, this is the first assessment of ratings of these facial parameters by this age group. Adults tend to give higher ratings of attractiveness to femininity in female faces, and to facial averageness and symmetry in male and female faces, and all of these characters have been linked to mate quality (review in Rhodes 2006). The finding that these characteristics are appealing to raters even before mate choice and mate competition are relevant (i.e. even in the younger group of children aged 11 – 13) suggests that preferences for these cues might be adaptive in non-sexual contexts. Physical trait attractiveness has positive influences on social interactions in childhood (Dion 1973; Eagly et al. 1991; Langlois et al. 2000), and associations have been made between pro-social personality traits and facial symmetry (Fink et al. 2005; Shackelford & Larsen 1997) and facial femininity (Perrett et al. 1998). An awareness of how specific traits affect the attractiveness of faces may have social benefits even before mate choice judgments become relevant.

The children preferred feminine male faces. Adult preferences for both masculinised and feminised male faces have been reported (e.g. DeBruine et al.

2006; Rhodes 2006). Masculine male faces may cue indirect genetic quality (Rhodes et al. 2003; Thornhill & Gangestad 2006), while feminine male faces may indicate positive personality traits such as warmth, honesty and cooperativeness (Boothroyd et al. 2007; Perrett et al. 1998) leading to context-dependent preferences for male facial masculinity or femininity (Little et al. 2001; Little et al. 2002; Penton-Voak et al. 1999; Penton-Voak et al. 2003). The finding that pre-reproductive children preferred male facial femininity may be in part due to the appeal and social relevance of positive personality traits in males (Perrett et al. 1998). Further, feminine faces also tend to look younger (Perrett et al. 1998), which may be appealing to the present sample. Additionally, a preference for male facial femininity could also reflect an age-related reproductive strategy. Rater quality co-varies positively with preference for facial masculinity (Little et al. 2001; Penton-Voak et al. 2003). Even the oldest girls in the sample must wait a number of years before they attain the age at which they are most desirable as a reproductive partner (Symons 1995), and as such their dislike of male facial masculinity may reflect a strategic preference that will attenuate as they age.

4.1 Age differences in facial attractiveness judgments

The older children gave significantly higher ratings than the younger children to facial averageness, male facial symmetry and, when judged by girls but not boys, male facial femininity. This is consistent with the idea that attraction to cues of mate quality increases during the years when assessment of potential partners is becoming biologically adaptive. It is not clear why judgments should increase in relation to some traits but not others.

4.2 Age differences in vocal attractiveness judgments

The older girls showed a significantly stronger preference than the younger girls for low pitch in male voices. Differences in voice pitch (or more strictly, fundamental frequency, of which pitch is the perceptual correlate) result from differences in the size and mass of the vocal chords (Meredydd et al. 1998; Titze 1994), and correspond negatively to differences in testosterone levels (Dabbs & Mallinger 1999; Evans et al. 2008) and positively to male reproductive success (Apicella et al. 2007; Puts et al. 2006). Age-related increase in attraction to low voice pitch suggests that adolescence co-occurs with an increasing ability to rate vocal cues of opposite-sex mate quality linked to testosterone levels (Folstad & Karter 1992).

The boys' preferences for raised pitch in female voices decreased with age. While the younger group of boys preferred higher-pitched female voices, the older group did not show any significant directional preference for raised or lowered voice pitch. This was unexpected; adults rate higher-pitched adult female voices more attractive (Collins & Missing 2003; Feinberg et al. 2005a; Jones et al. 2008b) and we predicted that boys would show more adult-like judgments as they aged. However, girls' voices lower in pitch during childhood (Lee et al. 1999). Thus, it is possible that the boys were using the lower pitches as a cue that the speaker was of older age and hence closer to sexual maturity. Further research could investigate whether additional experience is required before male adolescents show the previously demonstrated adult-like preferences for higher-pitched female voices.

4.3 Pubertal development and attractiveness judgments

We collected self-reported data on pubertal development. To maintain privacy and encourage truthfulness, children answered questions at an individual computer, or on an individual paper-based questionnaire. They were told that answers would be held confidentially and anonymously, and that they should leave blank any questions they did not want to answer. Despite these precautions, it is of course possible that some children were unable or unwilling to give accurate answers. Nevertheless, we found significant effects of pubertal development on attractiveness judgments.

In girls, pubertal development and chronological age were significantly, independently and positively linked to choice of greater proportions of the lower-pitched boys' voices as more attractive. While acoustic differences in male and female voice pitch may begin from around 11 years of age (Lee et al. 1999), boys' voices break at an age of around 13 to 14 years (Hollien & Malcik 1967; Lee et al. 1999; Tosi et al. 1976). Girls' preference for lower pitch therefore emerged around the time that some of their male peers' voices had dropped in pitch, indicating that exposure and familiarity as well as their own pubertal development may affect ratings of vocal attractiveness, in the same way as exposure affects facial judgments (Bereczkei et al. 2002; Bereczkei et al. 2004; Buckingham et al. 2006; Cooper et al. 2006; Little et al. 2003; Little et al. 2005).

In boys, judgments of femininity in male faces corresponded to individual differences in biological development. Controlling for age, boys with more somatic markers of pubertal development (voice change, underarm hair) chose greater numbers of the masculinised male faces as more attractive. Serum testosterone levels increase with the onset of underarm hair growth (Lee & Migeon 1975), and there is evidence for a relationship between testosterone levels and male facial masculinity (Penton-Voak & Chen 2004; Pound et al. 2009; Roney et al. 2006). If facial masculinity develops in tandem with underarm hair, the relationship between underarm hair and decreased rating of facial femininity may result from boys' experience with their own faces, or indeed from enhanced attention to other boys at a similar developmental stage.

4.4 Sex differences in attractiveness judgments

Girls showed significantly stronger preferences than boys for male facial averageness and male and female facial femininity. In general terms, girls tend to mature earlier than boys, and are more alert to socially relevant cues such as facial expression (McClure 2000). Accordingly, girls may be more practised in judging physical attractiveness. In addition, this could reflect greater choosiness by the girls. Good reproductive choice is more important for females than males because the cost of making a bad partner choice is greater for females (Trivers 1972); females tend to be the choosier sex in judging partners (Andersson 1994) and this psychological sexual dimorphism may have driven some of the sexual differences noted in our peri-pubertal sample.

4.5 Limitations

There are two aspects of the manipulations that limit our interpretations of the effects of age and pubertal development on judgments. Firstly, the face shape of the older children was used to manipulate both older and younger stimuli along the sexual dimorphism dimension. Facial sexual dimorphism increases with age (Enlow 1990; Enlow & Hans 1996) and pilot testing in adults revealed very little perceptual difference between images which had been masculinised and feminised using templates created from the younger stimuli (i.e. 11-13 years old). This design makes the assumption of something roughly equivalent to a linear trajectory of sexually dimorphic development between the ages of 11-13 and 13-15, such that the manipulation is not unnatural in the younger group. This has not been empirically tested, although work indicates that sexual dimorphism manipulations employing a range of techniques give rise to similar results (DeBruine et al. 2006).

Secondly, children judged age-matched faces and voices, a design that was chosen to increase ecological validity and appropriateness and to control for possible effects of own-age biases in perception (see e.g. Anastasi & Rhodes 2005); we did not match faces for race, another factor that is known to affect judgments (see e.g. Perrett et al. 1998). However, the age matching also means that we have not been able to distinguish between the situation where children become more adept at judging physical cues as they age, and a situation where children of all ages are equally adept, but cues are simply more highly rated in the context of older faces and voices. In the same way, the children further through puberty were more likely to be in the older group of children who rated the older stimuli, so confounding the effects of pubertal development with differences arising from rating a different stimuli set. In addition, our design did not attempt to distinguish the relative importance for attractiveness judgments of endocrine change compared with differences arising from the different social experiences of an individual who is further through puberty and who might be treated as though he or she is older than his or her peers, for instance. These issues constitute important topics for future research.

It appears unlikely that differences in cognitive ability, motivation, and concentration span can explain all of the differences between the sex and age groups. It is possible that the difference between girls and boys is due to girls' greater motivation for the task, but if this is the case, this motivation to assess faces and voices may be the proximate mechanism that expresses the adaptive requirement for greater care by females than males in their social decisions or their choice of mates. Although older children may be cognitively better equipped for the task than younger children, children of all ages were able to carry out the task, as demonstrated by their directional preferences for at least some categories of stimuli.

In sum, the study has shown that facial averageness, symmetry and sexual dimorphism, and vocal pitch, are cues used in attractiveness judgments among adolescents. We also found some evidence for independent effects of age and pubertal development on attractiveness judgments, results that would benefit from replication in a longitudinal study. Indeed, a longitudinal study of the development of preferences is an important project to be pursued in future research.

5.0 Acknowledgements

The authors thank David Feinberg (advice on voice stimuli creation), Thom Scott-Phillips (discussion and useful comments on earlier drafts), David Perrett and Bernard Tiddeman (use of Psychomorph software), Andrew Boardman, Kristina Gilbertson, Gideon Gluckman, Shelly Kemp, Robert Kennedy, Jenny Saxton, Sue Toole (help with stimuli collection), the staff and pupils from George Heriot's School, the schools and social groups who provided much-valued participants, and the editor Martie Haselton and two anonymous reviewers for their helpful comments. ACL is supported by a Royal Society University Research Fellowship. TKS was supported by the University of Liverpool, and is supported by an ESRC postdoctoral research fellowship.

6.0 References

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.

Andersson, M. (1994). Sexual Selection. Princeton, NJ: Princeton University Press.

Apicella, C.L., Feinberg, D.R. & Marlowe, F.W. (2007). Voice pitch predicts reproductive success in male hunter-gatherers. *Biology Letters*, 3, 682-684.

Apter, D. (1980). Serum steroids and pituitary hormones in female puberty: A partly longitudinal study. *Clinical Endocrinology*, 12, 107-120.

Apter, D. & Vihko, R. (1983). Early menarche, a risk factor for breast cancer, indicates early onset of ovulatory cycles. *Journal of Clinical Endocrinology and Metabolism*, 57, 82-86.

Bereczkei, T., Gyuris, P., Koves, P. & Bernath, L. (2002). Homogamy, genetic similarity, and imprinting; parental influence on mate choice preferences. *Personality and Individual Differences*, 33, 677-690.

Bereczkei, T., Gyuris, P. & Weisfeld, G.E. (2004). Sexual imprinting in human mate choice. *Proceedings of the Royal Society - Biological Sciences (Series B)*, 271, 1129-1134.

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.

Buckingham, G., DeBruine, L.M., Little, A.C., Welling, L.L.M., Conway, C.A., Tiddeman, B.P. & Jones, B.C. (2006). Visual adaptation to masculine and feminine faces influences generalized preferences and perceptions of trustworthiness. *Evolution and Human Behavior*, 27, 381-389.

Cartwright, J. (2000). Evolution and Human Behavior: Darwinian Perspectives on Human Nature. Cambridge, MA: MIT Press.

Cavior, N. & Lombardi, D.A. (1973). Developmental aspects of judgment of physical attractiveness in children. *Developmental Psychology*, 8, 67-71.

Collins, S.A. (2000). Men's voices and women's choices. *Animal Behaviour*, 60, 773-780.

Collins, S.A. & Missing, C. (2003). Vocal and visual attractiveness are related in women. *Animal Behaviour*, 65, 997-1004.

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.

Cross, J.F. & Cross, J. (1971). Age, sex, race and the perception of facial beauty. *Developmental Psychology*, 5, 433-439.

Dabbs, J.M. & Mallinger, A. (1999). High testosterone levels predict low voice pitch among men. *Personality and Individual Differences*, 27, 801-804.

DeBruine, L.M., Jones, B.C., Little, A.C., Boothroyd, L.G., Perrett, D.I., Penton-Voak, I.S., Cooper, P.A., Penke, L., Feinberg, D.R. & Tiddeman, B.P. (2006). Correlated preferences for facial masculinity and ideal or actual partner's masculinity. *Proceedings of the Royal Society B Biological Sciences*, 273, 1355-1360.

Dion, K.K. (1973). Young children's stereotyping of facial attractiveness. *Developmental Psychology*, 9, 183-188.

Eagly, A.H., Ashmore, R.D., Makhijani, M.G. & Longo, L.C. (1991). What is beautiful is good: A meta-analytic review of research on the physical attractiveness stereotype. *Psychological Bulletin*, 110, 109-128.

Ehrhardt, A.A. & Meyer-Bahlburg, H.F. (1994). Psychosocial aspects of precocious puberty. *Hormone Research*, 41, 30-35.

Ekman, P., Brattesani, K.A., O'Sullivan, M. & Friesen, W.V. (1979). Does image size affect judgments of the face? *Journal of Nonverbal Behavior*, 4, 57-61.

Enlow, D.H. (1990). Facial Growth. Philadelphia, USA: W.B. Saunders Company.

Enlow, D.H. & Hans, M.G. (1996). Essentials of Facial Growth. Philadelphia, PA: Saunders.

Evans, S., Neave, N., Wakelin, D. & Hamilton, C. (2008). The relationship between testosterone and vocal frequencies in human males. *Physiology and Behavior*, 93, 783-788.

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. (2005a). The voice and face of woman: One ornament that signals quality? *Evolution and Human Behavior*, 26, 398-408.

Feinberg, D.R., Jones, B.C., Little, A.C., Burt, D.M. & Perrett, D.I. (2005b). Manipulations of fundamental and formant frequencies influence the attractiveness of human male voices. *Animal Behaviour*, 69, 561-568.

Feinberg, D.R., Jones, B.C., Law Smith, M.J., Moore, F.R., DeBruine, L.M., Cornwell, R.E., Hillier, S.G. & Perrett, D.I. (2006). Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. *Hormones and Behavior*, 49, 215-222.

Fernald, A. & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. *Infant Behavior and Development*, 10, 279-293.

Fink, B. & Penton-Voak, I. (2002). Evolutionary psychology of facial attractiveness. *Current Directions in Psychological Science*, 11, 154-158.

Fink, B., Neave, N., Manning, J.T. & Grammer, K. (2005). Facial symmetry and the ‘big-five’ personality factors. *Personality and Individual Differences*, 39, 523-529.

Folstad, I. & Karter, A.J. (1992). Parasites, bright males, and the immunocompetence handicap. *American Naturalist*, 139, 603-622.

Garver-Apgar, C.E., Gangestad, S.W. & Thornhill, R. (2008). Hormonal correlates of women's mid-cycle preference for the scent of symmetry. *Evolution and Human Behavior*, 29, 223-232.

Halpern, C.T., Udry, J.R., Campbell, B. & Suchindran, C. (1993). Testosterone and pubertal development as predictors of sexual activity: A panel analysis of adolescent males. *Psychosomatic Medicine*, 55, 436-447.

Hollien, H. & Malcik, E. (1967). Evaluation of cross-sectional studies of adolescent voice change in males. *Speech Monographs*, 34, 80-84.

Ibanez, L., de Zegher, F. & Potau, N. (1999). Anovulation after precocious pubarche: Early markers and time course in adolescence. *Journal of Clinical Endocrinology and Metabolism*, 84, 2691-2695.

Jessica, E.H., Elaine, T.S., Gina, M.C., Theresa, A.A. & Kenneth, J. (1999). Formants of children, women, and men: The effects of vocal intensity variation. *The Journal of the Acoustical Society of America*, 106, 1532-1542.

Jones, B.C., Little, A.C., Boothroyd, L., DeBruine, L.M., Feinberg, D.R., Smith, M.J.L., Cornwell, R.E., Moore, F.R. & Perrett, D.I. (2005). Commitment to relationships and preferences for femininity and apparent health in faces are strongest on days of the menstrual cycle when progesterone level is high. *Hormones and Behavior*, 48, 283.

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

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

Jones, B.C., Feinberg, D.R., DeBruine, L.M., Little, A.C. & Vukovic, J. (2008b). Integrating cues of social interest and voice pitch in men's preferences for women's voices. *Biology Letters*, 4, 192-194.

Kissler, J. & Bäuml, K.-H. (2000). Effects of the beholder's age on the perception of facial attractiveness. *Acta Psychologica*, 104, 145-166.

Kitamura, C., Thanavishuth, C., Burnhama, D. & Luksaneeyanawin, S. (2002). Universality and specificity in infant-directed speech: Pitch modifications as a function of infant age and sex in a tonal and non-tonal language. *Infant Behavior & Development*, 24, 372-392.

Krantz, J.H., Ballard, J. & Scher, J. (1997). Comparing the results of laboratory and World-Wide Web samples on the determinants of female attractiveness. *Behavior Research Methods, Instruments, & Computers*, 29, 264-269.

Langlois, J.H., Ritter, J.M., Roggman, L.A. & Vaughn, L.S. (1991). Facial diversity and infant preferences for attractive faces. *Developmental Psychology*, 27, 79-84.

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.

Lee, P.A. & Migeon, C.J. (1975). Puberty in boys: correlation of plasma levels of gonadotropins (LH, FSH), androgens (testosterone, androstenedione, dehydroepiandrosterone and its sulfate), estrogens (estrone and estradiol) and progestins (progesterone and 17-hydroxyprogesterone). *Journal of Clinical Endocrinology & Metabolism*, 41, 556-562.

Lee, S., Potamianos, A. & Narayanan, S. (1999). Acoustics of children's speech: Developmental changes of temporal and spectral parameters. *The Journal of the Acoustical Society of America*, 105, 1455-1468.

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 - Biological Sciences (Series B)*, 268, 39-44.

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 - Biological Sciences (Series B)*, 269, 1095-1100.

Little, A.C., Penton-Voak, I.S., Burt, D.M. & Perrett, D.I. (2003). Investigating an imprinting-like phenomenon in humans: Partners and opposite-sex parents have similar hair and eye colour. *Evolution and Human Behavior*, 24, 43.

Little, A.C. & Jones, B.C. (2003). Evidence against perceptual bias views for symmetry preferences in human faces. *Proceedings Of The Royal Society Of London Series B-Biological Sciences*, 270, 1759-1763.

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 Series B-Biological Sciences*, 272, 2283 - 2287.

McClure, E.B. (2000). A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. *Psychological Bulletin*, 126, 424-453.

Meredydd, H., Sarah, H., Jeremy, H. & Ieuan, H. (1998). Changes in the male voice at puberty: Vocal fold length and its relationship to the fundamental frequency of the voice. *The Journal of Laryngology and Otology*, 112, 451-454.

Morton, J. & Johnson, M.H. (1991). CONSPEC and CONLERN: A two-process theory of infant face recognition. *Psychological Review*, 98, 164-181.

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.

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

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.S., 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.

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: Biological Sciences*, 276, 153-159.

Puts, D.A. (2006). Cyclic variation in women's preferences for masculine traits: Potential hormonal causes. *Human Nature*, 17, 114-127.

Puts, D.A., Gaulin, S.J.C. & Verdolini, K. (2006). Dominance and the evolution of sexual dimorphism in human voice pitch. *Evolution and Human Behavior*, 27, 283-296.

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.

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

Rhodes, G., Chan, J., Zebrowitz, L.A. & Simmons, L.W. (2003). Does sexual dimorphism in human faces signal health? *Biology Letters*, 270, S93–S95.

Rhodes, G. (2006). The evolutionary psychology of facial beauty. *Annual Review of Psychology*, 57, 199-226.

Roberts, S.C. & Little, A.C. (2008). Good genes, complementary genes and human mate choice. *Genetica*, 132, 309-321.

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 B: Biological Sciences*, 273, 2169-2175.

Roney, J.R. & Simmons, Z.L. (2008). Women's estradiol predicts preference for facial cues of men's testosterone. *Hormones and Behavior*, 53, 14-19.

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

Saxton, T.K., Caryl, P.G. & Roberts, S.C. (2006). Vocal and facial attractiveness judgments of children, adolescents and adults: the ontogeny of mate choice. *Ethology*, 112, 1179-1185.

Saxton, T.K., Burriss, R.P., Murray, A.K., Rowland, H.M. & Roberts, S.C. (2009). Face, body and speech cues independently predict judgments of attractiveness. *Journal of Evolutionary Psychology*, 7, 23-35.

Shackelford, T.K. & Larsen, R.J. (1997). Facial asymmetry as an indicator of psychological, emotional and physiological distress. *Journal of Personality and Social Psychology*, 72, 456-466.

Simmons, R.G., Blyth, D.A., Cleave, E.F.V. & Bush, D.M. (1979). Entry into early adolescence: The impact of school structure, puberty, and early dating on self-esteem. *American Sociological Review*, 44, 948.

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.

Symons, D. (1995). The Evolution of Human Sexuality. New York: Oxford University Press.

Thamdrup, E. (1961). Precocious Sexual Development, A Clinical Study of 100 Children. Kopenhagen: Munksgaard.

Thornhill, R. & Gangestad, S.W. (2006). Facial sexual dimorphism, developmental stability, and susceptibility to disease in men and women. *Evolution and Human Behavior*, 27, 131-144.

Tiddeman, B., Burt, D.M. & Perrett, D. (2001). Computer graphics in facial perception research. *IEEE Computer Graphics and Applications*, 21, 42-50.

Titze, I.R. (1994). Principles of Voice Production. New Jersey: Prentice Hall.

Tosi, O., Postan, D. & Bianculli, C. (1976). Longitudinal study of children's voices at puberty. XVIth International Congress of Logopedics and Phoniatrics, Interlaken 1974, S. Karger.

Trainor, L.J. & Zacharias, C.A. (1998). Infants prefer higher-pitched singing. *Infant Behavior and Development*, 21, 799-806.

Trivers, R.L. (1972). Parental investment and sexual selection. Sexual Selection and the Descent of Man. B. Campbell. London, Heinemann**:** 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.

Udry, J.R., Billy, J.O.G., Morris, N.M., Gross, T.R. & Raj, M.H. (1985). Serum androgenic hormones motivate sexual behavior in boys. *Fertility and Sterility*, 43, 90-94.

Udry, J.R. (1988). Biological predispositions and social control in adolescent sexual behavior. *American Sociological Review*, 53, 709-722.

Vukovic, J., Feinberg, D.R., Jones, B.C., DeBruine, L.M., Welling, L.L.M., Little, A.C. & Smith, F.G. (2008). Self-rated attractiveness predicts individual differences in women's preferences for masculine men's voices. *Personality And Individual Differences*, 45, 451-456.

Welling, L.L.M., 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.S. (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., Smith, F.G., Feinberg, D.R., Little, A.C. & Al-Dujaili, E.A.S. (2008). Men report stronger attraction to femininity in women's faces when their testosterone levels are high. *Hormones and Behavior*, 54, 703-708.

Willis, J. & Todorov, A. (2006). First impressions: Making up your mind after a 100-ms exposure to a face. *Psychological Science*, 17, 592-598.