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Testing a postulated case of intersexual selection in humans: The role of foot size in judgments of physical attractiveness and age ☆

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Abstract

The constituents of attractiveness differ across the sexes. Many relevant traits are dimorphic, suggesting that they are the product of intersexual selection. However, direction of causality is generally difficult to determine, as aesthetic criteria can as readily result from, as cause, dimorphism. Women have proportionately smaller feet than men. Prior work on the role of foot size in attractiveness suggests an asymmetry across the sexes, as small feet enhance female appearance, yet average, rather than large, feet are preferred on men. Previous investigations employed crude stimuli and limited samples. Here, we report on multiple cross-cultural studies designed to overcome these limitations. With the exception of one rural society, we find that small foot size is preferred when judging women, yet no equivalent preference applies to men. Similarly, consonant with the thesis that a preference for youth underlies intersexual selection acting on women, we document an inverse relationship between foot size and perceived age. Examination of preferences regarding, and inferences from, feet viewed in isolation suggests different roles for proportionality and absolute size in judgments of female and male bodies. Although the majority of these results bolster the conclusion that pedal dimorphism is the product of intersexual selection, the picture is complicated by the reversal of the usual preference for small female feet found in one rural society. While possibly explicable in terms of greater emphasis on female economic productivity relative to beauty, the latter finding underscores the importance of employing diverse samples when exploring postulated evolved aesthetic preferences.

Keywords: Sexual selection; Sexual dimorphism; Attractiveness; Foot size

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1. Introduction

1.1. The problem of direction of causality in the relationship between sexual dimorphism and aesthetic preferences

Considerable research explores the evolutionary underpinnings of physical attractiveness. While some features, such as symmetry and cues of health, play a role in the attractiveness of both sexes, the aesthetic value of other traits is sex-specific. When such a pattern is maintained over evolutionary time, via a process of intersexual selection, it can lead to sexual dimorphism (Darwin, 1871, 1872). Although many traits having sex-specific aesthetic value are sexually dimorphic, in practice, it is often difficult to demonstrate that dimorphism is the product of intersexual selection. Intersexual selection hypotheses predict a co-occurrence of sex-specific aesthetic preferences and sexual dimorphism, yet the same set of circumstances can, in principal, be explained by reversing the causal arrow—rather than being the product of such preferences, dimorphism can be the cause. If dimorphism is the result of other factors, such as sex-specific natural selection (see Slatkin, 1984) or developmental constraints stemming from another sex-specific trait, then, for at least three reasons, we might expect aesthetic preferences to reflect this difference between the sexes.

First, the sex-specific versions of a perceptible dimorphic trait can become associated in observers' minds with the respective sexes, leading observers to view each version as appropriately 'masculine' or 'feminine' (the observational hypothesis; Fessler et al., 2005b; Swami, Einon, & Furnham, 2006). Second, selective pressures favoring directing reproductive behavior toward members of the opposite sex can favor preferences for the sex-specific versions of the trait as a means of identifying the appropriate target of mating effort (the sex marker hypothesis). Lastly, if dimorphism is the product of sex-specific natural selection, then selection can favor a preference for that morphology optimal in the opposite sex in the service of choosing a maximally fit mate (the fitness indicator hypothesis).

One factor that can potentially clarify the evolutionary history of a paired sex-specific aesthetic preference and a sexually dimorphic trait is the existence of natural selection pressure favoring similarity across the sexes—whenever there are evident costs to a trait and such costs are comparable across the sexes, then a case can be made that dimorphism in the trait reflects an evolutionary history wherein intersexual selection has, at least to a degree, outweighed natural selection.

Although some dimorphic traits constitute an obvious handicap, for others, costs are less clear. A second tactic for discerning direction of causality is therefore to search for asymmetry in the relevant preferences. Specifically, the observational hypothesis, the sex marker hypothesis, and the fitness indicator hypothesis described above all predict symmetrical divergence in aesthetic preferences. If judges prefer the sex-specific average phenotype in one sex, then judges should likewise prefer the sex-specific average phenotype in the other sex. Likewise, to whatever extent judges prefer exaggeration from the sex-specific average phenotype in one sex, they should prefer the same degree of exaggeration (in the opposite direction) from the sex-specific average phenotype in the other sex. In contrast, intersexual selection is not intrinsically bilateral. In some cases of intersexual selection, the preferences of each sex regarding the other can be identical or nearly so (e.g., kindness is important in the mate selection criteria of both human males and females; Buss et al., 1990), with the result that two parallel processes of intersexual selection may be operating simultaneously. However, such symmetry is not inherent in intersexual selection, and, correspondingly, most well-documented examples of intersexual selection are unidirectional (see Andersson, 1994). If unidirectional intersexual selection is at work, we should expect an asymmetry of preferences, as follows: for the sex postulated to be the target of intersexual selection, judges should prefer an exaggerated version of the sex-specific trait relative to the sex-specific average phenotype, yet should display no equivalent preference regarding the other sex, either preferring the sex-specific average phenotype (because this will often be the most successful phenotype in the local environment; Koeslag & Koeslag, 1994; this indexes heterozygosity; Symons, 1979; Thornhill & Gangestad, 1993; or at a proximate level, prototypical exemplars are cognitively accessible; Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003) or else displaying no clear preference at all (if the observed range of variation in the other sex is within that favored by natural selection).

The above considerations indicate that, while finding symmetrical preferences does not definitively differentiate between intersexual selection and competing explanations, finding asymmetrical preferences makes it likely that intersexual selection alone applies. To date, one enterprise that has pitted an intersexual selection hypothesis against the alternatives by examining symmetry or the lack thereof in patterns of aesthetic preferences is the exploration of sexually dimorphic proportionate foot size.

1.2. The case of sexual dimorphism in foot size proportionate to stature

Fessler, Haley, and Lal (2005a) documented sexual dimorphism in foot size proportionate to stature in genetically disparate populations, a finding subsequently bolstered by Voracek, Fisher, Rupp, Lucas, and Fessler (2007) (see also Agnihotri, Purwar, Googoolye, Agnihotri, & Jeebun, 2007; Kanchan et al., 2008; Krishan & Sharma, 2007; Musiba, Tuttle, Hallgrimsson, & Webb, 1997; Ozden, Balcib, Demirüstü, Turgutd, & Ertugruld, 2005; Russell and Sheehan, 1942; Sanli et al., 2005; Zeybek, Ergur, & Demiroglu, 2008; but see Danborno & Elukpo, 2008, noting that ratios of means deviate from mean ratios, suggesting analytic error). Reasoning that foot size is a determinant of sagittal stability while walking, and noting that pregnancy

raises the center of gravity and displaces it ventrally while also increasing the costs of forward falls, Fessler et al. (2005a) argued that natural selection would be expected to have produced larger, rather than smaller, proportionate foot size in women relative to men and, hence, this female trait is costly. In light of evidence that foot size increases with age (also Atamturk & Duyar, 2008; Voracek et al., 2007) and may increase with parity, drawing on suggestions by Barber (1995) and Symons (2002), Fessler et al. (2005a) therefore hypothesized that pedal dimorphism reflects a history of intersexual selection driven by the human male preference for indices of female youth and nulliparity.

Fessler et al. (2005b) tested Fessler et al.'s (2005a) pedal intersexual selection hypothesis by asking participants in nine societies to select the most and least attractive individuals from two series of five line drawings that varied in foot size proportionate to stature. Pooling results across cultures, the authors found a preference for female figures with smaller-than-average feet, and a dislike of female figures with larger-than-average feet. In contrast, with regard to the male stimuli, the pooled results revealed a preference for average-sized feet and a dislike of both larger-than-average and smaller-than-average feet. Results thus displayed the directional asymmetry predicted by the intersexual selection hypothesis, and did not display the symmetry predicted by the competing hypotheses.

Although Fessler et al.'s pooled results were consistent with the intersexual selection hypothesis, the picture was less clear when their samples were considered individually. Participants displayed a significant preference for smaller female feet in Iran, Lithuania, Brazil, Russia, and the United States, with a nonsignificant trend in India. However, results from Cambodia and Papua New Guinea displayed no clear patterns, while those from Tanzania revealed a preference for larger, rather than smaller, female feet. With regard to the male stimuli, participants in Lithuania, Brazil, Russia, and the United States preferred figures with average-sized feet, and trends in the same direction were found in Iran, India, and Tanzania. However, results from Cambodia and Papua New Guinea again displayed no clear patterns.

Interpreting Fessler et al.'s findings is complicated by differences in the size of the samples, ranging from 150 in the United States to 29 in Tanzania. Moreover, the stimuli employed were crude, consisting of line drawings of a woman and a man on which the feet were resized on a photocopy machine, then retouched by hand. These drawings were not realistic; additionally, unintended variations between the images could have influenced judgments. Lastly, the postulated biomechanical disadvantages of proportionately smaller female feet have not been demonstrated—given both the complexity of bipedal locomotion and the existence of numerous relevant dimorphic traits (e.g., pelvis width) that reflect other selective pressures, it is possible that natural selection has not opposed, and may even have favored, proportionately smaller feet in women.

Although Fessler et al.'s effort is one of the few to probe the nature of the relationship between a sexually dimorphic trait and sex-specific aesthetic preferences, the case is far from proven. We therefore sought to subject the pedal intersexual selection hypothesis to more rigorous tests, employing realistic stimuli and large samples, and extending the original enterprise in a number of directions to further examine the underpinnings of this hypothesis. Below we report results from seven studies pitting the intersexual selection hypothesis against its competitors. First, replicating Fessler et al.'s method using improved procedures and larger samples, addressing the core prediction differentiating the intersexual selection hypothesis from its competitors, we begin by examining symmetry or the lack thereof in patterns of preferences for female and male targets of differing foot sizes. Second, we directly probe the unidirectionality of aesthetic valuation predicted by the intersexual selection hypothesis by asking whether men are more likely than women to notice differences in opposite-sex proportionate foot size, and whether such recognition influences judgments of attractiveness. Third, because the intersexual selection hypothesis rests in part on the relationship between female attractiveness and age, we explore whether proportionate foot size is indeed interpreted as a cue of age. Fourth, in keeping with the unidirectionality central to the intersexual selection hypothesis, we examine differences in the information conveyed by female and male foot size by investigating judgments of feet in isolation, and comparing these with judgments of bodies varying in size. Although the preponderance of our findings supports the intersexual selection hypothesis, these patterns were partially reversed in the one study conducted in a society in which people both frequently walk in open shoes or unshod and engage in extensive manual labor.

2. Study 1: role of proportionate foot size in aesthetic evaluations of women and men

2.1. Methods

A digital artist generated baseline images of a modestly attired barefoot female and male, of ambiguous ethnicity, with foot-length-to-stature ratios of 14.9% and 15.3%, respectively, proportions typical of the means in diverse populations (Fessler et al., 2005a). For each image, the artist then created two below-baseline images through duplication with successive reductions in foot size of 6%, and two above-baseline images through duplication with successive increases in foot size of 6%. The resulting arrays are illustrated in Figs. 1 and 2. Images were displayed in printed form; head-to-toe heights of the baseline images were 25.5 cm (female) and 26.5 cm (male). For convenience, we refer to the images, from smallest to largest foot size, as Images 1 through 5, the baseline image being Image 3; these numerical identifiers were not provided to participants.

Participants were unpaid volunteers. Data were collected in Austria, Brazil, Cambodia, Canada, China, Colombia,

Fig. 1. Female images used in Studies 1, 2, 3b, and 6 (images displayed here ordered from smallest to largest foot size).

Greece, and the United States; details of each sample, respective recruitment procedures, and other descriptive information are provided in the electronic supplementary material (available on the journal's website at www.ehbonline.org). Societies were selected for study on a convenience basis. Although we sought to capture some degree of cultural and geographical diversity, no claim is made as to the representativeness of these societies as

Fig. 2. Male images used in Studies 1, 2, 3b, and 6 (images displayed here ordered from smallest to largest foot size).

Table 1
Description of samples used in Study 1

	n	Age range (years)	Mean age (S.D.)	% Female
Austria	150	19–88	33.7 (13.54)	50.0
Brazil	157	18–75	32.0 (10.77)	51.0
Cambodia	149	18–63	25.7 (9.23)	49.7
Canada	150	17–64	26.0 (9.88)	50.0
China	149	18–83	30.7 (13.79)	47.0
Columbia	225	18–70	34.7 (12.52)	54.2
Greece	172	18–80	40.9 (16.55)	55.2
United States	148	19–86	34.6 (14.8)	45.3
Pooled	1300	17–88	32.6 (13.67)	50.6

regards the range of cultures in existence today, their respective contact with global media, or their practice of wearing footwear; likewise, no claim is made as to the representativeness of the samples with respect to the societies in which they were recruited.

All participants evaluated both sets of images. Fessler et al. (2005b) presented the female images first. Given the possibility of order effects, so as to put the possibility of replicating Fessler et al.'s results at maximal risk of failure, we therefore presented the male images first. The left-to-right sequence of each set of images was randomized for each participant. Holding the display screen approximately 1 m from the participant, the researcher asked the participant to point to the picture of the most attractive man. If, as not infrequently occurred, the participant complained that the pictures were all the same, the researcher replied, "There is no right or wrong answer. Just take a guess, which one do you think is most attractive?" The researcher then asked the participant to point to the picture of the least attractive man. The task was then repeated using the female images, randomized independently of the male images. All instructions were translated into the local language by the respective researchers. Prospective participants were unable to see the array or witness the current participant's responses.

2.2. Results

A total of 1300 participants from eight societies participated (see Table 1 for sample demographics; see supplementary material (available on the journal's website at www.ehbonline.org) for details on each constituent sample). Although the mean age of participants differed significantly between samples, $F(7,1292)=23.89$, $p<.001$, $\eta_p^2=.115$, participant age had only very weak effects on preferences for most attractive female image, $F(4,1295)=2.41$, $p=.048$, $\eta_p^2=.007$, least attractive female image, $F(4,1295)=2.59$, $p=.035$, $\eta_p^2=.008$, and least attractive male image, $F(4,1295)=2.99$, $p=.018$, $\eta_p^2=.009$, and no effect on most attractive male image. We therefore pooled data across samples for some analyses.

2.2.1. Female stimuli

Pooling data from all eight samples, participants showed systematic biases in their selections of most and least attractive female images. The distribution of the frequencies with which each of the female images was selected as most attractive is highly nonrandom, as is the distribution of the frequencies with which each female image was selected as least attractive (see Supplementary Fig. S1, available on the journal's website at www.ehbonline.org). Image 1, depicting the smallest feet, was most frequently selected as most attractive (39.8% of subjects), while an image depicting feet smaller than baseline (either Image 1 or 2) was selected as most attractive 59.0% of the time (had participants been choosing at random, these percentages would have been 20.0% and 40.0%, respectively). Conversely, Image 5, depicting the largest feet, was most frequently selected as least attractive (46.7% of subjects), while an image depicting feet larger than the baseline (Images 4 or 5) was selected as least attractive 62.6% of the time. Keeping in mind that differences were subtle and arrays were randomized, and hence participants often appeared to be guessing, it is revealing to ask whether, independent of the absolute sizes at issue, participants were internally consistent in their choices across the two questions, as revealed by whether the image selected by a given participant as most attractive depicted smaller feet than the image selected by the same participant as least attractive. This was overwhelmingly true—see Table 2.

Participant sex had no effect on the pattern of selections of female images; the frequencies with which men selected any given female image as most attractive did not differ from the frequencies with which women did so, $\chi^2(4)=2.05$, $p=.726$, nor did men's and women's selections differ for the least attractive image, $\chi^2(4)=7.71$, $p=.103$.

Comparisons across samples revealed between-population differences in the distributions of selections for the most attractive female image, $\chi^2(28)=138.94$, $p<.001$, and the least attractive female image, $\chi^2(28)=226.92$, $p<.001$. Despite this variation, examining patterns of choices within participants, in each population, a majority of individuals selected as most attractive an image exhibiting smaller feet than the image selected by the same participant as least attractive, with this rate uniformly significantly exceeding the chance value of 40% (see Table 2).

2.2.2. Male stimuli

Pooling data from all eight samples, the distribution of the frequencies with which each of the male images was selected as most attractive is nonrandom, as is the distribution of the frequencies with which each male image was selected as least attractive (Supplementary Fig. S1). However, compared with the results for the female images, the frequencies with which each of the male images was selected as most attractive is more uniform (Supplementary Fig. S1); baseline and below-baseline images are nearly identical in this regard, while images depicting feet larger than baseline are only slightly less likely to be selected. In contrast, more substantial differences are evident with regard to the images selected as least attractive (Supplementary Fig. S1), with the image depicting the largest feet and that depicting the smallest feet being most frequently selected. These patterns

Table 2
Within-participant consistency of answers, by study and subsample

Study	Instrument	Country (subsample)	Attractiveness judgment		Age judgment	
			Female images: % of participants who selected as most attractive an image having a smaller foot than that which the participant selected as least attractive. For whole-body image results in Study 5: % of participants who selected as most attractive an image less extreme than that selected as least attractive[a]	Male images: % of participants who selected as most attractive an image less extreme than that selected as least attractive[a]	Female images: % of participants who selected as youngest an image having a smaller foot than that which the participant selected as oldest[a]	Male images: % of participants who selected as youngest an image having a smaller foot than that which the participant selected as oldest[a]
			Expected value			
			40.0% (whole-body Study 5=33.3%)	33.3%	40.0%	40.0%
Study 1	Whole-body images	Austria	76.7***	41.3*		
		Brazil	54.1***	39.5^{+}		
		Cambodia	63.8***	45.0**		
		Canada	94.0***	60.0***		
		China	56.4***	43.0**		
		Columbia	86.2***	51.6***		
		Greece	65.7***	43.0**		
		United States	62.8***	43.9**		
		Pooled	70.8***	46.2***		
Study 2	Whole-body images[b]	United States (recognizers)	88.3***	58.7***		
		United States (nonrecognizers)	43.1	35.5		
Study 3a	Female whole-body line drawings	United States			75.6***	
Study 3b	Whole-body images	United States			57.6***	61.1***
Study 4	Images of soles	United States (UCLA)	65.3***	70.3***		
		South Africa (UKZN)	61.5***	57.5***		
Study 5	Images of soles	United States (MPCC)	72.0***	72.0***		
		Austria (UV)	82.0***	84.0***		
	Whole-body images	United States (MPCC)	85.2***	69.0***		
		Austria (UV)	74.3***	65.0***		
Study 6	Whole-body images	Indonesia	41.5	35.2	52.0***	48.5**
	Images of soles	Indonesia	33.7***	41.8**		

Note: $^{+}p<.10$, * $p<.05$, ** $p<.01$, *** $p<.001$ (one-tailed).
[a] Results of a binomial test assuming that all empirical values were significantly larger than would have been expected by chance.
[b] Male participants judged only female images; female participants judged only male images.

suggest that participants did not have strong preferences when selecting the most attractive stimulus, yet attended to deviations from the average proportions (centered around the baseline image) when judging which stimulus was least attractive. Because this pattern is relevant to adjudicating between the intersexual selection hypothesis and other explanations of sexual dimorphism in proportionate foot size, to examine this possibility further, following Fessler et al. (2005b), we created a new variable for each participant, an extremity score, representing the degree of deviation from the baseline foot size for each image chosen. Selections of Image 3 thus have an extremity score of 0, those of Images 2 and 4 have an extremity score of 1, and selections of Images 1 and 5, which deviate most from the baseline, have an extremity score of 2. Examining selections in this manner reveals that images having the greatest deviation from the baseline image were selected as least attractive in 53.0% of cases; in contrast, the baseline image was selected as least

attractive in only 16.0% of the responses. For 46.2% of the participants, the image selected as least attractive had an extremity score greater than the image selected as most attractive, compared with only 31.2% of participants who displayed the reverse pattern; extremity scores were systematically higher for selections of the least attractive male image than for the most attractive image (Wilcoxon $z=-5.90$, $p<.001$).

Men and women did not differ in the frequencies with which they selected male images with particular extremity scores as the most attractive (Mann–Whitney U test: $z=-1.26$, $p=.208$) or least attractive (Mann–Whitney U test: $z=-1.23$, $p=.219$). Likewise, examination of differences among the eight populations revealed no between-sample differences in the patterning of the extremity scores of the selections for most attractive [Kruskal–Wallis test: $\chi^2(7)=11.99$, $p=.101$]. Such a difference did appear for the extremity scores of the selections for least attractive [Kruskal–Wallis test: $\chi^2(7)=64.57$, $p<.001$]; however, as illustrated in Table 2, in all but one sample, extremity scores were significantly higher for images selected as least attractive than for those selected as most attractive, with the sole exception trending in the same direction.

2.3. Discussion

Study 1 revealed that, in samples from eight societies, a consistent pattern occurs wherein participants find small female foot size attractive and large female foot size unattractive. Participants do not display clear positive preferences with regard to male feet but do show patterns with regard to the converse, disliking both small and large male feet. The pattern of choices concerning female targets is consistent with both the intersexual selection hypothesis and competing accounts. Importantly, however, the pattern of choices concerning male targets is consistent only with the former—contrary to competing predictions, the strength of preferences with regard to what is attractive in a woman are not matched by equivalent preferences regarding men; moreover, participants not only dislike small male feet (as would be predicted by the competing hypotheses) but also dislike large male feet (contrary to competing predictions). This asymmetry in aesthetic preferences by sex of target suggests that sexual dimorphism in proportionate foot size is unlikely to be the source of aesthetic preferences; rather, these preferences are consistent with a history of directional intersexual selection acting exclusively on the feet of women.

A striking feature of Study 1 was the many anecdotal reports of participants complaining that the images were identical. The intersexual selection hypothesis predicts that proportionate foot size should be a salient feature in men's assessments of women's attractiveness, i.e., differences in female foot size should 'pop out' to male observers. In contrast, this hypothesis predicts that proportionate foot size should be no more salient in women's assessments of men's attractiveness than is true of many other traits that influence biomechanical efficiency, i.e., because male foot size is but one of many features judged with regard to general male proportionality, it should not 'pop out' to female observers to the same extent. Whereas the intersexual selection hypothesis predicts an asymmetry in the salience of foot size in cross-sex judgments, the competing hypotheses predict symmetry in this regard—if aesthetic preferences are a consequence, rather than a cause, of sexual dimorphism in proportionate foot size, then foot size should be equally salient in men's and women's judgments of the opposite sex.

A related question raised by participants' complaints that the images "look the same" is the issue of the extent to which conscious recognition of variation in proportionate foot size plays a role in expressed judgments. While it is possible that preferences shape judgments at a level not accessible to consciousness, people seem able to readily list the attributes that make an individual attractive, even if they cannot always articulate the criteria used to judge those attributes. This suggests that we should expect there to be a connection between conscious recognition of variation in proportionate foot size and expressed judgments. Relatedly, given that even relatively realistic computer-generated images are a weak stimulus compared with actual bodies, understanding the contributions of conscious recognition could shed light on the sometimes noisy nature of our findings. To explore these questions, we conducted a study using stimuli in which variations in proportionate foot size were intentionally made less evident.

3. Study 2: role of awareness of foot size in aesthetic evaluations of women and men

3.1. Methods

To reduce the perceptual salience of differences in foot size, the images used in Study 1 were reconfigured as follows: first, the images were shrunk, with the baseline images measuring only 14 cm from head to toe; second, the images were arrayed linearly from smallest to largest foot size, thus eliminating the juxtapositions of images having very small feet and those having very large feet that previously occurred through randomization. Similarly, on the presumption that repeated exposure to similar tasks would lead participants to scrutinize the stimuli more carefully, to reduce the number of tasks, male participants judged only female stimuli and female participants judged only male stimuli. A single array was presented to the participant on an 8.5×11-in. sheet of paper, and the participant was asked to indicate in writing the most and least attractive images. Additionally, participants rated each image on a scale of 1 (*not at all attractive*) to 9 (*extremely attractive*). Following completion of these tasks, participants were asked in free-response fashion how the images differed from one another, an issue not foreshadowed in the instructions that participants had received.

Participants were 643 undergraduate students (69.5% female; mean age 19.0 years, S.D.=1.55 years) in introductory psychology courses at the University of California, Los Angeles; participation was performed in exchange for course credit.

3.2. Results

3.2.1. Female images assessed by men

Participant age had no effect on selections of either most or least attractive image, nor did it affect the likelihood that a participant would correctly identify foot size as the manipulated feature. Over one third (39.3%) of participants correctly identified variation in foot size as the feature that distinguished the images from one another, with an additional 8.7% of participants listing foot size and an (incorrect) additional feature; 18.9% incorrectly exclusively listed attributes other than feet, while 33.2% stated that the images were identical. Because we are interested in the effects of conscious recognition of variation in foot size on aesthetic judgments, we pooled the first two categories (termed 'recognizers') and compared this subsample with one composed of the latter two categories (termed 'nonrecognizers').

Among both recognizers and nonrecognizers, the distribution of images selected as most attractive was nonrandom (see Supplementary Fig. S2, available on the journal's website at www.ehbonline.org). A large majority of recognizers selected Image 1 as most attractive, and more than three quarters selected a below-baseline image in this regard, while only a small fraction selected an above-baseline image. In contrast, among nonrecognizers, Image 3, the baseline image, was most frequently selected as most attractive, followed by Image 1. Although more nonrecognizers selected a below-baseline image than selected an above-baseline image, this pattern was greatly muted compared with recognizers. Correspondingly, the mean image number of the image selected as most attractive by recognizers, 1.70 (S.D.=1.11) was smaller than the mean image number of the image selected in this regard by nonrecognizers, 2.78 (S.D.=1.38), a highly significant difference, $t(194)=-6.02$, $p<.001$, $d=0.86$.

The difference between the two subsamples is even more dramatic with regard to the image selected as least attractive, with a substantial majority of recognizers choosing Image 5, and the vast majority selecting an above-baseline image, compared with a small fraction who selected a below-baseline image, a highly nonrandom distribution (Supplementary Fig. S2). In contrast, among nonrecognizers, the distribution of choices was random (Supplementary Fig. S2). Correspondingly, the mean image number of the image selected as least attractive by recognizers, 4.39 (S.D.=1.13) was much larger than the mean image number of the image selected in this regard by nonrecognizers, 2.84 (S.D.=1.46), a highly significant difference, $t(194)=8.27$, $p<.001$, $d=1.19$.

Whereas recognizers were highly consistent in their within-participant selections, with the vast majority of them selecting as most attractive an image having a smaller foot size than that selected as least attractive (Table 2), nonrecognizers were not internally consistent in their preferences, with the proportion of them performing in a consistent manner not differing from chance (Table 2). Consonant with these clear indications of a preference for smaller proportionate female foot size among recognizers, their Likert-scale attractiveness ratings declined in a perfectly linear fashion from Image 1 to Image 5 (mean [S.D.]: Image 1: 6.31 [2.02]; Image 2: 5.69 [2.32]; Image 3: 5.03 [2.07]; Image 4: 4.48 [2.27]; Image 5: 3.52 [2.04]). In contrast, nonrecognizers did not display a clear pattern (Image 1: 5.61 [1.95]; Image 2: 5.43 [2.06]; Image 3: 5.48 [1.87]; Image 4: 5.40 [1.86]; Image 5: 5.22 [2.04]).

3.2.2. Male images assessed by women

Participant age had no effect on selections of either most or least attractive image, nor did it affect the likelihood of being a recognizer. In contrast to the male participants, less than one fifth (19.2%) of female participants correctly identified variation in foot size as the feature that distinguished the images from one another, with an additional 5.1% of participants listing foot size and an (incorrect) additional feature; 15.7% incorrectly exclusively listed attributes other than feet, while a majority (60.0%) stated that the images were identical. The difference in the percentage of recognizers in the male and female samples (48.0% vs. 24.3%) is highly significant, $\chi^2(1)=35.05$, $p<.001$.

Among female recognizers, the distribution of choices for most attractive male image was random (Supplementary Fig. S2), although there was a slight preference for the central tendency. Among nonrecognizers, the distribution was not random, as Images 1 and 3 were selected slightly more frequently than Images 2, 4, or 5 (Supplementary Fig. S2). More clearly revealing a preference for the central tendency, recognizers most often selected Image 5 as least attractive (41.3%), followed by Image 1 (28.4%), with only 8.3% selecting the baseline image in this regard, a nonrandom distribution (Supplementary Fig. S2). In contrast, among nonrecognizers, the distribution of images selected as least attractive was almost entirely uniform (Supplementary Fig. S2). Attractiveness ratings of each of the images were not patterned among either subsample. Recognizers' preference for the average phenotype, in contrast to the nonrecognizers failure to discriminate, was evident with regard to within-participant preferences: recognizers selected as least attractive an image with a greater extremity score than the image selected by the same participant as most attractive at a rate far greater than chance (see Table 2), whereas nonrecognizers did not differ from chance in this regard, a significant difference between the two subsamples (Mann–Whitney U test, $z=-4.28$, $p<.001$).

3.3. Discussion

Overall, male participants detected that the female images differed in foot size at twice the rate that female participants

detected that the male images differed in foot size. This suggests that, in judging attractiveness, men pay more attention to women's feet than women do to men's feet, a conclusion bolstered by Voracek et al.'s (2007) finding that men reported liking women's feet more than women reported liking men's feet. This pattern is exactly what is to be expected if sexual dimorphism in proportionate foot size is the product of unidirectional intersexual selection acting on females.

Conscious recognition that stimuli vary in proportionate foot size has an effect on the judgments of both sexes. Male recognizers dramatically manifested the preference for small female foot size and the dislike of large female foot size found earlier, whereas male nonrecognizers showed no clear patterns. Similarly, female recognizers displayed a mild preference for the average male foot size and a clear dislike of both large and small male foot size, whereas female nonrecognizers did not display clear patterns in either regard. Our redundant findings (see Study 1, above, and additional studies, below) of a lack of patterned differences between women's and men's judgments of images of a given sex indicates that it is reasonable to generalize from the above sex-specific results. Taken together, with the caveat that it is possible that preferences may also influence recognition, these findings suggest that conscious recognition of variation in proportionate foot size enhances the manifestation of preferences for small female feet and the dislike of both large and small male feet.

The question of the role of conscious recognition in the contributions of proportionate foot size to aesthetic judgments raises a related issue stemming from the postulated ultimate function of male preferences for small female feet. In contrast to competing explanations—which are silent on the question—the intersexual selection hypothesis explicitly argues that proportionately small female feet are attractive in part because they are cues of youth. While natural selection could have crafted an aesthetic preference for proportionately small female feet without linking this to any conscious awareness of age, such a linkage nevertheless seems likely given that people are acutely aware of the role of youth in female mate value (Kenrick & Keefe, 1992), and, correspondingly, female faces judged to be attractive are also perceived as younger (Henss, 1991; Johnson & Franklin, 1993). Because such a linkage would speak to the cogency of the intersexual selection hypothesis, to explore this possibility, we conducted two studies investigating the influence of proportionate foot size on perceptions of age.

4. Study 3a: role of foot size in perceptions of female age—line drawings

4.1. Methods

Because the digital stimuli employed in Studies 1 and 2 were still in development at the time, we employed the female line drawings used by Fessler et al. (2005b). Passers-by in public locations in Los Angeles were asked to participate in a brief study on factors influencing estimations of age; no compensation was offered. The left-to-right sequence of drawings was randomized for each participant, and drawings were displayed approximately 1 m from the participant. Participants were asked to point to the picture of the youngest woman; if they complained that the drawings were identical, participants were told, "There is no right or wrong answer. Just take a guess, which one do you think is youngest?" Participants were then asked to point to the picture of the oldest woman. Individuals waiting to participate were prevented from seeing the array or witnessing the participant's responses.

4.2. Results

Data were collected from 406 participants (44.6% female), ranging in age from 18 to 76 years (mean 30.9, S.D.=11.44 years). Participant age had no effect on images selected as either youngest or oldest. Participant sex had an effect on images selected as youngest, $\chi^2(4)=11.86$, $p=.018$, with women tending to select a drawing exhibiting a slightly smaller foot as youngest compared with men; however, patterns for male and female participants were in the same direction. Participant sex had no effect on drawings selected as oldest. In light of the minor nature of the effect of sex on the first question and the absence of an effect on the second question, we pooled responses across sex of participant. Both the distribution for drawings selected as youngest and that for drawings selected as oldest were nonrandom (Supplementary Fig. S3, available on the journal's website at www.ehbonline.org). A majority of participants selected drawings with smaller feet as the youngest and a majority of participants selected drawings with larger feet as the oldest. The mean image number selected as youngest was 2.34 (S.D.=1.34), while the mean image number selected as oldest was 3.68 (S.D.=1.22). Evaluating the consistency of participants' choices across the two questions, we find that three quarters of participants selected as youngest a drawing depicting a smaller foot size than the drawing that the same participant selected as oldest, a significant deviation from chance (see Table 2).

4.3. Discussion

Results from Study 3a suggest that foot size influences observers' perceptions of female age and, consistent with the premise motivating the intersexual selection hypothesis, the drawing perceived as most attractive in Fessler et al.'s (2005b) original study was here perceived as youngest, while the drawing previously found to be least attractive was judged to be the oldest. However, confidence in this conclusion is constrained by methodological limitations. First, in addition to the problems with the line drawings discussed earlier, the manner in which the stimuli were produced introduced subtle differences in height, corresponding to differences in foot size, between the images. Given that, during maturation, height is one of the most obvious cues of age, and given that the facial and nonpedal somatic features in the images suggest a young

adult age, it is thus possible that participants were attending to stature rather than foot size when judging the age of the images. Second, the claim that there is a link between the role of foot size in aesthetic judgments of women's bodies and the role of foot size in assessments of women's ages hinges on the notion that youthfulness is a component of female attractiveness. Accordingly, to meaningfully combine studies of these two phenomena, both female and male images should be evaluated, as this claim generates the prediction that a) foot size should play a similar role in assessments of male age, but b) the patterning of such assessments should not map onto aesthetic preferences with regard to male bodies, given that youthfulness in and of itself is not thought to be a principal contributor to the latter. In order to address the limitations of Study 3a and test the aforementioned prediction, we therefore revisited the question of age assessments.

5. Study 3b: role of foot size in perceptions of age—computer-generated images

5.1. Methods

Although the stimuli employed in Study 1 are a substantial improvement over Fessler et al.'s (2005b) line drawings, for the purposes of assessing perceptions of age, they share with the latter the limitation that foot size and image height are correlated. Indeed, unless one is willing to introduce other anthropometric changes (potentially producing unknown effects on participants' assessments), it is impossible to alter the size of an image's feet without also altering its height. In using the stimuli employed in Study 1, we therefore sought to maximize the difficulty of comparing the height of the images by vertically displacing every other image in each array by approximately 1.25 cm. The left-to-right sequence of each array was again randomized for each participant. All participants viewed both female and male images, with the order of presentation counterbalanced across participants. All other aspects of the protocol, including recruitment procedures and study location, were identical to Study 3a.

5.2. Results

A total of 203 individuals (44.8% women) participated; ages ranged from 18 to 59 years (mean 28.1 years, S.D.= 10.0). Responses to all four questions did not differ by participant sex. Participant age influenced only responses to the request to select the youngest male, $F(4,198)=3.66$, $p=.007$, $\eta_p^2=.069$, with younger participants selecting a drawing depicting a slightly smaller foot size compared with that selected by older participants. No consistent effects of the order of presentation of stimuli emerged. In light of the generally similar patterns of responses across participants' sexes and ages, we pooled data for all subsequent analyses.

5.2.1. Female images

The distribution of images selected as youngest did not differ from chance, although there was a trend for participants to select images with smaller feet as the youngest, with more choosing below-baseline images than above-baseline images (Supplementary Fig. S3). More clearly, the distribution of images selected as oldest differed from chance: when selecting the oldest, almost one third of participants selected Image 5, the image with the largest feet (Supplementary Fig. S3). The mean image number selected as youngest (2.84, S.D.=1.47) was notably smaller than that selected as oldest (3.30, S.D.=1.51). Evaluating the consistency of participants' choices across the two questions, we find that a majority of participants selected as youngest an image depicting a smaller foot size than the image that the same participant selected as oldest, a significant deviation from chance (see Table 2).

5.2.2. Male images

The distribution of images selected as youngest trended toward being nonrandom, $\chi^2(4)=9.09$, $p=.059$, but the distribution of images selected as oldest was random (Supplementary Fig. S3). Participants tended to select images with smaller feet as the youngest, with more choosing below-baseline images than above-baseline images; the opposite was true with regard to images selected as oldest (Supplementary Fig. S3); the mean image number selected as youngest was 2.73 (S.D.=1.39), while the mean image number selected as oldest was 3.17 (S.D.=1.47). Evaluating the consistency of participants' choices across the two questions, we find that participants were significantly more likely than chance to select as youngest an image depicting a smaller foot size than the image that the same participant selected as oldest (see Table 2).

5.3. Discussion

With the addition of more realistic stimuli and a display format that obscures differences in height, the patterns found in Study 3a become somewhat less stark, with the distribution of images selected as youngest and oldest becoming more random. Nevertheless, although patterns of responses to only two of the four questions (oldest female image, youngest male image) were significantly different from chance, patterns of responses to the remaining two questions (youngest female image, oldest male image) trended in the predicted directions. Furthermore, participants were significantly internally consistent with regard to both female and male arrays, selecting as youngest an image depicting a smaller foot size than that which they selected as oldest. Taken together, these results support the conclusion drawn from Study 3a that participants correctly interpret female proportionate foot size as a cue of age and, moreover, the same is true of male proportionate foot size. The latter is noteworthy given the results of Studies 1 and 2, as cues of age generally play a central role in evaluations of female, but not male, physical attractiveness—the redundant patterns of

a preference for women with small feet, but a dislike of men with either small or large feet, are consistent with the importance of youth in female, but not male, mate value.

6. Study 4: contributions to attractiveness of relative vs. absolute foot size

An important feature of our exploration of the intersexual selection hypothesis is the presumption that the patterns documented thus far are driven by the contributions to attractiveness of relative, rather than absolute, foot size. Indeed, as regards male attractiveness, there is reason to believe that absolute foot size potentially plays a different role than does relative foot size. Because foot size scales with body size (Fessler et al., 2005a), in the absence of other information, absolute foot size should act as a cue of stature. Given that, consonant with its role in both dominance and prestige, height substantially enhances male attractiveness (Hensley, 1994; Pierce, 1996; Mueller & Mazur, 2001; Nettle, 2002a), this generates the prediction that, when judging male feet in the absence of other information, people should display a preference for greater absolute size and a dislike of lesser absolute size. However, because stature does not importantly contribute to female attractiveness (Hensley, 1994; Pierce, 1996; see also Nettle, 2002b), we expect that, in the absence of other information, people will revert to the criteria applicable to relative female foot size, wherein smaller is better. Hence, whereas Studies 1 and 2 reveal an asymmetry in the sex-specific criteria, with a clear preference for proportionately small female feet, but no equivalent preference for proportionately large male feet, we expect that, when disembodied feet are judged, more symmetrical preferences will appear.

6.1. Methods

In creating stimuli, we pursued two objectives. First, we wanted to focus participants' attention on the foot independent of the rest of the body. Second, to reduce demand characteristics, we wanted to disguise the fact that the size of the foot was the feature of interest. We therefore employed digitally scanned images of the soles of the right foot of five male and five female Austrian volunteers; these individuals ranged in age from 22 to 30, years ranged in height from 162 to 186 cm, had normal body mass indices, and lacked podiatric problems. These highly realistic images contain no information about the rest of the body, and vary on numerous parameters, obscuring the fact that the goal of the investigation is to measure the effect of foot size.

To gauge the impact of foot size independent of the many other parameters on which the scanned images differ from one another, we altered the images as follows: A single male image and a single female image were randomly selected to serve as the baseline images for each sex. All other images of the same sex were then rescaled so as to be the same size as the baseline image. The five male images and five female images then underwent two phases of modification. First, a randomly selected image was manipulated twice; in the first manipulation, the image was enlarged by 5%; in the second manipulation, the same image was shrunk (from baseline) by 5%. The same procedures were then performed on a second randomly selected image using alterations of 10%. The images were then sorted so as to create two arrays for each sex such that the same foot that constituted the smallest image in the first array also provided the largest image in the second array, and vice versa, and the same foot that was the second smallest in the first array served as the second largest in the second array, and vice versa (see Fig. 3). This ensured that features of a given foot other than its (apparent) size would not influence the patterns being investigated. The left-to-right sequence of the images was then randomized for each array. The images in each array were labeled with sequential letters.

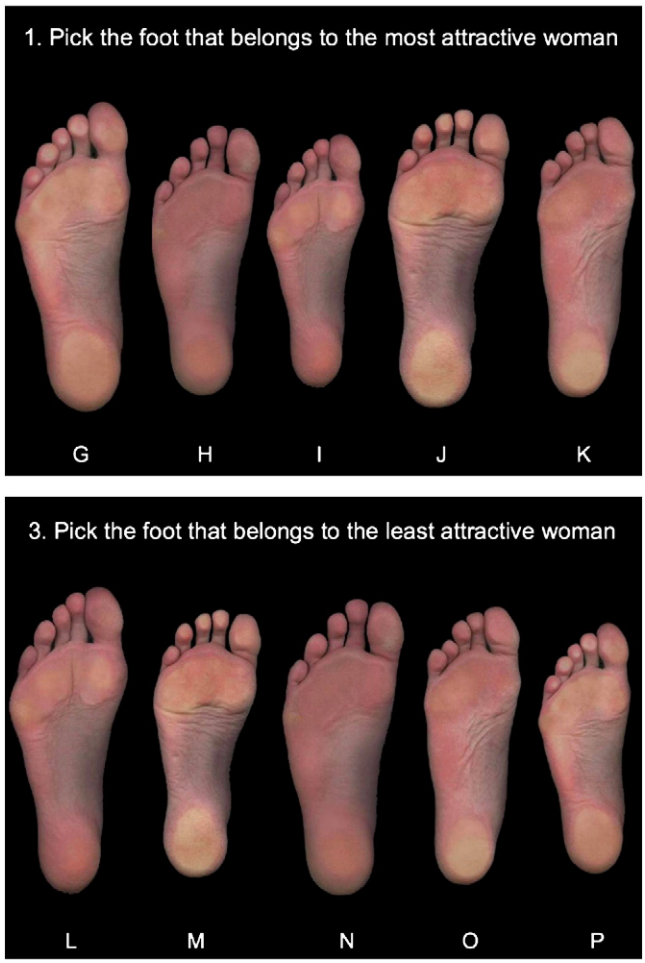

Fig. 3. Female foot arrays used in Studies 4, 5, and 6. Note: Image I is the same foot (resized) as Image L, Image G is the same foot (resized) as Image P, etc.

The arrays of manipulated scanned images were projected as PowerPoint slides on a large screen in undergraduate courses at the University of California, Los Angeles (UCLA) and the University of KwaZulu-Natal (UKZN, Durban, South

Africa). The first slide was accompanied by the instruction, "Pick the foot that belongs to the most attractive woman"; the second slide was accompanied by the instruction, "Pick the foot that belongs to the least attractive woman"; equivalent instructions then accompanied the two sets of male images. In between each of the test slides, distracter questions appeared. The final slide requested the participant's gender. To enhance anonymity, age data were not collected, a justifiable step given the lack of patterned effects of participant age in our previous studies. Participants wrote their answers on slips of paper. Participation was uncompensated.

6.2. Results

The UCLA sample was composed of 239 students (69.5% female) and the UKZN sample was composed of 174 students (81.6% female).

6.2.1. Female images

In neither sample did choices differ by participant sex, hence we collapsed across sex for both samples for subsequent analyses. At both locations, the distribution of choices was nonrandom for both most attractive image and least attractive image (Supplementary Fig. S4, available on the journal's website at www.ehbonline.org). At both UCLA and UKZN, the second smallest image was chosen most frequently as most attractive, with images below baseline being selected substantially more often in this regard than images above baseline (71.1% vs. 16.3% at UCLA; 51.8% vs. 31.6% at UKZN). Conversely, at both locations, the largest image was chosen most frequently as least attractive, with images above baseline being selected substantially more often in this regard than images below baseline (59.4% vs. 25.1% at UCLA; 61.5% vs. 18.4% at UKZN). Examining the internal consistency of participants' responses to these two questions, at both locations participants selected as most attractive an image that was smaller than that which the same participant selected as least attractive at a rate significantly different from chance (see Table 2).

6.2.2. Male images

Participant sex influenced choices only at UCLA, and only with regard to the least attractive male image, $\chi^2(4)=12.90$, $p=.012$, with women selecting a slightly smaller male foot than did men. As the sex difference was small, we collapsed across sex in both samples for subsequent analyses. The distribution of choices was nonrandom for both most attractive image and least attractive image (Supplementary Fig. S4). At both locations, the second largest image was chosen most frequently as most attractive, with images above baseline being selected substantially more often in this regard than images below baseline (79.9% vs. 6.3% at UCLA; 53.5% vs. 22.2% at UKZN; see Supplementary Fig. S4). However, in contrast to this clear directional bias, in both samples, the frequency of selections for least attractive male image was bimodal (Supplementary Fig. S4). At both locations, the vast majority of participants selected either the smallest image or the largest image. Despite the emergence of a preference for large male feet not found in the previous studies using whole-body images, the pattern of a dislike of extremes was again produced, with participants at both locations selecting as most attractive an image that was less extreme than that selected as least attractive at frequencies far above chance (see Table 2).

6.3. Discussion

Assessing only images of the soles of feet as an index of the attractiveness of the entire person, participants in the United States and South Africa produced patterns of choices similar to, but not identical with, the patterns obtained using depictions of whole bodies in Studies 1 and 2. While large female feet are again clearly disliked, the preferred female foot is now not the smallest, but the second smallest. More dramatically, whereas our studies using whole-body images showed no clear pattern with regard to preferred male foot size, particularly in the United States, the present study reveals a preference for slightly larger than average foot size, even while the dislike of both very large and very small feet evident in the whole-body studies appears again in judgments of images of soles.

Given that foot size scales with body size, one plausible interpretation of the above patterns is that, as we expected, when viewing only the soles of feet, participants asked to evaluate the attractiveness of the entire person employ absolute foot size to infer height in addition to any guesses that they might make regarding proportionate foot size. This would explain the most dramatic difference between the results of Study 4 and those of Studies 1 and 2, namely, the clear preference for slightly larger than average male feet, as this would translate into a preference for slightly taller than average male height. At the same time, such a pattern could explain why the dislike of very large and very small male feet is maintained in this study, as there is likely a ceiling to the positive contributions of height to male attractiveness (Hensley, 1994). To both examine the reliability of these findings and test this explanation more directly, we conducted a similar study designed to allow for a comparison of participants' preferences concerning absolute foot size with their preferences regarding overall body size.

7. Study 5: connections between preferences for absolute foot size and preferences for body size

7.1. Methods

Two sets of stimuli were presented as PowerPoint slides in university classroom settings. The first set consisted of the same scanned images of actual feet used in Study 4, including the same distracter questions. The second set, intended to evaluate preferences for height/body size, were created by repeatedly resizing the baseline computer-

generated images from Studies 1 and 2 to create two arrays of five female images each and two arrays of five male images each, with images within each array differing only by size. The relative sizes employed were precisely the same as the relative sizes of the resized scanned images of feet from the corresponding slides from Study 4, and the left-to-right sequence was similarly randomized. Participants were again asked to pick out the most and least attractive images, again with distracter questions displayed between each array slide. The first set of stimuli (scanned feet) was presented at the beginning of a lecture; without prior announcement, the second set of stimuli (computer-generated whole-body images) was presented at the end of the same lecture, a delay of approximately one hour. Participation was uncompensated and anonymous. Data were collected at Mount Palomar Community College (MPCC, San Marcos, CA) and the University of Vienna (UV, Vienna, Austria).

7.2. Results

The MPCC sample was composed of 214 students (44.4% female) and the UV sample was composed of 101 students (82.2% female).

7.2.1. Female scanned foot images

Once again, in neither sample did choices differ by participant sex, hence we collapsed across sex for both samples. At both locations, the distribution of choices was nonrandom for both most attractive image and least attractive image (Supplementary Fig. S5, available on the journal's website at www.ehbonline.org). At both locations, the second smallest image was again chosen most frequently as most attractive, with images below baseline again being selected substantially more often in this regard than images above baseline (75.4% vs. 16.1% at MPCC; 70.3% vs. 16.8% at UV). Conversely, at both locations, the largest image was again chosen most frequently as least attractive, with images above baseline being selected substantially more often in this regard than images below baseline (53.0% vs. 29.1% at MPCC; 73.3% vs. 10.9% at UV). Examining the internal consistency of participants' responses to these two questions, at both locations, the vast majority of participants selected as most attractive an image that was smaller than that which the same participant selected as least attractive (see Table 2).

7.2.2. Male scanned foot images

Again participant sex had no effect on choices, hence we collapsed across sex for subsequent analyses. The distribution of choices was nonrandom for both most attractive image and least attractive image (Supplementary Fig. S5, available on the journal's website at www.ehbonline.org). At both locations, the second largest image was again chosen most frequently as most attractive, with images above baseline being selected substantially more often in this regard than images below baseline (64.0% vs. 19.7% at MPCC; 80.2% vs. 5.9% at UV). However, once again, in contrast to this clear directional bias, in both samples, the frequency of selections for least attractive male image was bimodal. At both locations, the vast majority of participants selected either the smallest image or the largest image (Supplementary Fig. S5). To characterize the differences in the frequency of selections for the most attractive and least attractive images, we again compare extremity scores. At both locations, the percentage of participants whose extremity score for the most attractive selection was less than their extremity score for the least attractive selection was again vastly greater than chance (see Table 2).

7.2.3. Female whole-body images

Given that the patterns of results from samples at MPCC and UV for the scanned foot images are quite similar to those obtained using these images in Study 4 from samples at UCLA and UKZN, we can confidently explore patterns with regard to body size images. At both MPCC and UV, the distribution of choices was nonrandom for both most attractive female body image and least attractive female body image (Supplementary Fig. S5). When judging female body size, participants at both locations showed a clear preference for the central tendency and a dislike of both very small and, particularly, very large female bodies (Supplementary Fig. S5). We can quantify this pattern using the extremity score procedure—at both locations, a significantly greater than chance percentage of participants had an extremity score for the most attractive body size that was less than their extremity score for the least attractive body size (see Table 2).

7.2.4. Male whole-body images

At both MPCC and UV, the distribution of choices was nonrandom for most attractive male body image and least attractive male image (Supplementary Fig. S5). Directly paralleling the results for the images of feet, at both locations, Image 4, the second largest image, dominated selections for most attractive, followed by Image 5 (Supplementary Fig. S5). However, the bimodal distribution of images selected for least attractive male foot was not paralleled by selections for least attractive male body, as nearly all participants selected Image 1 (Supplementary Fig. S5); rather than reflecting a preference for the central tendency, highly significant extremity score calculations for male whole-body images (Table 2) thus reflect the asymmetry between the preference for second largest male body and the uniform dislike of the smallest male body.

7.3. Discussion

In a second study of judgments of the attractiveness of an entire person based exclusively on scanned images of the soles of actual feet, results from a different California sample and from a new Austrian sample replicate the findings of Study 4 derived from samples in California and South Africa. Participants again display a preference for smaller female feet, with the second smallest again dominating and a dislike of larger female feet, with largest again dominating.

Likewise, when judging male feet in isolation, participants again show a preference not for the central tendency, but for the second largest foot, and again show a dislike for both the smallest and largest feet, with the former again dominating. With the caveat that inferences are being made on the basis of frequencies of choices across participants (rather than measured hierarchies of preferences within participants), comparing these patterns with those obtained from the same participants using computer-generated images of whole bodies that differ only in bodily size (not proportionate foot size) sheds light on the similarities and differences between results obtained using images of feet alone and images of feet in proportion to body size.

Participants show a strong dislike of both large female feet in isolation and large female body size, a conjunction that could indicate that either (a) participants are interpreting feet in isolation as revealing of body size or (b) participants are interpreting feet in isolation as revealing of proportionate foot size, and also happen to dislike large female bodies. However, while patterns of disliking are not revealing in this regard, patterns of attraction are more informative. Specifically, the prevailing attraction to the second smallest female foot differs markedly from the prevailing attraction to intermediate-sized female bodies. This suggests that, when making judgments about female feet in isolation, most participants are operating primarily on the basis of a preference for small proportionate foot size. Participants appear to only secondarily be interpreting female feet in isolation as a cue of female body size, a possibility that would account for the preference for second smallest female foot (rather than smallest proportionate female foot, as in Studies 1 and 2), as this is consistent with the dislike of very small female bodies by a subset of participants.

Whereas participants seem to be employing foot size in isolation primarily as the basis for inferences regarding proportionate foot size when they are judging women, the reverse appears to be true when they are judging men. In stark contrast to the absence of a preference for large feet when judging proportionate male foot size in Studies 1 and 2, Studies 4 and 5 reveal a strong preference for second largest male foot size when feet are viewed in isolation, along with an increased preference for the largest foot size and an increase in the dislike for the smallest foot size. Given that the second largest male body size is strongly preferred, followed by the largest male body size, and that the smallest male body size is overwhelmingly disliked, these patterns suggest that, when judging men on the basis of their feet in isolation, participants primarily interpret feet as cues of male body size, and only secondarily attend to the question of proportionate foot size.

If correct, the above interpretations reveal a reversal of the priority assigned to the cue values associated with proportionality and absolute size when judging female and male feet. Although foot size proportionate to body size seems to take precedence when assessing female feet in isolation, foot size as a cue of body size seems to take precedence when assessing male feet in isolation. These are exactly the patterns to be expected if proportionate foot size —operating as a cue of age, as revealed in Studies 3a and 3b —plays a significant role in evaluating female attractiveness; likewise, consonant with the lesser role of age in male attractiveness, and the greater role of physical formidability (and thus body size), foot size should have less relevance in evaluating male attractiveness beyond its association with body size.

8. Study 6: assessing the role of foot size in judgments of attractiveness and age in a society in which locomotory efficiency matters and closed footwear is rarely worn

Although conducted in diverse societies, Studies 1 through 5 share the feature that participants were primarily, often exclusively, urban dwellers. For the vast majority of individuals sampled in these studies, locomotory efficiency is likely to be a minor concern, as access to motorized transportation is extensive, and manual labor is minimal. Similarly, although subject to some variation as a function of latitude and degree of economic prosperity, these populations are characterized by frequent, if not exclusive, use of confining or closed footwear. Just as between-population differences in food availability appear to influence the relative aesthetic priority assigned to waist-to-hip ratios and overall adiposity (e.g., Sugiyama, 2004; Swami & Tovée, 2007), so too may considerations of locomotory efficiency influence judgments of foot size. Likewise, given that the habitual use of confining footwear likely alters foot proportions (Ashizawa, Kumakura, Kusumoto, & Narasaki, 1997) and inherently limits visual access to feet, it is possible that judgments may vary as a function of shoe use. In order to explore these possibilities, we employed the methods of Studies 1, 3b, and 4 among the Karo Batak, a rural population in highland Sumatra, Indonesia. Living in a hilly, tropical region and depending predominantly upon subsistence and cash-crop agriculture, people in this area engage in substantial manual labor, and commonly walk significant distances, often wearing simple open rubber or plastic sandals or going barefoot (see supplementary material, available on the journal's website at www.ehbonline.org, for additional background information).

8.1. Methods

The tasks and stimuli of Study 1 (attractiveness judgments of artificial images varying in proportionate foot size), Study 3b (age judgments of artificial images varying in proportionate foot size), and Study 4 (attractiveness judgments based on scanned actual feet in isolation) were presented sequentially, in that order, to most participants, with no delay between tasks. Stimuli for the first and second tasks were presented as in Studies 1 and 3b; stimuli for the third task were displayed on the screen of a laptop computer. Due to miscommunications, some participants were given

only the second and third tasks, and a few participants were given only the third task.

8.2.1. Results: attempted replication of Study 1 (attractiveness of whole-body images)

One hundred fifty-nine individuals (50.9% female) ranging in age from 19 to 90 years (mean 40.3, S.D.=15.6 years) participated. Examining results for the Study 1-style task, participant age had an effect only on selections of least attractive male image, $F(4,154)=3.49$, $p=.009$, $\eta_p^2=.083$, with younger participants selecting a male image with a slightly larger foot as least attractive. Turning to judgments of the female images, participant sex had no effect on selections of either most or least attractive image; hence, we pooled results across sex.

With regard to judgments of the most attractive female image, in contrast to all prior results, the distribution of images selected was random (Supplementary Fig. S6, panel 1, available on the journal's website at www.ehbonline.org). Moreover, Image 5, possessing the largest proportionate foot, was most frequently selected as most attractive. Forty-four percent of participants selected an image larger than the baseline as most attractive, while only 32.7% selected an image smaller than the baseline—strikingly, Image 1 was least frequently selected.

With regard to judgments of the least attractive female image, again in contrast to prior results, the distribution of images selected was random (Supplementary Fig. S6, panel 1). An image smaller than baseline was selected by 43.4% of participants as least attractive, while an image larger than baseline was selected by 37.1%. Despite these patterns, there was a nonsignificant trend for participants to select as most attractive an image that was smaller than that which the same participant selected as least attractive (see Table 2).

Turning to judgments of male images, participant sex again had no effect on selections of either most or least attractive image; hence, we pooled results across sex. The distribution of male images selected was random for both most attractive and least attractive (Supplementary Fig. S6, panel 1). Forty-four percent of participants selected an image larger than baseline as most attractive, while 40.9% of participants selected and image smaller than baseline in this regard. In contrast to prior results in which participants exhibited a dislike of the extreme male images, Image 3, the baseline image, was most commonly selected as least attractive, followed by Image 5. Correspondingly, the percentage of participants selecting an image as least attractive that had an extremity score greater than the image selected as most attractive did not differ from chance (see Table 2).

8.2.2. Results: attempted replication of Study 3b (age of whole-body images)

The task was completed by 200 individuals (53.0% female), ranging in age from 18 to 90 years (mean 41.5, S.D.=16.6 years). Neither participant age nor participant sex had an effect on responses to any of the items.

Turning first to age judgments of the female images, both the distribution of images selected as youngest and that for images selected as oldest did not differ from a random distribution (Supplementary Fig. S6, panel 2). Image 1 was most frequently selected as youngest, but this was closely followed by Image 5; correspondingly, the percentage of participants selecting an image smaller than baseline as youngest was nearly identical to that selecting an image larger than baseline (Supplementary Fig. S6, panel 2). Reversing previous findings, more participants selected images smaller than baseline as oldest (41.5%) than selected images larger than baseline (33.5%). Despite these patterns, however, when we examine consistency within individual participants' choices, we find that, consonant with prior results, a majority of participants selected as youngest an image with a smaller proportionate foot size than the image that the same participant selected as oldest, a highly significant pattern (see Table 2).

With regard to age judgments of male images, again, both the distribution of images selected as youngest and that for images selected as oldest did not differ from a random distribution. However, the pattern of choices for youngest image was nonetheless somewhat clearer than was true of female images, with 46.5% of participants selected an image smaller than baseline, compared with 38.5% who selected an image larger than baseline (Supplementary Fig. S6, panel 2). The distribution was more uniform with regard to images selected as oldest, with nearly identical percentages of participants selecting, respectively, an image smaller than baseline or an image larger than baseline. However, examining consistency within individual participants' choices, again consonant with prior results, 48.5% of participants selected as youngest an image with a smaller proportionate foot size than the image that the same participant selected as oldest, a significant pattern (see Table 2).

8.2.3. Results: attempted replication of Study 4 (attractiveness of scanned images from actual feet)

Attractiveness judgments of scanned images of actual feet were provided by 208 participants (52.9% female), ranging in age from 18 to 90 (mean 40.8, S.D.=16.3). Participant's age had modest effects on judgments of the most attractive female stimuli and least attractive male stimuli, but the patterns were not consistent. Participant sex had no effect on any of the items.

Turning first to judgments of female feet, the distribution of images selected as most attractive was not random; the same was true of the distribution of images selected as least attractive (Supplementary Fig. S6, panel 3). Image 2 was most frequently selected as most attractive, but this was followed by Image 5; nevertheless, overall, images smaller than baseline were selected substantially more frequently than images larger than baseline (53.8% vs. 38.5%, respectively) (Supplementary Fig. S6, panel 3). However, a similar pattern also held with regard to female images selected as least attractive, with Image 2 again being most

frequently selected, and 51.9% of participants selecting as least attractive an image smaller than baseline, compared with 27.9% who selected an image larger than baseline. Examining consistency of choices within participant, 33.7% of participants selected as most attractive an image having a smaller foot than that which the same participant selected as least attractive, a fraction that is significantly smaller than predicted by chance (see Table 2), i.e., the pattern is in the opposite direction to that predicted.

Turning to attractiveness judgments of male feet, neither the distribution of images selected as most attractive nor that concerning least attractive was random (Supplementary Fig. S6, panel 3). There was a clear attraction to large feet, with Image 5 being most frequently selected as most attractive, followed by Image 4; images larger than baseline were selected by 70.2% of participants, compared with only 19.8% for images smaller than baseline (Supplementary Fig. S6, panel 3). However, tempering this pattern somewhat, Image 5 was also most frequently selected as least attractive, followed by Images 1 and 3. Correspondingly, examining consistency of choices within participants, 43.8% of participants chose as most attractive a larger foot than that which the same participant chose as least attractive, a pattern that was not significantly different than chance, but which trended in the direction of a preference for larger male feet.

8.3. Discussion

In a population in which locomotory efficiency is important, production involves substantial manual labor and people frequently walk barefoot or in open sandals, patterns of attractiveness judgments based on both female foot size proportionate to stature and absolute female foot size in isolation did not match the results redundantly obtained in other populations. While the distributions for judgments of female attractiveness were not highly patterned, when patterns did emerge, they occurred in the opposite direction to previous findings—subtly in judgments of whole-body images, and more markedly in judgments of feet in isolation, participants displayed a preference for large female feet. Findings were less divergent for assessments of male feet, with no clear patterns emerging for judgments of whole-body images (albeit with a trend in the direction of previous results), and a clear preference for large absolute male foot size.

It is possible that features of this protocol, and features of this sample were such as to introduce substantial noise into these results. The protocol employed in this study differed somewhat from the procedures used previously, primarily in regard to the sequential presentation of tasks that earlier constituted separate studies. Moreover, all of the previous studies described in this paper primarily drew participants from urban populations. In contrast, this sample was drawn from a rural population in a developing nation, individuals who may have been less familiar with surveys and tasks akin to those involved in this research. Consonant with this possibility, across the board, results in this study were substantially less patterned than in previous studies. Nevertheless, despite these considerations, the reversal of preferences regarding female foot size found in this population must be taken seriously, particularly given that there are indications that both female and male relative foot size were correctly interpreted as a cue of age, suggesting that the reversal of preferences is not readily attributable to confusion.

Although participants' comments were not systematically recorded, researchers noted that, in addition to the common complaint that the whole-body images "all look the same," a frequent remark among these participants was that women with large feet are stronger and thus better able to work in the fields. This suggests that participants (or their folk model) may implicitly recognize a biomechanical cost to small female foot size.

9. General discussion

Relative to their stature, women have smaller feet than men, a pattern of dimorphism that would seem to be the inverse of that favored by biomechanical considerations. In Study 1, conducted among people of all walks of life from eight societies, and employing stimuli superior to those of Fessler et al. (2005b), we replicated the latter's finding that both men and women exhibit a preference for smaller foot size proportionate to stature when judging female attractiveness. On its own, this result does not reveal the direction of causality in the relationship between pedal dimorphism and aesthetic preferences. However, these preferences are not mirrored in assessments of male attractiveness, as there is a clear dislike of both large and small male feet proportionate to stature. This pattern is inconsistent with a variety of competing accounts wherein dimorphism in foot size predates preferences, but is consistent with a history of intersexual selection, acting exclusively on women, wherein ancestral males assigned higher mate value to females exhibiting cues of greater residual reproductive potential.

In Study 2, using a U.S. undergraduate sample, we documented that, when differences in proportionate foot size are difficult to detect, men are much more likely to recognize variation in women's foot size than women are to recognize variation in men's foot size, where such recognition has a substantial impact on assessments. These patterns suggest that, consonant with unidirectional intersexual selection, foot size plays a greater role in judgments of women's attractiveness than in judgments of men's attractiveness. In Study 3, in two U.S. public samples, employing both crude line drawings and refined computer-generated stimuli, we demonstrated that proportionate foot size is correctly processed as a cue of age, a pattern that, in keeping with men's overarching predilection for signs of youth in women, is again in keeping with the intersexual selection hypothesis. In Study 4, U.S. and South African undergraduates inferred whole-body attractiveness based only on images of actual foot soles. The preference for small female feet persists in

this study, albeit slightly tempered, while the preferred male foot size increases; Study 5, conducted among U.S. and Austrian undergraduates, sheds light on this pattern, as foot size proportionate to stature appears to take precedence when assessing female feet in isolation, but foot size as a cue of stature appears to dominate when assessing male feet in isolation, indicating again that the foot has different meanings in aesthetic judgments of females and males.

Study 6 was conducted among the Karo Batak, a rural Indonesian population in which people engage in substantial manual labor and frequently walk barefoot or with feet exposed. Results replicated our earlier findings regarding the relationship between proportionate foot size and inferred age, but reversed previous patterns of aesthetic preferences, with participants preferring large-footed women, possibly because they are perceived as stronger and more economically productive.

Results from Studies 1 through 5 paint a consistent portrait supporting the intersexual selection hypothesis. However, results from Study 6, while less clearly patterned than in the aforementioned studies, nonetheless challenge these conclusions. How are we to reconcile these findings? First, Studies 1 through 5 were conducted in urban areas, raising the possibility that, despite being international in scope, rather than revealing a common feature of evolved psychology, these investigations might instead be capturing the impact of modernization (see Yu & Shepard, 1998) via the power of mass media to influence judgments of attractiveness (Bilukha & Utermohlen, 2002; Groesz, Levine, & Murnen, 2002). However, this is unlikely to explain the discrepant results of Study 6, as, despite their rural surroundings, our Karo Batak participants were also regularly exposed to such influence—in the villages where Study 6 was conducted, between 25% and 35% of the households have a television (airing both domestic and international programs), and people commonly gather in cafes to watch many of the same movies viewed elsewhere around the world. While additional research in similar settings is needed, we therefore propose the following preliminary explanation of the difference between the results of Study 6 and our previous findings: As noted earlier, the informal remarks of participants in Study 6 indicated that women with larger feet were viewed as stronger and better able to work in the fields. This suggests that, despite having been instructed to provide judgments of physical attractiveness, participants in Study 6 may actually have been generating judgments of overall mate value. In these agricultural communities in which women's labor is a key component of economic success and social status, physical robustness may loom larger relative to aesthetic considerations than is true in more industrialized populations—farmers who toil in the fields cannot afford to prioritize beauty relative to robustness and efficiency to the same degree as urbanites. Granted, in ancestral hunter–gatherer societies, female 'strength' or locomotory efficiency would doubtless also have been a crucial determinant of reproductive success. Nevertheless, it is possible that agricultural intensification and pecuniary prestige competition have led Karo Batak participants to place greater weight on cues of female productivity, and less weight on cues the attraction to which evolved due to their linkage with residual reproductive potential, than would have been true in more egalitarian hunter–gatherer groups. To both test this specific proposition and more definitively establish the factors influencing aesthetic judgments of proportionate foot size, it will be necessary to conduct additional research targeting habitually unshod populations in which locomotory efficiency is of great importance. Until such time, the exact nature of the relationship between aesthetic preferences and sexual dimorphism in foot size proportionate to stature must remain an open question.

At the methodological level, even as we continue to explore the particulars of this one aspect of human morphology, it is increasingly clear that scholars interested in postulated evolved components of human aesthetic criteria would be well advised to employ culturally, economically, and ecologically diverse samples. At the theoretical level, the studies presented here demonstrate that it is possible to design investigations that shed light on direction of causality in the relationship between a sexually dimorphic trait and aesthetic preferences pertaining to that trait.

Supplementary Materials

Supplementary materials related to this article can be found online at doi:10.1016/j.evolhumbehav.2011.08.002.

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