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How Sexually Dimorphic Are Human Mate Preferences?

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Abstract

Previous studies on sex-differentiated mate preferences have focused on univariate analyses. However, because mate selection is inherently multidimensional, a multivariate analysis more appropriately measures sex differences in mate preferences. We used the Mahalanobis distance (D) and logistic regression to investigate sex differences in mate preferences with data secured from participants residing in 37 cultures (n = 10,153). Sex differences are large in multivariate terms, yielding an overall D = 2.41, corresponding to overlap between the sexes of just 22.8%. Moreover, knowledge of mate preferences alone affords correct classification of sex with 92.2% accuracy. Finally, pattern-wise sex differences are negatively correlated with gender equality across cultures but are nonetheless cross-culturally robust. Discussion focuses on implications in evaluating the importance and magnitude of sex differences in mate preferences.

Keywords: mate selection; sex differences; multivariate analysis; cross-cultural analysis

How Sexually Dimorphic Are Human Mate Preferences?

Mate preferences directly impact mating and reproduction and are thus central to understanding the evolution of human psychology and physiology. Sexual dimorphism in mate preferences has cascading sex-specific consequences for important human endeavors such as marriage, child rearing, and divorce and suggests the sexes face importantly different evolutionary histories and trajectories (Andersson, 1994; Pettay et al., 2007). Women and men do differ, on average, in their desire for physical and behavioral features of the opposite sex (Buss, 1989; Kenrick & Keefe, 1992; Widerman, 1993). These sex differences are patterned as predicted by *a priori* evolutionary hypotheses (Sugiyama, 2005); they also show a striking level of cross-cultural universality (Buss, 1989). However, this research has suffered from an important limitation: mate preference research has focused almost exclusively on univariate analyses, examining sex differences along each mate preference variable separately. Because mate selection is an inherently multidimensional process, a conceptually appropriate appraisal of sexual dimorphism in mate selection psychology requires assessment of sex differences in the overall pattern of mate preference. Here we employ the Mahalanobis distance and logistic regression to quantify sexual dimorphism in the overall pattern of human mate preferences both on average and across cultures.

Natural selection favors distinct, sex-specific mate selection adaptations to the extent that sexes recurrently face distinct reproductive challenges—“adaptive problems”—in the mating domain (e.g., Buss & Barnes, 1986; Symons, 1979). Over human evolution, women experienced a higher obligatory parental investment due to the sex-specific demands of gestation and breastfeeding. Consequently, in long-term mating, women more severely faced the adaptive problem of acquiring resources to produce and support offspring. Women are therefore predicted to greater prefer long-term, committed mates who possess resources and qualities linked to resource acquisition such as status, ambition, and slightly older age. In contrast, men, more than women, faced adaptive problems of identifying fertile mates because women's fertility is concealed and declines sharply with age. Men, more than women, are thus predicted to prefer youth and physical attractiveness in a long-term mate—cues to current fertility and future reproductive value (Buss, 1987; Symons, 1979; Williams, 1975). Both sexes are predicted to prefer kindness, health, and dependability in a long-term mate—domains in which both sexes recurrently faced similar adaptive problems (Buss, 1995).

The most extensive test of these predictions remains Buss's (1989) cross-cultural study of mate preferences. Buss (1989) collected data on mate preferences for 19 traits from participants in 37 cultures that varied in ecology, mating system, religious orientation, and political system. The results were consistent with the predictions. In all 37 cultures, men more than women desired younger, physically attractive mates, and women more than men desired older mates with good financial prospects (see also Kenrick & Keefe, 1992). Sex differences in ambition and chastity were less universally sex-differentiated, showing significant sex differences in 78% and 62% of cultures, respectively. The key theoretically-predicted patterns of sex differences in mate selection appear to be cross-culturally universal. These findings have been replicated across different cultures (e.g. Grøntvedt & Kennair, 2013; Marlowe, 2004), across methods (e.g. Wiederman, 1993), and across generations (e.g. Buss, Shackelford, Kirkpatrick, & Larsen, 2001).

Nonetheless, extant mate preference research may underestimate sexual dimorphism in human mate preferences. Sex differences in mate preferences have been analyzed almost exclusively in unidimensional terms: in assessing the presence, pattern, and magnitude of sex difference in mate selection, researchers have compared the sexes on each dimension of mate preference individually. Even studies that require participants to evaluate their mate preference holistically analyze sex differences in these preferences only along single dimensions (e.g. Li, Bailey, Kenrick, and Linsenmeir, 2002). However, humans select mates by considering multiple traits simultaneously–each differing in weight and threshold (Li, et al., 2002). For example, men, more than women, prefer their partners to be physically attractive, but they must also be kind, educated, and share their political values; women, more than men, desire partners with good financial prospects, but they must also be ambitious, emotionally stable, and share their religious views. Importantly, mates do not come *a la carte* but *prix fixe*: each potential mate has a set of features that must be accepted or rejected wholesale.

Mate selection is thus a complex multidimensional task that requires matching a *pattern* of mate preferences to a potential mate's *pattern of* features. Appraisals of sex differences based solely on individual dimensions will be misleading because they miss the fact that individual preferences come together to form a broader whole. People may differ radically in the overall pattern of their mate preferences even if they differ only slightly on individual dimensions of mate choice. Two friends might fight endlessly over potential mates if their ideal mates differ only in physical attractiveness. They would experience less conflict if one also preferred their mates outgoing and the other introverted.

The multidimensionality of mate choice is critical because small differences along individual dimensions can accumulate to large differences in multidimensional space. Del Giudice, Booth, and Irwing (2012) used an analogy of physical distance between cities. Imagine two towns, Southwest and Northeast, separated by 100 miles in the North-South direction and 100 miles in the East-West direction. A naïve traveler, planning to travel along the straight-line distance between the cities may plan for a journey 100 miles long: the average distance between the towns on each axis. However, because of the multidimensional nature of physical space, the naïve traveler would not reach their destination: the actual distance is 141 miles, 41% longer than the traveler planned.

Understanding the magnitude and importance of sex differences in mate selection psychology conceptually requires multidimensional analyses that capture sex differences in the *overall pattern* of mate choice, in addition to analyses that capture sex differences on single dimensions. Here we use two methods for assessing the magnitude of sex differences in the overall pattern of mate choice: (1) quantifying the distance between the sexes in the multivariate preference space and (2) assessing the discriminability of the sexes' patterns of mate preference.

Multivariate Distance

The Mahalanobis distance (*D*) assesses the magnitude of sex differences in multivariate terms by quantifying the distance between the sexes in multivariate space. When measuring group differences (e.g., sex differences), *D* is the same as Cohen's *d* because both measure the difference between two means in standard deviation units. Thus, *D* and *d* are directly comparable. However, whereas Cohen's *d* is the linear distance between two means in a one-dimensional space, *D* is the linear distance between two means in an *n*-dimensional space. Imagine comparing soda cans produced by two companies. Cylinders are defined by two principal dimensions: height and radius. One could compare these two sets of cans on each dimension at a time and find that they differ in height and radius by, for instance, two standard deviations along each dimension. The average Cohen's *d* is 2.0; however, *D* in Figure 1 gives the *actual* magnitude of the difference by measuring the linear distance through the total two-dimensional space defined by can height and radius. The dashed line in the bottom panel of Figure 1 shows the *D* between the two groups: 2.8.

Mahalanobis distances allow more appropriate appraisal of the differences between groups in multidimensional processes like mate selection. If the sexes are monomorphic in their mate selection psychology, then the distance between them in the multivariate preference space should be small. A large Mahalanobis distance would suggest a large sex difference in the overall pattern of mate selection and thus a sexually dimorphic mate selection psychology. The Mahalanobis *D,* but not univariate statistics such as Cohen's *d,* captures this pattern-wise difference. Further, assuming multivariate normality, Mahalanobis *D*s can be translated into the overlap between group distributions. Whereas a *D* of 2.0 translates into a 31.7% overlap between the two groups, a *D* of 2.8 corresponds to an overlap of just 16.2%.

Additionally, the Mahalanobis distance explicitly accounts for correlations between mate preferences in analyzing sex differences. Many factors can introduce covariation between mate preferences—for instance, higher mate value women are known to have higher standards for potential mates (Buss & Shackelford, 2008). Such mate value effects could introduce positive correlations between mate preferences that univariate analysis of sex differences would miss. The Mahalanobis distance adjusts for these correlations between dimensions, thereby providing more accurate appraisals of sex differences. In sum, the most conceptually appropriate and valid assessment of differences in multivariate processes is produced by assessing distances in multivariate terms.

The Mahalanobis *D* has a long history in psychology. Cronbach and Gleser (1953) discussed using the Mahalanobis *D* for comparing profiles of scores between groups—precisely our goal in comparing mate preferences between the sexes. However, the statistic has only rarely been used for comparing groups and is more often used as a method of multivariate outlier detection (e.g. see Stevens, 1984). The Mahalanobis *D* has been employed in the artificial intelligence of face detection because multivariate distances allow computers to quantitatively compare *patterns* of image features to those of prototypical faces (e.g. see Sung & Poggio, 1998; Zhao, Chellapa, & Rosenfield, 2003). Within psychology, the Mahalanobis *D* has been used to quantify sex differences in personality (Del Giudice, Booth, & Irwing, 2012). Although the average difference in each personality dimension is just 0.29, Del Giudice et al. (2012) found a Mahalanobis *D* between the sexes of 1.72 on item-level personality variables. For a more thorough review of the application of Mahalanobis *D* to appraise patterns of differences, see (Del Giudice, 2009).

Discriminatory Power

In addition to the distance in multivariate space, sex differences in mate preferences can be quantified by the degree to which the sexes' patterns of mate preferences can be discriminated. If the sexes substantially differ in their patterns of mate selection, then these patterns should be distinguishable. The range of mate preference patterns displayed by women should be distinct from the range displayed by men such that knowledge of mate preferences provides power in predicting sex. Logistic regression, predicting sex from mate preferences, can assess the accuracy with which mate preferences distinguish the sexes.

Predictions

Here we apply these methods to estimate sex differences in the overall pattern of mate preferences. We expect that these new pattern-wise analyses will show that the sexes differ in mate preference more than has previously been appreciated. Further, we predicted that these pattern-wise sex differences in mate preferences would be driven principally by those preference dimensions predicted to be sex differentiated by evolutionary psychological theory (Buss, 1989). Additionally, Gangestad, Haselton, and Buss (2006) demonstrated that cultures with more equivalent gender empowerment had smaller sex differences in some mate preferences than in cultures with less equivalent gender empowerment. We thus also analyzed cross-cultural patterns in sex differences in the overall pattern of mate preferences. We expect that, consistent with Gangestad et al., the sex difference in the pattern of mate preferences will be attenuated by gender empowerment across cultures, but that these sex differences will nonetheless remain universally robust.

Method

Data

We analyzed data from 37 samples, each from a different culture across 33 countries (Buss, 1989). The total sample size is n = 10,153 (5,389 women). We focused analyses on 20 variables: sex and the 19 original mate preference variables. For 18 variables, participants rated the desirability of the characteristic in a potential mate on a 4-point scale (0 = irrelevant or unimportant, 3 = indispensable). The 19th mate preference variable, age difference, was reported as the ideal age difference in years between self and partner. Five of these 19 variables were predicted by Buss (1989) to be sex-differentiated according to evolutionary hypotheses: good financial prospects, good looks, chastity, ambition and industriousness, and age difference. Hereafter we refer to these five preference variables as the “sexually dimorphic” preferences; the remaining 14 variables are referred to as the “sexually monomorphic” preferences. We separately report analyses for the sexually dimorphic and sexually monomorphic preferences alone, as well as with all 19 preference variables together.

We use the 1995 Gender Empowerment Measure (GEM) as an index of gender equality for each country (United Nations Development Programme, 1995). The GEM measures sex disparity in empowerment as a function of relative income, relative access to professional opportunities, and relative share of governmental power such as parliamentary seats. Although the United Nations replaced the GEM with the Gender Inequality Index in 2010 (United Nations Development Programme, 2010), we chose to use GEM data from 1995 because this was the gender equality data available closest to the time that the original data were collected. GEM data was unavailable for six countries: South Africa, Israel, Taiwan, Germany, Yugoslavia, and Estonia.

Data analysis

We used two analyses for assessing sex differences in the overall pattern of mate preference: (1) Mahalanobis *D* and (2) logistic regression.

Mahalanobis *D*. We calculated Mahalanobis *D* and overlap coefficients using R script from Del Giudice, et al. (2012). We separately calculated the *D* between the sexes for all 19 preference variables, for the sexually dimorphic preference variables and the sexually monomorphic preference variables. We calculated confidence intervals on Mahalanobis distances through bootstrapping. We sampled with replacement from the original data, calculated *Ds* between the sexes within the resampled data, and stored the resulting *Ds.* This process was iterated 10,000 times. The Mahalanobis *Ds* that delineated the bottom 2.5% and top 2.5% of the resulting 10,000 *Ds* are reported as the 95% confidence intervals.

Hyde (2014) argued that adding dimensions to analyses might artificially inflate *D* because random noise in each variable could increase distance between groups in multivariate space even in the absence of a true difference. To address this concern empirically, we calculated the *D* between the sexes for a set of 19 synthetic preference variables. To generate these synthetic variables, we first subtracted the female mean value for each preference variable from the male mean value. For each preference variable, we next subtracted half of the mean difference from each male value and added half of the mean difference to each female value. The result was a dataset with identical distributional properties to the real data but with no population-level sex differences. Finally, we resampled from this synthetic dataset 10,000 times, generating 10,000 synthetic data samples in which sex differences were due entirely to noise. We calculated and stored the Mahalanobis *D* on each sample, giving an estimate of the *D* that would occur between the sexes if there were no true sex differences in mate selection.

Logistic regression. We conducted a logistic regression predicting sex from mate preferences. We employed a Monte Carlo cross-validation procedure to assess the predictive accuracy that mate preferences afford in discriminating between the sexes. The data were split into two random subsets: a training set comprised of 90% of the data and a testing set comprised of the remaining 10% of the data. Logistic regression equations were developed on the training set and then used to assess discriminatory power on the unseen testing set. Predicted sex probabilities from the logistic regression of .50 or above were categorized as predicted-male whereas lower probabilities were categorized as predicted-female. We then calculated the percentage of accurate predictions to quantify the discriminatory power afforded by mate preferences. This process was iterated 10,000 times, and we saved predictive accuracies from each iteration. Confidence interval boundaries were defined as those values that delineated the top 2.5% and bottom 2.5% of the resulting 10,000 accuracy values. We conducted these analyses separately with all 19 mate preference variables and with the five predicted *a priori* to be sex-differentiated. For an assessment of the predictive power in the absence of true sex differences, we also conducted a logistic regression using synthetic variables calculated in the same manner as for the Mahalanobis *D*.

Results

Mahalanobis distance

The Mahalanobis *D* between the sexes for all 19 preference variables was *D* = 2.41, CI [2.33, 2.51]. This corresponds to an overlap between the sexes of just 22.8%, CI [21.0, 24.4]. The Mahalanobis *D* between the sexes for just the sexually dimorphic preference variables was *D* = 2.28, CI [2.20, 2.36]. This corresponds to an overlap between the sexes of 25.5%, CI [23.7, 27.1]. The Mahalanobis *D* between the sexes for the sexually monomorphic preference variables was *D* = .96, CI [.92, 1.00]. This corresponds to an overlap between the sexes of 63.23%, CI [61.58, 64.63].

In contrast to Hyde's (2014) concerns regarding artificial *D* inflation, across the 10,000 iterations, the average Mahalanobis distance for the synthetic variables was just *D* = .09, CI [.06, .12], well below the *D* for all 19 preference variables and for the sexually dimorphic preferences. This Mahalanobis distance corresponds to an overlap between the sexes of 96.4%, CI [95.2, 97.5]. Figure 2 compares the Mahalanobis distances (Panel A) and overlap coefficients (Panel B) for all 19 preference variables, the sexually dimorphic preference variables, the sexually monomorphic variables, and the 19 synthetic mate preference variables.

Logistic regression

We first conducted a logistic regression predicting sex from all 19 mate preference variables. The average predictive accuracy across Monte Carlo trials was 92.2%, CI [90.3, 94.0].

Figure 3 shows the mean predicted sex probabilities across all 10,000 iterations of the logistic regression. These probabilities represent probabilities that each participant was male based on their mate preferences alone. The plot is bimodal: most cases were predicted to be very likely male or very likely female. Approximately 70% of cases had predicted sex probabilities below .1 or above .9; 84% were below .2 or above .8.

Five of the 19 mate preference variables (for which no evolutionary hypotheses predict sex-differentiation) did not predict sex: pleasing disposition, sociability, similar religion, similar political views, and mutual attraction (all *p*s > .08). Removing these five variables from the logistic regression changed the predictive accuracy to 92.4%, CI [90.4, 94.2]. For just the sexually dimorphic mate preference variables, predictive accuracy across the 10,000 trials was 92.4%, CI [90.6, 94.2]. The predictive accuracy afforded by the synthetic variables was just 54.8%, CI [49.0, 60.3].

Sex differences in age differences

The sex difference in preference for age difference, $d = 2.01$, was much larger than the sex difference for any of the other 19 mate preference variables. Although there is a strong *a priori* rationale for including age difference with the other mate preference variables, the multivariate sex differences may be due to the large sex difference in preference for age difference with little contribution from the other 18 variables. We therefore re-ran the above analyses excluding the sex difference in preference for age difference to assess the impact of this variable. The 18-variable Mahalanobis *D* without age difference was $D = 1.46$, CI [1.42, 1.52], corresponding to an overlap of 46.4%, CI [44.9, 47.7]. The Mahalanobis distance for the sexually dimorphic preferences without age difference was $D = 1.20$, CI [1.15, 1.24], corresponding to an overlap of 54.9%, CI [53.4, 56.4]. Predictive accuracy in the logistic regression with all mate preference variables except age difference was 79.7%, CI [76.7, 82.3]; accuracy for the sexually dimorphic regression without age was 75.4%, CI [72.2, 78.2].

Cross-cultural differences

For cross-cultural analyses, we focused on the Mahalanobis *D* as a measure of sex differences in the overall complex of mate preferences. Table 1 shows the correlation between each sex difference effect size and the gender empowerment measure (GEM) across cultures. Many sex differences were negatively correlated with gender empowerment, including preference for cooking ability ($r(25) = -.46$, $p = .02$), similar educational attainment ($r(25) = -.52$, $p = .01$), similar religion ($r(25) = -.43$, $p = .01$), age differences ($r(25) = -.58$, $p = .001$) and overall educational attainment ($r(25) = -.50$, $p = .01$). As such, the overall Mahalanobis *D* was also moderately negatively correlated with gender empowerment across cultures ($r(25) = -.48$, $p = .01$). This was true for both the Mahalanobis *D* based on sexually dimorphic variables ($r(25) = -.51$, $p = .006$) and the sexually monomorphic Mahalanobis *D* ($r(25) = -.40$, $p = .04$). As gender empowerment became increasingly equivalent across cultures, the difference between the sexes in their mate preferences decreased along several individual dimensions as well as in their overall patterns of mate preference.

The correlations between the GEM and sex differences were sometimes strong, implying that gender empowerment accounts for a large amount of the variance in mate preference sexual dimorphism. However, interpreting these correlations requires appreciating the extent of this cross-cultural variance relative to the magnitude of sex differences across dimensions. We calculated a difference-to-variability ratio (i.e., a signal-to-noise ratio) for each of the 19 mate preference dimensions as well as for the overall mate preference complex. These ratios divided the absolute magnitude of each sex difference ignoring culture by the standard deviation in the sex difference across cultures. A large difference-to-variability ratio indicates that the magnitude of the sex difference remains large regardless of its cross-cultural variability; a small difference-to-variability ratio indicates the sex difference's cross-cultural variability is much larger than its actual magnitude. Table 2 shows the ratio for each sex difference. Several preference dimensions that were not predicted to be sex differentiated showed very small difference-to-variability ratios (DTV): health (DTV = .32), refined (DTV = .49), and political views (DTV = .55). Four of the five variables originally predicted to be sex differentiated were among the six highest difference-to-variability ratios: age difference (DTV = 3.18), physical attractiveness (DTV = 2.21), good financial prospects (DTV = 1.82), and ambition (DTV = 1.43). Chastity was more variable across cultures (DTV = .89).

The Mahalanobis *D* between the sexes was highly stable (DTV = 2.93). That is, the magnitude of the sex difference in the overall pattern of mate preference was nearly three times the variability in that sex difference across cultures. Splitting the Mahalanobis *D* in to the sexually monomorphic and sexually dimorphic versions reveals that this stability is due largely to the five mate preference dimensions predicted to be sexually dimorphic. The sexually dimorphic preference Mahalanobis *D* had a difference-to-variability ratio of DTV = 3.60; for just the preference variables predicted to be sexually dimorphic, the sex difference in the overall pattern of mate preferences was more than three and a half times the variability in that difference across cultures. Conversely, the Mahalanobis *D* for the sexually monomorphic preferences had a difference-to-variability ratio of just DTV = 1.37, indicating that the pattern of these preferences was barely more sexually dimorphic than it was cross-culturally variable.

Regression analysis confirms that the difference-to-variability ratios for the variables predicted to be sex differentiated are mostly consistent with gender empowerment moderating but not encapsulating these sex differences. By regressing GEM scores against sex differences for these five dimensions and the three versions of the Mahalanobis *D*, we generated predicted sex differences for the full theoretical range of gender empowerment equality (Figure 4). For each effect, we started with third-order polynomial effects and removed non-significant terms; all analyses retained only linear terms. Across the full theoretical range of gender empowerment, only the sex difference in chastity approaches zero and reverses direction and only in a society with perfect equality in gender empowerment. In terms of the overall patterns of mate preferences, the Mahalanobis *D* is predicted to remain at D = 1.80 even in a society with perfect gender empowerment equality as measured by the GEM. The Mahalanobis *D* for sexually dimorphic preferences remains similarly large in a perfectly egalitarian society (D = 1.51) whereas the sexually monomorphic Mahalanobis *D* drops to a smaller but still large D = .46.

Discussion

Evolutionary researchers have hypothesized that human mate selection psychology is somewhat sexually dimorphic, patterned according to the distinct adaptive problems the sexes have recurrently faced throughout human evolution, as in many sexually reproducing species (Buss, 1995). This rationale has proven powerful: sex differences in mate preferences have been discovered in cultures throughout the world using multiple methods across diverse samples ranging from the U.S., to Jordan, to the Hadza hunter-gatherers of Tanzania (Buss, 1989; Khallad, 2005; Marlowe, 2004). However, sex differences have thus far been understood only in unidimensional terms.

The results of our analyses of mate preferences, with theoretically appropriate multivariate statistics, suggest a new appraisal of sexual dimorphism in human mate preferences. Sex differences are large by any standard when assessing the pattern of mate preferences rather than along individual dimensions of mate selection. At 2.41, the Mahalanobis *D* between the sexes for all mate preference variables is more than eight times larger than typical effect sizes in psychological studies (Funder & Ozer, 1983; Rosnow & Rosenthal, 2003). The selection of a mate is, in evolutionary terms, one of the most important decisions a sexually reproducing organism can make. Who we desire affects who we pursue, with whom we compete, who we wed, and who we raise children with; mate choice is thus also one of the most impactful decisions a person makes in their lives.

Our new appraisal of sex differences in terms of the overall pattern of mate preferences shows that this important domain of life is dramatically different for the sexes—much more than researchers have thus far appreciated. Humans are commonly considered a relatively monomorphic species on the basis of our low bodily sexual dimorphism; however, given our species entrance into the cognitive niche, psychological sex differences might be more indicative of where human evolution has been sex-differentiated. Figure 5 compares the sex difference in the overall pattern of mate preferences to sex differences in body dimensions such as height, muscle mass, or total body mass across humans, chimpanzees and gorillas. Unlike the Mahalanobis distance, each of these differences is unidimensional. Comparable multidimensional sex differences—for instance, muscle mass distribution—would certainly be larger. Nonetheless, these unidimensional differences are generally considered evidence of sexual dimorphism (Lassek & Gaulin, 2009) and are comparable to, and even smaller than, the sex difference in the overall pattern of mate choice. Against these measures, human mating psychology appears clearly sexually dimorphic, underscoring how differently men and women experience the mating domain.

The ongoing debate about the magnitude of sex differences further highlights the importance of the current research (see Hyde, 2014). For instance, a recent meta-synthesis found that the “overall” difference between men and women is $d = .24$ (Zell & Krizan, 2015). Although not limited to mating, this finding would seem to suggest that sex differences are small. However, this meta-synthesis relied on averaged effect sizes that merely aggregate individual differences rather than truly assess overall differences between the sexes. The pattern-wise differences captured by the Mahalanobis distance and logistic regression both indicate that the sexes are extremely discrepant in their patterns of mate choice regardless of the average difference across individual dimensions. Separately, Zentner & Mitura (2012) claimed that variability in gender equality fully explained sex differences in mate preferences again based on *averaged* Cohen’s d values. However, our new analyses indicate that the magnitude of *a priori predicted* sex differences dwarfs their variability across cultures. These sex differences further show no evidence of disappearing under conditions of gender equality. Furthermore, averaging across sex differences merely serves to eliminate the differences between mate preference dimensions within and across cultures (see Schmitt, 2012). The Mahalanobis distance instead captures differences across dimensions, showing that the individual sex differences that persist in perfectly gender egalitarian societies are still sufficient to produce large overall differences between the sexes in their patterns of mate preference.

Our Mahalanobis distance is impressive not because it is larger than the Cohen’s *d*s that composed it, but because of its actual magnitude. Mahalanobis distances are not invariantly large; they will be small if there truly are small differences in the patterns of mate preference between two groups. Our synthetic variables demonstrate this. The synthetic variables were based on preferences with no population sex differences. The Mahalanobis distance for the synthetic variables was indeed *larger* than the individual dimension used to calculate it, but was nonetheless miniscule because there was no true pattern-wise difference between the sexes. The Mahalanobis distance was also greatly reduced for those preference variables not predicted to be sex differentiated.

The key question in evaluating a Mahalanobis difference is whether it is large on its own, absolutely or relative to *other* sex differences. The answer to this question in terms of sex differentiated mate preferences appears to be an emphatic “yes.” The Mahalanobis distance for mate preferences on its own is large by any standard—indicating the sexes are separated in terms of their patterns of mate selection by more than two standard deviations. Furthermore, this large difference persists when limited only to those preference dimensions *a priori* predicted to be sex differentiated. The magnitude of our Mahalanobis distance indicates a substantial difference between the sexes in their overall patterns of mate preference: an important sex difference that would be missed were analyses confined to unidimensional sex differences alone.

Knowledge of a person’s mate preferences alone allows prediction of that person’s sex with 92% accuracy, a further testament to the sex-differentiated nature of human mate selection psychology. These differences remain large when analyzing just those preference variables originally predicted to be sex-differentiated on the basis of evolutionary hypotheses (Buss, 1989)—$D = 2.28$ and predictive accuracy = 92.4%. The large sex differences in mate selection psychology are thus driven specifically by those dimensions predicted to be sex differentiated on the basis of evolutionary theory.

Finally, sex differences in the overall pattern of mate preference are linked to equality in gender empowerment across cultures. Nonetheless, the cross-cultural variability explained by GEM is dwarfed by the magnitude of the sex difference itself. In fact, if we extrapolate our regression equations to a hypothetical society with perfect gender equality, then the overall pattern of sex differences in mate preference would remain large. Although predictions of unobserved data should be interpreted cautiously, this analysis indicates that gender empowerment equality would need to have complex, non-linear effects on mate preferences—effects not proposed in the extant literature nor observed in our data—in order to serve as an explanation of observed sexual dimorphism. Combined with evidence that some sex differences *increase* with increasing gender equality (see Schmitt, 2014 for a review), this suggests that, rather than being an *origin* of sexual dimorphism in mate preferences, gender equality appears to be just one of many inputs to sexually dimorphic mating adaptations.

Limitations and Future Directions

The results of the current research indicate that the sex difference in the preference for age difference was much larger than on the other individual dimensions. Age difference therefore contributed heavily to sex differences in the overall pattern. Theoretically, age is an important cue to other traits for which mate preferences are strongly sex differentiated: timing of sexual maturation, fertility, reproductive value, status, and resources. The age preference thus has several potential sources of sex differentiation that render it an especially powerful marker of overall value as a mate. Psychometrically, the preference for age difference is scaled on a wider range and thus may be more sensitive to group differences. Hence, both conceptual and measurement factors could have contributed to the relatively large magnitude of the age difference preference. Importantly, the multivariate sex differences remained large even after excluding age difference preference from the analyses, indicating that the multivariate sex difference was not being driven by this variable alone. Furthermore, age difference is an *a priori* theoretically predicted dimension of mate selection and thus remains conceptually appropriate within a multivariate analysis of mate preferences. Inclusion of the sex difference in age difference preference is required for an accurate assessment of the sex difference in the pattern of mate selection.

Additionally, the overlap coefficients calculated based on Mahalanobis distance statistics assume multivariate normality. This assumption was difficult to strongly validate in this sample because of the limited response range of the ideal preferences. Participants rated their ideal mate for most preference dimensions on only a narrow, four-point Likert scale. Future studies could use a wider scale that more validly allows tests of multivariate normality.

Precisely why mate preference adaptations are sensitive to gender equality and which cues they use to moderate sex differences is a promising avenue for future research. For instance, by cross-referencing data from the UN Human Development Report (United Nations Development Programme, 2014) and the CIA World Factbook (Central Intelligence Agency, 2014), we found there exists a correlation of $r(44) = .27$, $p = .07$ between gender inequality and sex ratio. Across countries, gender inequality increases as men increasingly outnumber women. Sex ratio is an enormously important variable to mating because under skewed sex ratios, the sex that is relatively scarce finds more power of choice on the mating market whereas the sex that is relatively numerous must compete more vigorously for access to mates. Part of gender equality's explanatory power may therefore come from its links to sex ratio through mate preference shifts designed to navigate the unique challenges posed by skewed sex ratios. Grounding gender inequality in similarly evolutionary cogent terms promises to be fruitful in understanding what cultural variation does exist in mate preferences and sex differences therein.

A limitation of the current study is that our analysis is limited to the 19 variables measured in the cross-cultural sample (Buss, 1989). A richer analysis might include other mate preference variables predicted to be sex-differentiated, such as facial masculinity/femininity (Perrett et al., 1998), body shape (Dixson, et al., 2003; Singh, 1993), and sexual accessibility (Goetz, Easton, Lewis, & Buss, 2012). Including more theoretically relevant variables provides a more complete representation of the landscape of mate preferences. Future research exploring mate selection using multivariate methods should attempt to include these and other variables to provide broad assay of the sex differences in the pattern of mate selection and mating strategies. Further, our measurements were limited to single-item assays of preferences. The unreliability of such measurements may have attenuated the sex differences we observed. A fuller appraisal of sex differences in human mate selection requires more reliable measurement of a wider array of relevant variables.

Other areas investigating sex differences can benefit from the Mahalanobis distance and other multivariate methods, including direct and indirect aggression (see Del Giudice, 2009), mental rotation and spatial memory, and quantitative and verbal ability. An evolutionary psychological approach makes clear predictions about which of these domains should be sex differentiated: the sexes should differ only in those domains where they recurrently faced distinct adaptive problems (Buss, 1995). Multivariate differences provide a powerful new methodology for testing this prediction: Mahalanobis distances should be relatively small in multidimensional domains where the sexes recurrently faced similar adaptive problems (e.g. quantitative and verbal reasoning) and large in those domains where the sexes faced distinct adaptive problems (e.g. mate preferences).

Multivariate differences also need not be limited to psychological sex differences. For instance, many of the sex differences in Figure 5 are unidimensional but could also be conceptualized multidimensionally. Consider muscle mass: a researcher could compare the sexes in terms of overall muscle mass but also in terms of the pattern of mass across individual muscles (e.g. biceps, triceps, and trapezius). The latter comparison would be akin to comparing the sexes in their *distribution* of muscle mass and could indeed be a very large difference depending on the relationship between individual muscle masses. Applying appropriate multivariate analyses to psychological and physiological sex differences can dramatically improve our understanding of sex differences and similarities.

Finally, future research might apply multivariate assays of mate preferences to within-sex differences. The sexes are distinct in the overall pattern of mate selection, but there also exists substantial within-sex variation in mate preferences because of differences including mating strategies (Buss & Schmitt, 1993), mate value (Buss & Shackelford, 2008), and ovulatory cycle shifts (Gildersleeve, Haselton, & Fales, 2014). Multivariate assays of these within-sex differences would complement multivariate assays of between-sex differences.

Conclusions

Mate preferences are of enormous importance for understanding human life and human evolution. Sex differences in mate preferences identify regions of this critical domain that the sexes experience differently. A large body of research demonstrates that mate preferences are universally sex differentiated along individual dimensions, but our multivariate analyses show that these individual dimensions contribute to a much larger (and underappreciated) sexual dimorphism in the overall pattern of preferences. This pattern-wise sex difference is large, cross-culturally robust, and driven primarily by those dimensions predicted to be sex differentiated by prior evolutionary hypotheses. Because we evaluate potential mates based on several mate preferences simultaneously, this pattern-wise sex difference is a crucial index of sexual dimorphism in human mating and indicates just one conclusion: human mate choice psychology is strongly sex-differentiated.

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Table 1

Correlations between Sex Difference Effect Sizes and the Gender Empowerment Measure (GEM)

Sex Difference	*r*
Good looks	.31
Desires a home and child	.20
Refined	.09
Dependable	.03
Health	.02
Sociability	-.08
Ambition	-.13
Mutual Attraction	-.28
Chastity	-.30
Emotionally Stable	-.30
Similar Political Views	-.31
Good Financial Prospect	-.33
Status	-.34
Mahalanobis *D*—sexually monomorphic	-.40*
Similar religion	-.43*
Good Cook	-.46*
Pleasing Disposition	.47*
Mahalanobis *D*	-.48*
Education	-.50**
Mahalanobis *D*—sexually dimorphic	-.51**
Similar Education	-.52**
Age difference	-.58***

Note. *p < .05; **p < .01; ***p < .001.

Table 2

Difference-to-variability Ratios for Sex Difference in Mate Preferences

Sex Difference	Difference-to-variability Ratio
Health	.32
Refined	.49
Similar Political Views	.55
Pleasing Disposition	.70
Similar Religion	.71
Desires a Home and Children	.73
Mutual Attraction	.84
Dependable	.85
Chastity	.89
Sociability	.94
Good Cook	1.04
Education	1.16
Similar Education	1.17
Status	1.21
Emotionally Stable	1.35
Mahalanobis *D*—sexually monomorphic	1.37
Ambition	1.43
Good Financial Prospects	1.82
Good Looks	2.21
Mahalanobis *D*	2.93
Age Difference	3.18
Mahalanobis *D*—sexually dimorphic	3.60

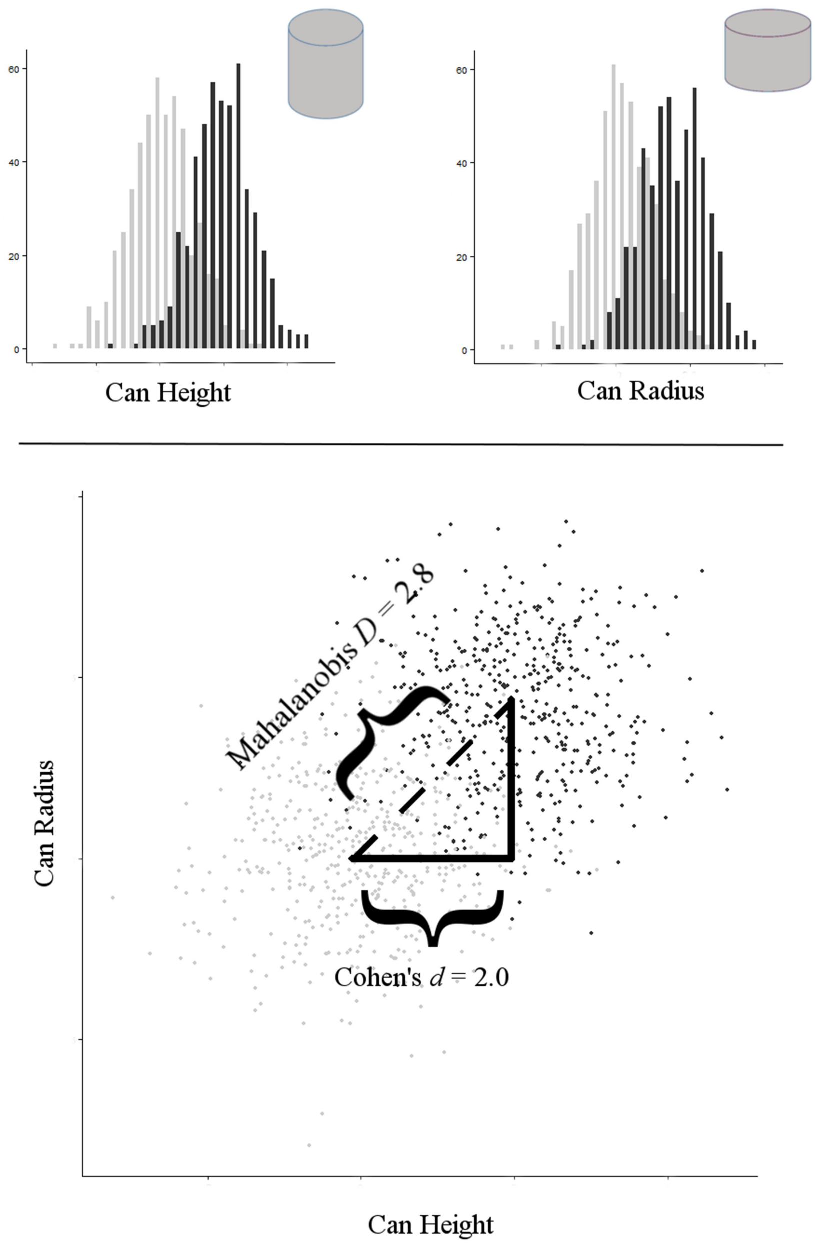

Figure 1. A graphical representation of the Mahalanobis *D*. Two sets of cans differ in their average height and radius with a Cohen's *d* of 2.0 each. Comparing the groups in the two-dimensional space gives the true distance: *D* = 2.8.

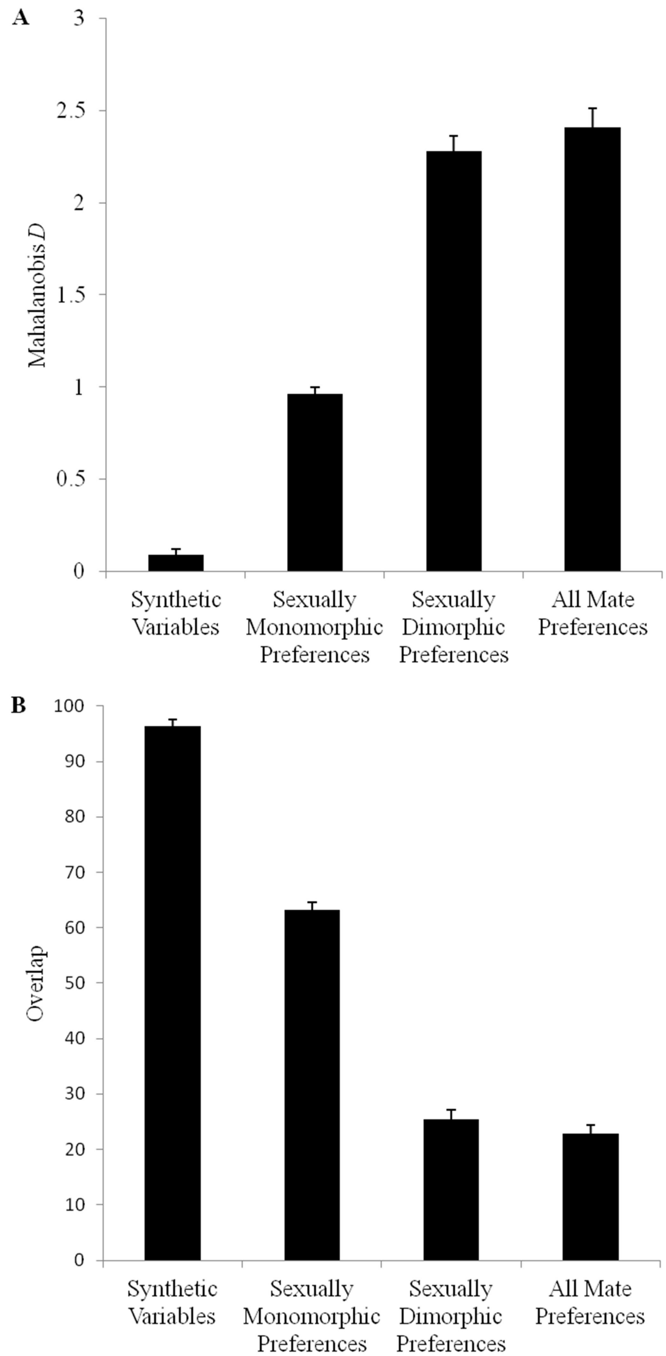

Figure 2. Mahalanobis *D* (Panel A) and overlap between the genders (Panel B) by analysis group. The sexually dimorphic mate preferences produced large a Mahalanobis *D*—comparable to the *D* for all mate preferences. The low Mahalanobis *D* for the synthetic variables confirm that these *D*s are larger than would be expected from chance alone. The sexually monomorphic mate preferences produced a substantially smaller *D* than those preferences predicted to be sex differentiated.

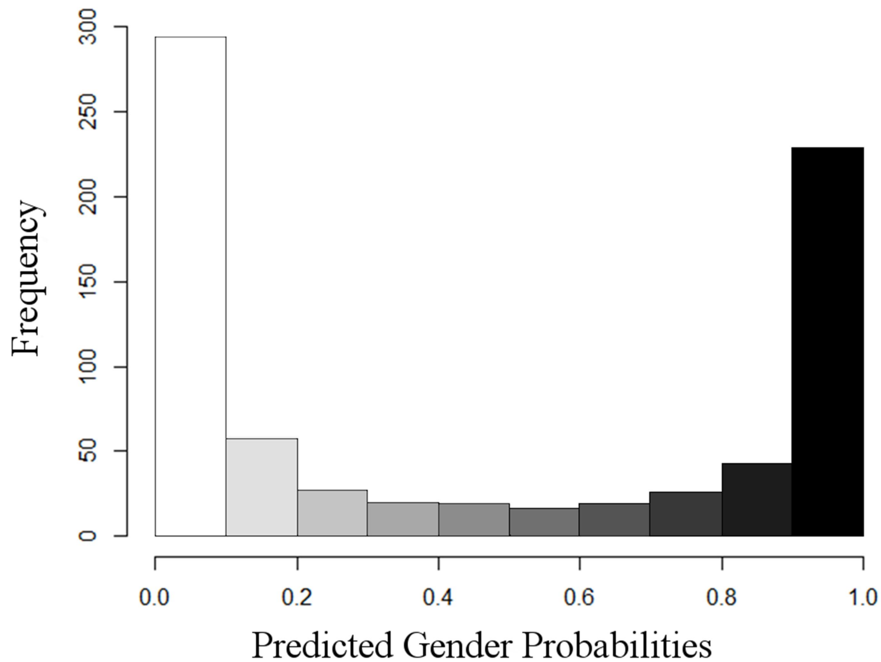

Figure 3. Histogram of the average predicted gender probabilities across iterations of the Monte Carlo cross validation. Each probability is the probability that the participant was male. The distribution is bimodal, with approximately 70% of cases falling below .1 or above .9.

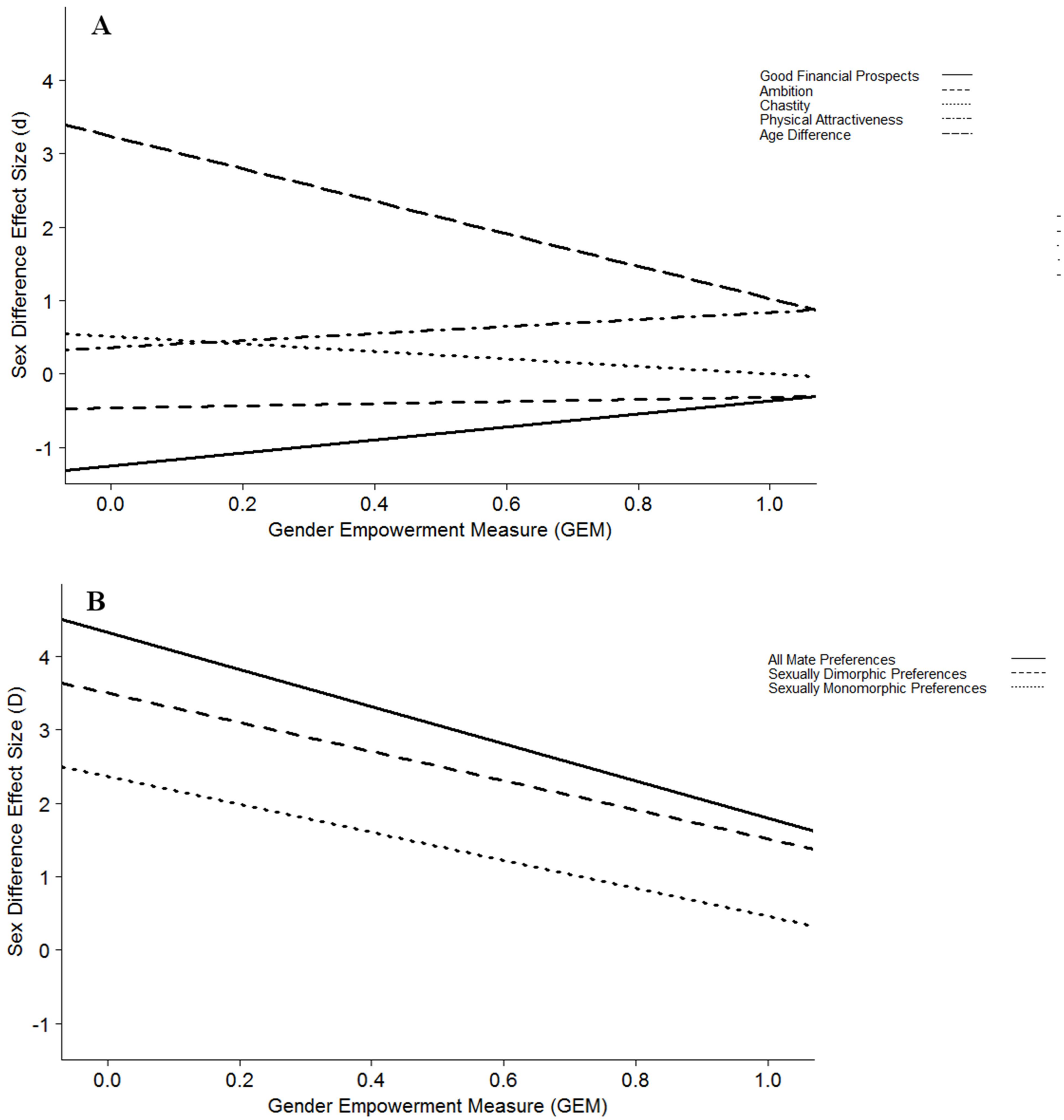

Figure 4. Predicted sex differences for individual preference dimensions (A) and Mahalanobis *D*s (B) as a function of the gender empowerment measure (GEM). The Mahalanobis *D* between the sexes would remain large (*D* = 1.83) even in a society with perfect gender equality.

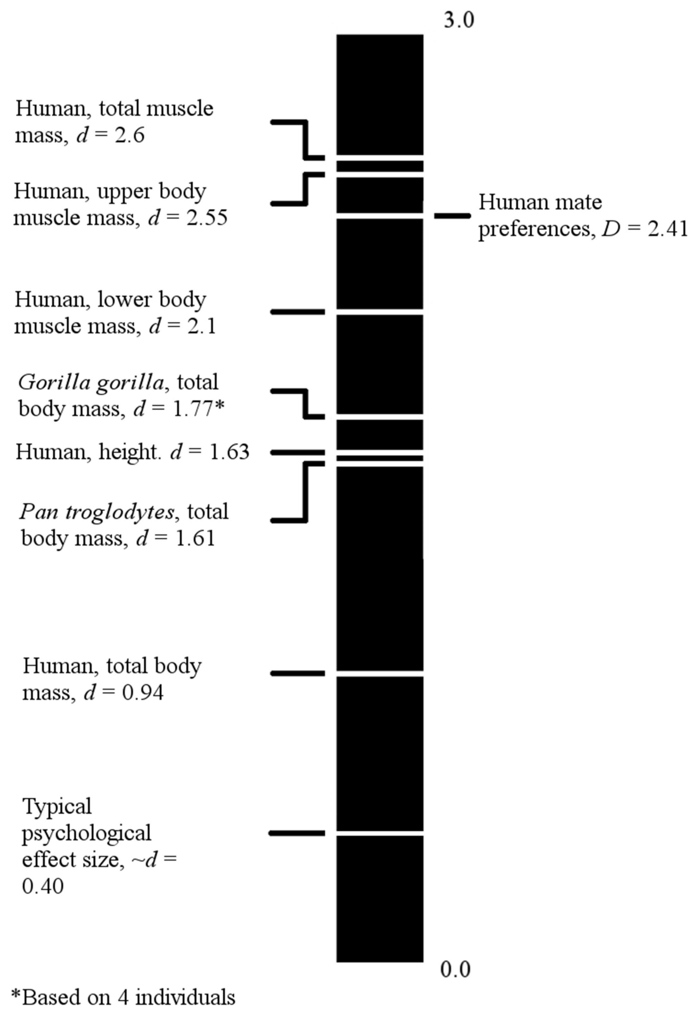

Figure 5. Sex difference in the overall pattern of mate preferences compared to sex differences in body dimensions across humans (Janssen, Heymsfield, Wang, & Ross, 2000; Lippa, 2009), chimpanzees (Smith & Jungers, 1997), and gorillas (Zihlman & McFarland, 2000), and the typical magnitude of psychological effects (Funder & Ozer, 1983; Rosnow & Rosenthal, 2003; Meyer et al., 2001)