


# Mate preference priorities in the East and West: A cross-cultural test of the mate preference priority model

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## Abstract

**Objective:** Mate choice involves trading-off several preferences. Research on this process tends to examine mate preference prioritization in homogenous samples using a small number of traits and thus provide little insight into whether prioritization patterns reflect a universal human nature. This study examined whether prioritization patterns, and their accompanying sex differences, are consistent across Eastern and Western cultures.

**Method:** In the largest test of the mate preference priority model to date, we asked an international sample of participants ( $N = 2,477$ ) to design an ideal long-term partner by allocating mate dollars to eight traits using three budgets. Unlike previous versions of the task, we included traits known to vary in importance by culture (e.g., religiosity and chastity).

**Results:** Under low budget conditions, Eastern and Western participants differed in their mate dollar allocation for almost every trait (average  $d = 0.42$ ), indicating that culture influences prioritization. Despite these differences, traits fundamental for the reproductive success of each sex in the ancestral environment were prioritized by both Eastern and Western participants.

**Conclusion:** The tendency to prioritize reproductively fundamental traits is present in both Eastern and Western cultures. The psychological mechanisms responsible for this process produce similar prioritization patterns despite cross-cultural variation.

## KEYWORDS

cultural differences, evolutionary psychology, mate choice, mate preferences, sex differences

## 1 | INTRODUCTION

From humor and creativity to sexual history and body composition, psychologists have comprehensively catalogued the mating preferences of men and women (Buss, 1989; Chang, Wang, Shackelford, & Buss, 2011; Lukaszewski & Roney, 2010; Phelps, Rand, & Ryan, 2006; Singh & Young, 1995; Stewart-Williams, Butler, & Thomas, 2017). Still,

knowledge of how these preferences are integrated and prioritized when choosing mates remains an underdeveloped area within both psychology and ethology (Li, Bailey, Kenrick, & Linsenmeier, 2002; Rosenthal, 2017). For some time, evolutionary theorists have used cross-cultural comparisons to establish the universals of human behavior. These comparisons have advanced psychological science by exploring the interaction between evolved psychological mechanisms and

culture (Buss et al., 1990; Schmitt, 2003). However, studies that examine mate preference prioritization tend to use homogenous samples and thus neglect valuable opportunities to investigate the role of culture in mate selection. For this research, we collected a large international sample to examine cross-cultural similarities in how long-term mate preferences are prioritized. To our knowledge, this constitutes the largest and most diverse test to date of the mate preference priority model.

## 1.1 | Measuring preference interaction

Historically, the traits that people prefer in their mates have been studied independently of one another (Buss, 1989; Kenrick, Groth, Trost, & Sadalla, 1993; Ting-Toomey, 1994; Yue, Chen, & Zhang, 2005), a tendency that has largely continued to the present day (Buss, Shackelford, & LeBlanc, 2000; Little, Jones, & DeBruine, 2011; Meltzer, McNulty, Jackson, & Karney, 2014). In reality, however, mate choice is a multivariate process that requires integrating and trading-off several preferences (Conroy-Beam, Goetz, & Buss, 2016; Rosenthal, 2017). A number of studies have examined this trade-off process in humans. For example, the priority of facial versus bodily attractiveness has been tested by observing which people choose to reveal first when asked to judge the attractiveness of a covered model (Wagstaff, Sulikowski, & Burke, 2015). Similarly, multivariate analysis has been used to map how facial attractiveness, sexual dimorphism, and intelligence combine to influence overall attractiveness (Lee, Dubbs, Von Hippel, Brooks, & Zietsch, 2014). Other research has shown that social norms (e.g., the age of consent) can affect how people judge physical attractiveness (Bennett, Lowe, & Petrova, 2015) and that potential suitors must reach a basic threshold of physical attractiveness before other traits, like intelligence, play a role in mate choice (Jonason et al., 2019). One common element these studies share is that they focus on interactions between a small numbers of variables within homogenous samples (e.g., Australian college students). A more effective way to examine the design features, and performance parameters, of psychological mechanisms is to test how they react to varying contextual input (Confer et al., 2010). Thus, there is scope to examine preference trade-offs within a diverse sample to observe how culture affects prioritization patterns.

One method of examining preference trade-offs, and one which we use here, involves participants constructing a hypothetical romantic partner using “mate dollars” to “buy” levels of various traits (Li et al., 2002). When given a large budget to spend, decision-making is relatively unconstrained, as with most preference surveys. This allows people to satisfy all of their preferences. However, when given a smaller budget, participants have to choose among their conflicting preferences and decide which traits are most important to them.

This forced-choice method provides unique insights over traditional Likert-style assessments of mate preferences because it is more ecologically valid—real-life mate choice requires one to consider and weigh-up the variety of features in a whole person, not isolated traits (e.g., Buss, 1989; Kenrick et al., 1993).

Comparing how participants allocate their mate dollars when budgets are small versus large gives us insight into how they prioritize traits in a mate. Participants allocate their most important traits (*necessities*) a large proportion of dollars first, causing these to dominate low budgets. Then, as budgets become relaxed, these traits attract fewer and fewer additional dollars as participants turn their attention to other characteristics. In contrast, the least important traits (*luxuries*), which tend to take a back seat when budgets are low, receive more dollars as budgets increase. Finally, some traits (*indispensables*) are given priority when budgets are low but to a lesser extent than necessities and then continue to attract dollars at a similar rate when budgets are relaxed (Li et al., 2002).

Findings from the budget allocation task tend to support the *mate preference priority model* (Li, Valentine, & Patel, 2011). According to this model, ancestral humans who chose long-term partners that were unable to reproduce or function within a pair-bond, even if they possessed other desirable characteristics, typically produced fewer offspring than those who chose otherwise. Thus, there was a selection pressure for men and women to prioritize traits crucial to reproductive success when picking a mate. This pressure led us to evolve psychological mechanisms that bias our mate preferences toward ensuring, first and foremost, that we obtain a sufficient level of those attributes fundamental for successful reproduction (Jonason, Nolland, & Tyler, 2017; Li et al., 2002, 2011, 2013).

Three traits that consistently emerge as necessities in tests of the model are physical attractiveness, kindness, and social status. Each would have been important for successful reproduction in the ancestral past. Physical attractiveness would have been a cue of fertility, and offspring produced with a physically attractive partner would likely be desirable mates themselves (Bovet, Barkat-Defradas, Durand, Faurie, & Raymond, 2018; Cornwell & Perrett, 2008; Pflüger, Oberzaucher, Katina, Holzleitner, & Grammer, 2012; Rosenthal, 2017). Choosing a kind and empathetic partner would have been fundamental to successful pair-bonding, the primary mating arrangement in humans (Geary, 2000; Stewart-Williams & Thomas, 2013). Kindness is also associated with greater parenting skills (e.g., responsiveness; Prinzie, Stams, Deković, Reijntjes, & Belsky, 2009) and may reflect the extent to which a partner is capable of cooperating and willing to share his or her reproductive resources (Jensen-Campbell, Graziano, & West, 1995; Li et al., 2002). Finally, having a high-status partner would have been beneficial for

both sexes, because of its association with preferential access to resources within the community (Mulder & Beheim, 2011; Nelissen & Meijers, 2011; von Rueden, 2014).

## 1.2 | Group differences in prioritization

The partner traits most important for reproductive success differ for each sex due to historical asymmetries in the adaptive problems faced when reproducing (Buss & Schmitt, 1993; Jonason, Li, & Cason, 2009; Li et al., 2002; Li & Kenrick, 2006). For example, because female fertility declines relatively quickly with age, men may have evolved to prioritize at least a moderate amount of physical attractiveness and youthfulness in their long- and short-term mates. Such prioritization is adaptive because, in ancestral times, a moderately physically attractive woman was likely to be sufficiently healthy and fertile (Singh & Young, 1995). In contrast, because men's fertility declines less and more slowly over the lifespan, male fertility has not been much of an adaptive problem for women. However, men do differ widely in their ability to provide resources for a family. Thus, women may have evolved to prioritize having at least a moderate amount of social status and resources—a level that likely ensured offspring survivability in the ancestral past—in their long-term mates (Li et al., 2002).

These sex differences are often least evident in long-term relationships where the sexes' interests converge, and most evident in short-term relationships, where the greatest conflicts arise (Buss & Schmitt, 1993; Jonason et al., 2009; Stewart-Williams & Thomas, 2013; Thomas, 2018; Trivers, 1972). Thus, it is not surprising that previous versions of the budget allocation task have found that trait prioritization changes based on participant sex and proposed relationship context. For example, men tend to place a greater premium on physical attractiveness than women, and both sexes prioritize kindness more in a long-term mate compared with a short-term mate (Li & Kenrick, 2006; Li et al., 2011).

Although humans have likely evolved to prioritize reproductively fundamental traits, this process may nevertheless be influenced by sociocultural factors. For example, while an American MTurk sample and a sample of Australian undergraduates did not differ in how they prioritized traits (Jonason et al., 2017), differences were found when comparing students from Singapore and the United States (Li et al., 2011), arguably more culturally discrepant groups. As in previous research, both groups of participants gave priority to physical attractiveness and kindness over creativity, and sex differences were found consistent with the reproductive asymmetries of each sex. However, cultural differences were also found. For example, women from Singapore placed more of a premium on social status and less on physical attractiveness than their US counterparts. This provides a good example of how culture can interact with evolved mating

psychology (Gangestad, Haselton, & Buss, 2006). In Eastern countries, where local norms favor long-term harmony and stability, social status is a highly valued indicator of relative social standing (Tu & Du, 1996) and used as a way of preserving harmony. Deferring to others with higher social status is important as direct confrontation is highly devalued in Asian cultures (Markus & Kitayama, 1991). Consistent with the difference in the valuation of social status, Asians, compared to Westerners, demonstrate higher expectations for academic performance (Sue & Okazaki, 1990) and place greater emphasis on financial and achievement aspects in career and business (Begley & Tan, 2001; Kim, Li, & Ng, 2005).

Of course, cultural norms and customs themselves may have adaptive significance (e.g., they may promote fitness enhancing behavior) or they could be arbitrary and maintained as a signal of group commitment (Richerson & Boyd, 2001). Nonetheless, exploring the extent to which cultural variety impacts mate preference prioritization can help us understand how much of an influence our evolved psychology has on mate choice. For example, if prioritization patterns are fairly canalized, then we might expect group differences to be restricted to a narrow window, with most cultures giving the same traits “high priority.”

In this research, we embarked on the largest and most diverse exploration of the mate preference priority model to date by asking an international sample of participants from both Eastern and Western cultures to design long-term partners using the budget allocation task. We used eight traits in the task, including some from previous mate preference research (e.g., Buss, 1989; Li et al., 2002): *kindness, physical attractiveness, good financial prospects, humor, creativity, chastity, wants children, and religiosity*. According to the mate preference priority model, participants should prioritize those traits historically crucial for reproductive success (Li et al., 2002). Of the eight traits, we predicted that kindness, physical attractiveness, and good financial prospects (a modern cue of social status), would receive priority because of their ties to reproductive success in the ancestral environment and the fact that they have been consistently prioritized in previous budget allocation studies (Li et al., 2002, 2011; Li & Kenrick, 2006). While we expect that participants from both culture groups will prioritize these traits, this process is likely to be influenced by culture. For example, the stronger cultural focus on harmonious, non-confrontational relationships in East Asian countries, may cause participants from Eastern nations to prioritize social status more than those from Western ones. However, it is possible that this variation will not qualitatively change the overall necessity/luxury pattern.

How might participants treat other traits during the task? Both creativity and humor may have been somewhat important for reproductive success in our ancestral past, functioning as sexually selected ornaments and, in the case of humor,

a means of reinforcing pair-bonds (Hall, 2017; Li et al., 2009; Miller, 2000). However, under constrained budgets we expect preferences for these traits to take a back seat to those fundamental for reproductive success. The benefits of having a creative partner do not outweigh the costs of pair-bonding with someone who is unable to produce attractive offspring, bring resources into the relationship, or support their partner. We can apply a similar logic to traits that have a short evolutionary history or little association with reproductive success. We included three such traits in this study, each known to vary in importance between cultures and previously unused in a budget allocation study: religiosity, chastity, and the desire for children (Buss et al., 2000; Chen, Austin, Miller, & Piercy, 2015; Pearce, Chuikova, Ramsey, & Galyautdinova, 2010). Depending on culture, these attributes are often considered important traits for suitors to have. For example, chastity was selected as important by less than 5% of a British sample compared to almost 40% of a Chinese one (Higgins, Zheng, Liu, & Sun, 2002) and may be particularly unimportant in a more sexually liberal countries like Norway (Kennair, Nordeide, Andreassen, Strønen, & Pallesen, 2011). Similarly, irreligiosity continues to be more prevalent in Western cultures than Eastern ones (Hackett et al., 2012). Thus, the attributes of religiosity and chastity are likely to be given greater priority by Eastern participants, which may subsequently restrict how they spend their budget relative to Western ones.

Having a partner with a strong desire for children may be more important to Western participants. *Prima facie*, it seems this trait should be a universal necessity because of its ties to reproduction. However, in terms of evolutionary history, family planning is only a recent occurrence. In the Pleistocene, having children was a natural consequence of having sex, regardless of the desire for offspring. Thus, it is hard to imagine a selection pressure to prioritize such a trait, unless used as an indirect signal of partner commitment and fidelity. Nonetheless, as contraception use is much more widespread in Western cultures (e.g., Monstad, Propper, & Salvanes, 2008; Rowe et al., 2016) than Eastern ones (e.g., Najimudeen & Sachchithanantham, 2014; Singh, Fong, & Loh, 2002), an interest in producing offspring may be a useful family planning cue in the West. Including these types of traits will allow us to observe how culturally variable preferences influence the prioritization of the more reproductively relevant ones. This constitutes a unique test of the mate preference priority model, which has traditionally been used with attributes that are reliably favored across cultures. As with humor and creativity, we anticipate these attributes to fall by the wayside when pitted against kindness, physical attractiveness, and good financial prospects, despite cross-cultural differences in their importance.

We tested three main hypotheses. First, in the overall sample, the traits of good financial prospects, physical

attractiveness, and kindness will emerge as necessities (H1). Second, women will tend to give good financial prospects greater priority than men, who in turn will tend to prioritize physical attractiveness more than women (H2). Finally, these necessities and sex differences will be present across culture groups, despite cultural differences between them (H3).

## 2 | METHOD

### 2.1 | Participants

Participants were recruited from seven academic institutions in five countries: Australia, Malaysia, Norway, Singapore, and the United Kingdom. Institutions in Malaysia, Norway, and Singapore exclusively recruited students while the UK and Australian institutions encouraged students from their institutions to advertise the study online via social media to further recruitment using a snowballing method. Depending on institution, volunteers received either course credit or no compensation for participation. In total, 3,223 participants completed the task. After excluding those who did not provide sufficient information, the final sample consisted of 2,587 participants from 59 different countries.

To allow for cross-cultural comparisons, we took the top 10 countries represented in the sample and collapsed them into two groups (Table 1). The first group contained countries that were either in Europe or historically influenced by European culture (i.e., Australia, Norway, UK, United States, and New Zealand). The second group contained countries from East and South East Asia (i.e., Malaysia, Singapore, Hong Kong, China, and Indonesia). For simplicity, we refer to these groups as “Western” and “Eastern,” respectively. The application of these labels is not without controversy (Hermans & Kempen, 1998; Vignoles et al., 2016); however,

**TABLE 1** Culture group allocation based on self-reported country of socialization

Country	<i>n</i>
Eastern cultures ( <i>n</i> = 773)	
Malaysia	445
Singapore	269
Hong Kong	37
China	11
Indonesia	11
Western cultures ( <i>n</i> = 1,704)	
Australia	819
Norway	492
United Kingdom	357
United States	23
New Zealand	13

continuing with countries as a unit of analysis would have introduced problems of unequal sample sizes. Thus, collapsing these countries into larger culture groups allowed us to retain more participants in the analysis.

There were four notable differences in demographics between the Eastern and Western groups. The Eastern sample was younger ( $M = 21.48$ ,  $SD = 2.59$ ) than the Western sample ( $M = 27.03$ ,  $SD = 9.64$ ;  $t(2,485) = 15.76$ ,  $p < .001$ ,  $d = 0.79$ ) and were less likely to be in a committed relationship (31.70% vs. 55.00%,  $\chi^2(1, N = 2,487) = 116.15$ ,  $p < .001$ ;  $\phi = 0.22$ ). To control for these differences, we included age and relationship status as covariates in the analysis. The importance of religion was also different between the groups. On a scale from 1 (*not important at all*) to 5 (*very important*), Eastern participants typically reported that religion was of average importance to them ( $M = 3.20$ ,  $SD = 1.47$ ), whereas Western participants reported that it was fairly unimportant ( $M = 1.70$ ,  $SD = 1.20$ ;  $t(2,393) = 26.05$ ,  $p < .001$ ,  $d = 1.12$ ). However, because religiosity was one of the preferences featured in the task, we did not include it as a covariate. Finally, 98.6% of the Eastern sample were students compared to 80.5% in the Western one. See the supplementary materials for general demographic information about the culture groups.

## 2.2 | Country of socialization

The participants self-reported their country of socialization by answering the question “In which country were you raised?” If this was unavailable, we used the country in which they were born. The only exception to this was the Norwegian sample. Here, the local ethics board did not allow us to ask about country of birth or socialization, as they felt that this could threaten the anonymity of any non-Norwegian native because of the cultural homogeneity in Norway. However, given that this version of the study was completed in Norwegian, it is highly likely that all the participants were either born or raised in Norway. Thus, we categorized all participants from the Norwegian sample as Western.

## 2.3 | Materials and procedure

The first author received ethical approval for the study from his local ethics committee in the UK. Other authors sought additional approval from their local committees where necessary. All institutions conducted the study in English apart from in Norway, where the materials were translated into Norwegian by one of the co-authors.

Participants began by providing informed consent and completing a demographic form. They were then given an introduction to percentiles using height as an example (e.g., that a person at the 50th percentile of height would be taller than 50% of all other people) and given a description of the seven traits used in the task (kindness, physical

attractiveness, good financial prospects, humor, creativity, chastity, wants children, and religiosity). Next, they created three long-term partners by allocating “mate dollars” to these traits whereby \$1 bought a 10-percentile increase for a given attribute. The task was repeated three times using low (\$16), medium (\$32), and high (\$48) budgets. See the supplementary materials for full details and participant instructions. At the conclusion of the study, participants received a full debrief.

## 2.4 | Data analysis and handling

Following Li et al. (2002), we began by subtracting the number of dollars assigned to each attribute in the medium budget from their equivalents in the high budget. This told us how the participants allocated their last 16 mate dollars. For simplicity, we refer to this as the “high budget” condition. By comparing this to how they allocated their first 16 dollars, which we call the “low budget” condition, we were able to observe how the participants’ allocation pattern changed as the budgets increased and choice became less constrained. We also converted these numbers into percentages, which allowed us to retain the 7.2% of the sample who allocated slightly too few or too many dollars (up to  $\pm 10\%$ ).

## 3 | RESULTS

Our analyses consisted of general linear models incorporating the within-subjects factors of budget and trait and the between-subjects factors of sex and culture group. We explored significant interactions using Bonferroni corrected pair-wise comparisons. Age was included as a covariate, as was relationship status (1 = *married or in a committed relationship*, 2 = *divorced, single, or in an uncommitted relationship*).

As mentioned, *necessity* traits are those that are given priority during the allocation of the first 16 dollars (i.e., the low budget condition) and receive fewer dollars during the allocation of the last 16 dollars (i.e., the high budget condition). *Indispensable* traits are also prioritized when using a low budget and continue to receive a similar number of dollars in the high budget. Finally, *luxury* traits are not prioritized and receive more dollars when using the high budget compared to the low budget. To determine whether a trait was given priority, we used one-sample *t*-tests to see if it was allocated more than 12.5% of the dollars in the low budget condition (typically \$2). As there were eight traits, we would expect a trait to receive this many dollars by chance.

As with previous versions of the task (Li et al., 2002; Li & Kenrick, 2006), there was a main effect of trait ( $F[7, 17,297] = 54.990$ ,  $p < .001$ ,  $\eta_p^2 = 0.02$ ) and a significant interaction between trait and budget ( $F[7, 17,297] = 13.103$ ,  $p < .001$ ,  $\eta_p^2 < .01$ ). These significant effects confirmed that (a)

participants spread their dollars unevenly among the traits and (b) this pattern differed between low and high budgets.

Follow-up analyses revealed that kindness, physical attractiveness, and good financial prospects were necessities. Humor, despite being a priority, received more dollars in the high budget condition than the low one, for reasons that became clear as we broke down larger interactions. The remaining traits were all luxuries (see Figure 1).

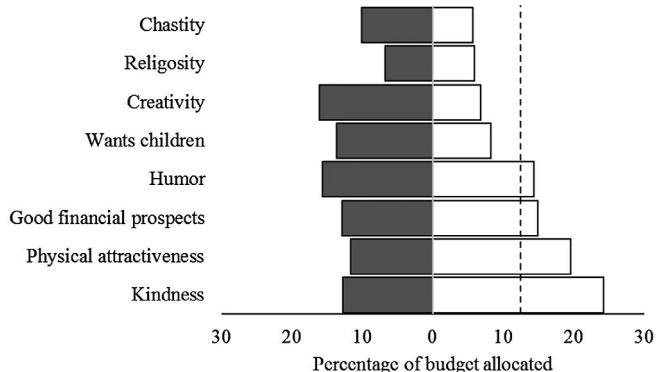
### 3.1 | Sex differences

An interaction between trait, budget, and sex ( $F[7, 17,297] = 41.830, p < .001, \eta_p^2 = .02$ ) suggested that the pattern of necessities and luxuries might differ by sex. Upon breaking down this interaction, we found that kindness and physical attractiveness were necessities for both sexes. Good financial prospects, however, was now a luxury for men, and a necessity for women (see Figure 2).

We also found that a partner's humor was indispensable for men, receiving a similar amount of dollars across both budgets. The unusual pattern surrounding humor in the overall sample appeared to be driven by women, who, despite prioritizing humor, tended to assign slightly more dollars in the high budget, as is typical with luxury traits.

Of the remaining traits, chastity, creativity, and wants children were luxuries for both sexes. Religiosity, however, was only a luxury for men; women instead continued to allocate a similar number of dollars to religiosity in both budgets. As with humor, this pattern departs from what is normally found for luxury traits.

Sex differences were found in the low budget condition for all traits with the exception of kindness and humor. The most noticeable sex differences were for physical attractiveness ( $d = 0.55$ ), which tended to receive more dollars from men, and good financial prospects ( $d = 0.56$ ), which tended to receive more dollars from women (see Table 2).



**FIGURE 1** Percentage of mate dollars assigned to each trait in the low budget (white) and high budget (gray) conditions. The vertical dashed line indicates how many dollars we would expect each trait to receive by chance

## 3.2 | Cross-cultural differences

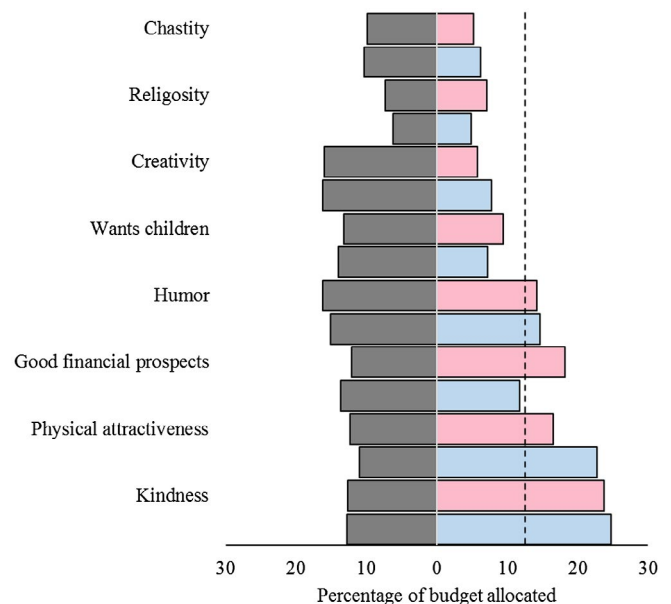
The most complex significant interaction in the analyses was between trait, budget, sex, and culture group ( $F[7, 17,297] = 6.810, p < .001, \eta_p^2 < .01$ ), suggesting that budget and sex differences in dollar allocation may further vary by culture.

### 3.2.1 | Eastern and Western women

Like the sample as a whole, kindness, physical attractiveness, and good financial prospects were necessities for both groups of women. However, humor was indispensable for Western women and a luxury for Eastern women. These two divergent patterns, when collapsed, made it difficult to categorize how women prioritized humor within the previous analysis (see Table 3).

Of the remaining traits, chastity and creativity were luxuries for both groups of women as was religiosity for Western women. However, Eastern women, much like their male counterparts, followed a pattern unusual among non-priority traits. Specifically, they allocated fewer dollars to religiosity in the high budget condition. Similarly, while the desire for children was a luxury for Eastern women, Western women allocated a similar number of dollars to it across both budgets, despite it not being a priority.

Within the low budget, the groups of women differed in the number of dollars they allocated to all traits with the exception of physical attractiveness. The most noticeable culture group differences were for religiosity, which tended



**FIGURE 2** Sex differences in mate dollar allocation. The colored bars indicate the percentage of mate dollars assigned to each trait in the low budget condition (blue = men, pink = women). The gray bars indicate the percentage assigned in the high budget condition [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

**TABLE 2** The percentage of dollars allocated to each trait when spending the first (low budget) and last (high budget) 16 mate dollars. Changes between budgets are displayed as well as sex differences

Trait	Women				Men				Sex differences			
	M (SE)		d		M (SE)		d		Low		High	
	Low	High	Δ	d	Low	High	Δ	d	Δ	d	Δ	d
Kindness	23.78 <sub>a</sub> (0.35)	12.61 <sub>a</sub> (0.25)	-11.17**	-1.01	24.74 <sub>a</sub> (0.37)	12.82 <sub>a</sub> (0.27)	-11.92**	-1.14	-0.96	-0.08	-0.20	-0.02
Physical attractiveness	16.52 <sub>b</sub> (0.31)	12.31 <sub>a</sub> (0.24)	-4.21**	-0.41	22.73 <sub>b</sub> (0.34)	10.95 <sub>b</sub> (0.25)	-11.78**	-1.22	-6.21**	-0.55	1.36**	0.16
Good financial prospects	18.16 <sub>c</sub> (0.31)	12.04 <sub>a</sub> (0.26)	-6.12**	-0.57	11.80 <sub>c</sub> (0.34)	13.69 <sub>a</sub> (0.28)	1.89**	0.19	6.37**	0.56	-1.64**	-0.17
Humor	14.16 <sub>d</sub> (0.32)	16.25 <sub>b</sub> (0.28)	2.10**	0.19	14.69 <sub>d</sub> (0.34)	15.12 <sub>c</sub> (0.30)	0.43	0.04	-0.53	-0.05	1.13**	0.11
Wants children	9.40 <sub>e</sub> (0.31)	13.20 <sub>a</sub> (0.32)	3.80**	0.33	7.21 <sub>e</sub> (0.33)	13.98 <sub>ac</sub> (0.34)	6.77**	0.61	2.19**	0.2	-0.78	-0.07
Creativity	5.72 <sub>f</sub> (0.24)	15.99 <sub>b</sub> (0.30)	10.27**	1.02	7.82 <sub>e</sub> (0.26)	16.18 <sub>c</sub> (0.33)	8.36**	0.88	-2.10**	-0.24	-0.19	-0.02
Religiosity	7.07 <sub>g</sub> (0.29)	7.34 <sub>c</sub> (0.26)	0.28	0.03	4.84 <sub>f</sub> (0.31)	6.20 <sub>d</sub> (0.28)	1.36**	0.14	2.23**	0.21	1.14**	0.12
Chastity	5.20 <sub>i</sub> (0.28)	9.84 <sub>c</sub> (0.30)	4.64**	0.43	6.18 <sub>g</sub> (0.30)	10.33 <sub>b</sub> (0.33)	4.16**	0.41	-0.98*	-0.1	-0.50	-0.05

Note: Within each column, means with different subscripts are significantly different.

Abbreviations: *d*, Cohen's *d* effect size; *M*, estimated marginal mean; *SE*, standard error of the mean;  $\Delta$ , difference between marginal means.

\* $p < .05$ ; \*\* $p < .01$ .

to receive more dollars from Eastern women, and the desire for children, which tended to receive more from Western women. With the exception of humor, these differences were not sufficiently large to cause a change in the overall pattern of necessities and luxuries between the two groups of women (see Table 4).

### 3.2.2 | Eastern and Western men

Kindness and physical attractiveness were necessities for both groups of men. Humor was also a necessity, but only for Western men. Eastern men considered it a luxury (see Table 3). Though not significantly above the “priority trait” threshold that we set, Eastern men gave slightly more dollars to good financial prospects than expected by chance in the low budget (13.06%) and as the budget increased, they assigned roughly the same amount of dollars, similar to *indispensable* traits (12.53%). In contrast, a partner with good financial prospects was a clear luxury for Western men.

Of the remaining traits, chastity, creativity, and the desire for children were luxuries for both groups of men as was religiosity in Western men. However, Eastern men allocated a similar amount of dollars to religiosity across both budgets, a pattern not usually found among non-priority traits.

Within the low budget, Eastern and Western men differed in the number of dollars they allocated to all traits with the exception of the desire for children. The most noticeable culture group differences were for humor, which tended to receive more dollars from Western men, and religiosity, which tended to receive more from Eastern men. With the exception of humor, these differences did not affect which traits were necessities and which were luxuries (see Table 4).

### 3.2.3 | Other sex and cultural differences

All within-culture sex differences are displayed in Table 3. For brevity, we only discuss those relevant to our third hypothesis. As predicted, men allocated more dollars to physical attractiveness than women did in both Eastern ( $d = 0.44$ ) and Western ( $d = 0.73$ ) cultures. In turn, women allocated more dollars to good financial prospects than men did in both Eastern ( $d = 0.71$ ) and Western ( $d = 0.48$ ) cultures.

We also found a general cultural difference in the importance of a partner's financial prospects. Both Eastern men ( $d = 0.24$ ) and women ( $d = 0.47$ ) allocated more dollars to good financial prospects than their Western counterparts. While these differences did not result in good financial prospects being a necessity in one culture group and a luxury in the other, this came close in the case of men (see above). The increase in importance of good financial prospects appeared

**TABLE 3** The percentage of dollars allocated to each trait when spending the first (low budget) and last (high budget) 16 mate dollars. Sex and culture groups are displayed separately

Trait	Women				Men				Sex differences			
	Low		High		Low		High		Low		High	
	<i>M</i> ( <i>SE</i> )	$\Delta$	<i>d</i>	<i>d</i>	<i>M</i> ( <i>SE</i> )	$\Delta$	<i>d</i>	<i>d</i>	$\Delta$	<i>d</i>	$\Delta$	<i>d</i>
Eastern sample												
Kindness	21.57 <sub>a</sub> (0.59)	12.05 <sub>a</sub> (0.43)	-9.53**	-0.94	25.57 <sub>a</sub> (0.60)	11.86 <sub>a</sub> (0.43)	-13.71**	-1.37	-3.99**	-0.34	0.19	0.02
Physical attractiveness	16.23 <sub>b</sub> (0.54)	11.39 <sub>ab</sub> (0.41)	-4.84**	-0.51	20.90 <sub>b</sub> (0.55)	10.38 <sub>ab</sub> (0.41)	-10.52**	-1.13	-4.67**	-0.44	1.01	0.13
Good financial prospects	20.71 <sub>a</sub> (0.54)	10.65 <sub>ac</sub> (0.45)	-10.07**	-1.02	13.06 <sub>c</sub> (0.55)	12.53 <sub>ac</sub> (0.45)	-0.531	-0.05	7.65**	0.71	-1.89**	-0.21
Humor	11.06 <sub>c</sub> (0.54)	15.98 <sub>d</sub> (0.48)	4.92**	0.49	11.03 <sub>cd</sub> (0.55)	14.72 <sub>cde</sub> (0.49)	3.69**	0.36	0.03	0.00	1.26	0.13
Wants children	6.19 <sub>de</sub> (0.53)	12.91 <sub>ac</sub> (0.55)	6.72**	0.63	6.58 <sub>efg</sub> (0.54)	14.47 <sub>ce</sub> (0.56)	7.89**	0.74	-0.39	-0.04	-1.55*	-0.14
Creativity	4.94 <sub>d</sub> (0.41)	15.17 <sub>de</sub> (0.52)	10.23**	1.11	6.24 <sub>eh</sub> (0.42)	14.85 <sub>de</sub> (0.53)	8.61**	0.93	-1.30*	-0.16	0.32	0.03
Religiosity	11.64 <sub>c</sub> (0.50)	9.92 <sub>bcd</sub> (0.45)	-1.72*	-0.18	8.48 <sub>dff</sub> (0.51)	8.53 <sub>b</sub> (0.45)	0.06	0.01	3.16**	0.32	1.39*	0.16
Chastity	7.64 <sub>c</sub> (0.48)	11.60 <sub>af</sub> (0.52)	3.96**	0.40	8.14 <sub>g</sub> (0.49)	12.50 <sub>ae</sub> (0.53)	4.35**	0.44	-0.50	-0.05	-0.90	-0.09
Western sample												
Kindness	25.98 <sub>a</sub> (0.37)	13.18 <sub>a</sub> (0.27)	-12.80**	-1.27	23.91 <sub>a</sub> (0.44)	13.77 <sub>a</sub> (0.31)	-10.14**	-1.02	2.07**	0.18	-0.60	-0.07
Physical attractiveness	16.81 <sub>b</sub> (0.34)	13.23 <sub>a</sub> (0.25)	-3.57**	-0.38	24.56 <sub>a</sub> (0.40)	11.52 <sub>b</sub> (0.30)	-13.04**	-1.40	-7.76**	-0.73	1.71**	0.22
Good financial prospects	15.61 <sub>b</sub> (0.34)	13.44 <sub>a</sub> (0.28)	-2.17**	-0.22	10.53 <sub>b</sub> (0.40)	14.84 <sub>ac</sub> (0.33)	4.31**	0.44	5.08**	0.48	-1.40**	-0.16
Humor	17.25 <sub>b</sub> (0.34)	16.53 <sub>b</sub> (0.30)	-0.72	-0.07	18.35 <sub>c</sub> (0.40)	15.52 <sub>c</sub> (0.36)	-2.83**	-0.28	-1.10*	-0.10	1.01*	0.11
Wants children	12.61 <sub>c</sub> (0.33)	13.48 <sub>a</sub> (0.34)	0.87	0.08	7.84 <sub>d</sub> (0.39)	13.50 <sub>a</sub> (0.40)	5.66**	0.54	4.77**	0.46	-0.02	0.00
Creativity	6.50 <sub>d</sub> (0.26)	16.81 <sub>b</sub> (0.33)	10.31**	1.11	9.40 <sub>bd</sub> (0.30)	17.51 <sub>d</sub> (0.39)	8.11**	0.89	-2.90**	-0.36	-0.70	-0.07
Religiosity	2.49 <sub>e</sub> (0.31)	4.76 <sub>c</sub> (0.28)	2.27**	0.24	1.20 <sub>e</sub> (0.37)	3.86 <sub>c</sub> (0.33)	2.66**	0.29	1.29*	0.13	0.90*	0.10
Chastity	2.76 <sub>c</sub> (0.30)	8.07 <sub>d</sub> (0.33)	5.32**	0.53	4.21 <sub>f</sub> (0.35)	8.17 <sub>f</sub> (0.39)	3.96**	0.40	-1.46**	-0.15	-0.10	-0.01

*Note:* Within each column, means with different subscripts are significantly different. Abbreviations: *d*, Cohen's *d* effect size; *M*, estimated marginal mean; *SE*, standard error of the mean;  $\Delta$ , difference between marginal means. \**p* < .05; \*\**p* < .01.



	<i>M (SE)</i>		$\Delta$	<i>d</i>
	East	West		
<b>Women</b>				
Kindness	21.57 <sub>a</sub> (0.59)	25.98 <sub>a</sub> (0.37)	-4.41**	-0.38
Physical attractiveness	16.23 <sub>b</sub> (0.54)	16.81 <sub>b</sub> (0.34)	-0.57	-0.05
Good financial prospects	20.71 <sub>a</sub> (0.54)	15.61 <sub>b</sub> (0.34)	5.11**	0.47
Humor	11.06 <sub>c</sub> (0.54)	17.25 <sub>b</sub> (0.34)	-6.19**	-0.58
Wants children	6.19 <sub>de</sub> (0.53)	12.61 <sub>c</sub> (0.33)	-6.42**	-0.61
Creativity	4.94 <sub>d</sub> (0.41)	6.50 <sub>d</sub> (0.26)	-1.56**	-0.19
Religiosity	11.64 <sub>c</sub> (0.50)	2.49 <sub>e</sub> (0.31)	9.15**	0.93
Chastity	7.64 <sub>e</sub> (0.48)	2.76 <sub>e</sub> (0.30)	4.88**	0.51
<b>Men</b>				
Kindness	25.57 <sub>a</sub> (0.60)	23.91 <sub>a</sub> (0.44)	1.66*	0.14
Physical attractiveness	20.90 <sub>b</sub> (0.55)	24.56 <sub>a</sub> (0.40)	-3.66**	-0.34
Good financial prospects	13.06 <sub>c</sub> (0.55)	10.53 <sub>b</sub> (0.40)	2.54**	0.24
Humor	11.03 <sub>cd</sub> (0.55)	18.35 <sub>c</sub> (0.40)	-7.32**	-0.69
Wants children	6.58 <sub>efg</sub> (0.54)	7.84 <sub>d</sub> (0.39)	-1.26	-0.12
Creativity	6.24 <sub>eh</sub> (0.42)	9.40 <sub>bd</sub> (0.30)	-3.15**	-0.39
Religiosity	8.48 <sub>dff</sub> (0.51)	1.20 <sub>e</sub> (0.37)	7.28**	0.74
Chastity	8.14 <sub>ghi</sub> (0.49)	4.21 <sub>f</sub> (0.35)	3.93**	0.42

Note: Within each column, means with different subscripts are significantly different.

Abbreviations: *d*, Cohen's *d* effect size; *M*, estimated marginal mean; *SE*, standard error of the mean;  $\Delta$ , difference between marginal means.

\**p* < .05; \*\**p* < .01.

to come at the expense of physical attractiveness (in men) and kindness (in women; see Table 4).

### 3.3 | Summary of findings

Despite a host of differences between the sexes and culture groups, kindness and physical attractiveness were consistent necessities and creativity and chastity were consistent luxuries. Good financial prospects was a necessity for the sample as a whole. However, follow-up analyses revealed that women drove this pattern. Men did not prioritize good financial prospects in a partner, but while this followed the typical pattern of a luxury for Western men, Eastern men did not differ in their allocation between budgets. Eastern participants of both sexes appeared to place an additional premium on good financial prospects compared to their Western counterparts.

We found that sex differences in the number of dollars given to physical attractiveness and good financial prospects in the low budget condition were similar for both culture groups. Men tended to allocate more dollars to physical

**TABLE 4** Cultural differences in the percentage of dollars allocated to each trait for the first (low budget) 16 mate dollars spent during the task. Men and women are shown separately

attractiveness than women, though this difference was smaller in the Eastern sample. Conversely, women typically allocated more dollars to good financial prospects than men, though this difference was smaller in the Western sample.

The task also revealed some interesting cultural differences in the importance of a partner's humor. When looking at the sample overall, dollars were allocated to humor in an unusual way. Specifically, while participants gave it priority, they also tended to increase their allocation to humor in the high budget as if it were a luxury. Further analysis revealed that this pattern was the collective result of differences between the subgroups. Western participants of both sexes prioritized humor in a partner, with it being a necessity for men and indispensable for women. However, humor was a luxury for Eastern participants of both sexes. Despite cultural differences being present for almost every trait, humor was the only trait where it was luxury for one culture group and a necessity/indispensable trait for the other. Non-priority traits followed a luxury pattern, with two exceptions: (a) Western women allocated a similar amount of dollars to the desire for children in both budgets and (b) Eastern men continued to

allocate the same amount of dollars to religiosity during the high budget while women allocated fewer.

## 4 | DISCUSSION

Previous research on mate choice trade-offs has revealed that individuals prioritize reproductively fundamental traits when their ability to fully realize their mating desires is restricted and that this pattern of prioritization may be influenced by culture (Li et al., 2002, 2011). In the present research, we used the budget allocation task to explore similarities and differences between Eastern and Western groups using a large international sample. We also included traits previously unused in the task, known to vary in importance across cultures (i.e., religiosity, chastity, and the desire for children). Overall, we found good support for our hypotheses. As predicted, kindness, good financial prospects, and physical attractiveness were necessities for the sample overall, replicating previous research in more homogenous samples (H1; Buss, 1989; Li et al., 2002; Li & Kenrick, 2006).

When the sexes were examined separately, both gave similar priority to kindness ( $d = 0.08$ ). However, the sexes differed in how they prioritized physical attractiveness and good financial prospects (H2). Namely, physical attractiveness was typically more important to men ( $d = 0.55$ ) and good financial prospects was more important to women ( $d = 0.56$ ). These sex differences are consistent with the evolutionary psychological literature and reflect the sexual asymmetry in the benefits of having these traits in a partner (Buss, 1989; Jonason, Valentine, & Li, 2012). Furthermore, having a partner with good financial prospects was only a necessity for women, and was actually a luxury for men. In contrast, physical attractiveness was a necessity for both sexes.

Finally, despite variation in how they spend their mate dollars, we found the same pattern of necessities and sex differences in both culture groups (H3). However, good financial prospects came close to our “priority threshold” in Eastern men, likely because of an enhanced interest in this trait within Eastern participants overall. Recent research gives a possible explanation for this increased premium. In East Asian cultures, collectivist values that emphasize hierarchy and respect of authority combine with a desire for social harmony which channels intrasexual competition for status away from direct confrontation and toward the acquisition of prestigious occupations (Yong, Li, Jonason, & Tan, 2019).

Our results suggest the presence of a universal aspect of human mate selection that sees people prioritize those traits that were fundamental for reproductive success in the ancestral past. This process is also strongly influenced, but not counteracted, by sociocultural factors. That is, people appear to separately adhere to both their evolved mate preferences and socioculturally imposed ones (Gangestad et al., 2006).

These two forces are not necessarily at odds. From an evolutionary perspective, it may be adaptive for mate choice mechanisms to incorporate cultural norms and other environmental cues that have adaptive significance (e.g., traits are valued by a culture can reflect local conditions pertinent to survival) and not following norms may be socially costly as it indicates a lower commitment to the group (Richerson & Boyd, 2001). It may also be the case that cultural differences in prioritization are the product of evoked culture. In other words, prioritization mechanisms are facultative and use sociocultural and environmental factors to calibrate themselves in predictable ways (Gangestad et al., 2006; Schmitt, 2015; Tooby & Cosmides, 1990). While our findings are consistent with both these interpretations, they do not allow us to disentangle the relative contribution of evoked culture and cultural transmission to the cross-cultural variation found for each trait. What we do know is that, regardless of the specific mechanism by which culture affects prioritization, the tendency to prioritize traits fundamental to successful reproduction is somewhat canalized, causing similar necessity and luxury patterns to emerge across culture groups.

### 4.1 | Additional findings

In addition to these key findings, we found differences between the sexes and culture groups that we did not predict *a priori*. Of these, the most noticeable difference involved humor. This was the only trait that was prioritized in one culture group (Western) but not the other (Eastern). This should not be taken as evidence that a partner's humor is unimportant in Eastern cultures. Rather it appears that Eastern participants spread their dollars more evenly than Western ones. For example, in the low budget condition, the smallest percentage of the budget Western participants allocated to a trait (religiosity) was 1.20% and 2.49% for men and women, respectively. In contrast, the smallest percentage for Eastern men and woman was 6.24% and 4.94% (creativity). Thus, the Western group appeared to have more free dollars to allocate to other traits, while Eastern participants were more constrained, resulting in fewer dollars spent on humor by the Eastern group. This cultural difference is consistent with the idea that humor is fairly high up the mating “hierarchy of needs” but is less fundamental to reproductive success than kindness, physical attractiveness, and social status (Hall, 2017; Li et al., 2009; Miller, 2000). Thus, it becomes a priority only when needs for more culturally important traits are satisfied. An alternative explanation for this cultural difference may lie in humor's relationship with social status. Among Western samples, humor was found to enhance social status in some contexts and interact with status to increase attractiveness in others (Greengross & Miller, 2008). Should cultural norms sever these associations, then we may expect people to give humor less priority. However, there

has yet to be a comprehensive examination of the cultural differences in the function of humor as a pathway to status (Greengross, Silvia, & Nusbaum, 2019) and so this idea warrants investigation.

The fact that Western women showed a stronger preference than all other sub-groups for their partner to want children also requires further exploration. A possible source of this pattern involves culture differences in family planning and contraceptive use (Najimudeen & Sachchithanatham, 2014; Singh et al., 2002). However, it is also worth considering if this effect was the result of differences in age and relationship status between samples (see *Limitations*), despite our efforts to statistically control for them.

A final noteworthy finding concerns the small number of non-priority traits that showed an unusual pattern of change between budgets. Luxury traits tend to attract fewer dollars in low budgets, when participants focus on their necessities. Then, once these preferences are satisfied, participants begin to allocate more dollars to them. The result is that luxury traits receive fewer dollars in low budgets than in high ones. Yet, in a few cases here (e.g., religiosity in the Eastern group, desire for children in Western women) participants gave non-priority traits the same amount of dollars, regardless of budget. One possible explanation for this finding is that the benefits of these traits suffer from diminished returns. Religion is a highly assortative trait (Watson et al., 2004), and a small amount of commitment to the same religion may indicate that a partner's belief system is compatible with one's own, compared to following a different denomination or being irreligious. Having a partner with similar religious views can be important in cultures where intra-faith marriage is the norm (Shenhav, Campos, & Goldberg, 2017; Yahya & Boag, 2014). However, increases in religiosity beyond this level may not yield the same benefits. That is, moving from an irreligious partner to one who follows the same faith but is not committed to it, is a larger qualitative shift than moving from a partner who is somewhat committed to a faith to one who is highly committed. Another way of conceptualizing this issue is that not all traits share the same preference functions (Rosenthal, 2017). Some, like social status, may have a directional or sigmoidal function, whereby status increases attractiveness in a linear or curvilinear manner. Others, like religiosity, may have a unimodal function with an "optimal" level and attractiveness dissipating the more an individual deviates from this value.

## 4.2 | Limitations

The study had three main limitations. First, there was a large discrepancy in the sample sizes between the Eastern and Western groups. While unlikely to affect the analysis itself, a more balanced sample of Eastern participants would have allowed us to investigate country-specific effects. With the current sample, we could only do this for the Malaysian and

Singaporean subsamples, leading to the exclusion of participants from China, Hong Kong, and Indonesia. Second, the Eastern sample was considerably younger than the Western one, and less likely to be in a relationship. It is well established that mate preferences can change with age (e.g., Schwarz & Hassebrauck, 2012) and so we attempted to control for these differences during the analyses. However, as the differences were large, this may not have been wholly successful and may explain the large cross-cultural differences found for a partner's desire for children.

A final limitation surrounded sampling. Our sample was not WEIRD (Henrich, Heine, & Norenzayan, 2010), but it was arguably "EIR" as participants were predominantly well-educated students from industrialized countries. Thus, while our study was more diverse than other studies of mate preference prioritization, it provides only a starting point for considering the impact of culture on this process. Those traits most fundamental to reproductive success appear to be necessities among students from different cultures, but to fully explore the mate preference priority model we would need to examine more diverse samples, including non-students and those from different types of societies (e.g., pastoralists and hunter-gathers). That being said, research has shown that cultural differences emerge between groups even when the samples share traits that are not representative of their wider populations. For example, a recent investigation of sexual regret as a function of sociosexuality and religiosity found meaningful cultural differences between Norwegian and US participants despite their shared student status, given the relevant cultural differences in gender egalitarianism, secularism, and sexual liberalism (Bendixen, Asao, Wyckoff, Buss, & Kennair, 2017).

## 4.3 | Future directions

Understanding how mating preferences are integrated and traded-off as part of mate choice remains a relatively unexplored area of psychology, both in human and non-human animals (Conroy-Beam et al., 2016; Rosenthal, 2017). In humans, this exploration is generally limited to considering how a small number of preferences interact within typically homogenous groups (e.g., Bennett et al., 2015; Lee et al., 2014; Wagstaff et al., 2015). The budget allocation task allows one to examine group similarities and differences in the prioritization of several traits across contexts. Thus, it provides a powerful tool for establishing the design features of the psychological adaptations behind mate choice.

Future research could use the task to examine trade-offs in a more nuanced manner by examining sub-components of reproductively important traits. For example, although physical attractiveness is consistently found to be a dominant trait, there is scope to explore this in a more nuanced manner by considering separate elements of physical attractiveness,

including facial symmetry, skin complexion, body composition, and muscle mass (Lassek & Gaulin, 2009; Little et al., 2011). Similarly, social status could be broken down into dominance and prestige (von Rueden, Gurven, & Kaplan, 2011). Other traits that may be of interest include intelligence and sexual compatibility. Intelligence has been used with budget allocation tasks before (Li et al., 2002) and, like humor and creativity, is hypothesized to be a sexually selected ornament (Miller, 2000). While we chose to exclude it here in favor of more culturally variable traits, a similar cross-cultural study including intelligence would be of great theoretical value to researchers interested in the universal nature of this preference. If mate preference mechanisms have evolved to prioritize traits fundamental to reproductive success, then we would expect traits that signal consistency in sexual access to be highly sought after. Thus, sexually compatibility, which signals concordance in sexual desire and habits, may also prove an interesting characteristic to include in prioritization research.

Another environmental cue that could affect prioritization is relationship context. While the task has been applied to short- and long-term relationships (e.g., Li & Kenrick, 2006) as well as partner proximity (e.g., Jonason et al., 2017), other relationship arrangements that might be worthy of study include polyamory, “booty calls,” friends-with-benefits arrangements, and swinging (Jonason et al., 2012). Similarly, change in preference patterns over time or following exposure to evolutionarily relevant cues (e.g., threat and resource availability) could be measured using budget allocation (Thomas & Stewart-Williams, 2018).

## 5 | CONCLUSION

Using an international sample, we found that a long-term partner's kindness, physical attractiveness, and good financial prospects were necessities in both Eastern and Western cultures and that these groups showed similar sex differences in the importance of physical attractiveness and good financial prospects. Our findings suggest that (a) humans prioritize traits that are fundamental for reproductive success when selecting mates and (b) the mechanisms responsible for this process produce similar prioritization patterns despite cross-cultural variation. At the same time, we found that culture can influence prioritization, with a greater Eastern emphasis on good financial prospects and a Western emphasis on sense of humor providing good examples. These results are consistent with the idea that mate preference prioritization results from an interaction between evolved mate preferences and socioculturally imposed ones, with the former being of stronger influence when it comes to reproductively fundamental traits. They demonstrate that using diverse samples to examine the mate preference trade-offs can help us

understand the universal nature of mating preferences, which ultimately offers us a deeper insight into the mechanisms that govern human mate choice.

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## CONFLICT OF INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research authorship, and/or publication of this article.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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