What is a Mate Preference? Probing the Computational Format of Mate Preferences Using Couple Simulation

Daniel Conroy-Beam[1*], Kathryn V. Walter[1], Krystal Duarte[2]

[1]Department of Psychological and Brain Sciences, University of California, Santa Barbara, Santa Barbara, CA 93106-9010

[2]Department of Psychology, CSU Fresno, Fresno, CA 93740

*Corresponding author: Daniel Conroy-Beam, Department of Psychological and Brain Sciences, University of California, Santa Barbara, 93106-9010, dconroybeam@ucsb.edu

Abstract

What is the computational format of mate preferences? Different researchers hold a range of assumptions: weights, thresholds, ranges, ideal templates, or combinations thereof. These varying assumptions have important implications for theory and methods in studying human mating; however, this inconsistency has scarcely been acknowledged or empirically addressed. Here, we use two samples of U.S. romantic dyads (*n*s = 1052, 590), a newly developed mate preference questionnaire, and a new computational modeling technique, "couple simulation," to empirically compare alternative models of the format of ideal romantic partner preferences. We find evidence that preferences are best understood as representing ideal trait values integrated into mate value evaluations using distance metrics.

Keywords: mate choice, human mating, relationships, agent-based modeling, mate preferences

What is a Mate Preference? Probing the Computational Format of Mate Preferences Using Couple Simulation

Mate preferences research has been big business in psychology for decades. Central lines of research in both evolutionary and social psychology have focused on the contents of human mate preferences (e.g. Hill, 1945), their variation across people and across cultures (e.g. Buss, 1989; Eagly & Wood, 1999), and their role in actual mating behavior (e.g. Kenrick & Keefe, 1992; Kurzban & Weeden, 2007; Todd et al., 2007). But what exactly is a mate preference and how does it work? Is it a slope that determines the desirability earned by a given amount of some quality? A threshold that potential mates must exceed? An imagined other to which potential mates are compared? What kind of thing is a preference in the mind?

One might expect that, given the sustained focus on mate preferences across theorists and across decades, the answer to this basic question would be clear. However, it is not. Here, we illustrate that notions and measurements of preferences are quite heterogenous across the mate preferences literature. This heterogeneity yields ambiguity in what psychologists mean when they refer to such a thing as a "mate preference." We attempt to answer the basic question, "What is a mate preference?" by applying a novel technique, couple simulation (Conroy-Beam et al., 2019), to compare a wide range of models of mate preferences. In doing so, we are able to determine empirically the relative plausibility of alternative notions of human mate preferences and answer fundamental questions about their computational format.

1.1 The Many Origins of 'Preferences'

Human mate choice is a very broad field of study. Researchers have long observed that people choose romantic partners non-randomly with respect to several dimensions, including physical attraction (Berscheid & Walster, 1974), similarity (Condon & Crano, 1988), familiarity (Saegert et al., 1973), and others. Documenting the patterns and origins of non-random partner choice have been core research traditions in social psychology (e.g. Thibault & Kelley, 1959), behavioral genetics (e.g, Vandenberg, 1972), sociology (e.g, Mare, 1991), anthropology (e.g, Symons, 1979), and economics (e.g, Greenwood et al., 2014). These disparate fields have variously labeled their efforts as research into attraction, assortative mating, or homogamy.

Within this broader space of research into human mate choice, a substantial subset has emerged that studies mate choice while centering the construct of a "mate preference.[1]" Much of the modern research on "mate preferences" can trace at least some roots to work in evolutionary psychology and anthropology in the 1970s and 1980s. These researchers turned to mating research in evolutionary biology for inspiration in studying human mating. Non-human animals also mate non-randomly; and while not the only explanation (e.g., see Ryan et al., 1990), mate preference adaptations have been the most common explanation for observed deviations from randomness. The core rationale is straightforward: over evolutionary time, not all mate choices would have the same reproductive consequences. Mutations that caused pursuit of potential mates who promoted reproduction—and/or avoidance of potential mates who hindered it—would reproduce themselves more reliably and increase in frequency over time. In this way, species tend to evolve mate preferences that bias their mate choices in favor of some phenotypes (or extended phenotypes) over others.

Following this rationale, evolutionary psychologists and anthropologists have proposed that humans too should possess evolved, species-typical mate preference adaptations that bias

[1] For scale, a PsychInfo database search for articles including the keywords "romantic partner choice," "homogamy," "assortative," or "mate choice" yields 6,140 results at the time of writing. A search that includes any of those keywords *and* "prefer*" yields 2,530 results, 41.21% of the total.

mate choices. Research and debate stimulated by this hypothesis has consequently focused largely on documenting the contents of these preferences (Buss & Barnes, 1986); understanding variation in these contents as a function of sex (Buss, 1989), context (Kenrick et al., 1990), and ecology (Eagly & Wood, 1999; Gangestad et al., 2006; Walter et al., 2020); and understanding the links between preferences and choice behavior (Eastwick & Finkel, 2008; Gerlach et al., 2019; Joel et al., 2017; Kenrick & Keefe, 1992; Kurzban & Weeden, 2007; Todd et al., 2007). Notably, this work has been relatively unique within approaches to human mate choice in centering the mate preference itself as an important unit of analysis rather than, for instance, the homogamy generated by preferences.

Evolutionary psychologists have furthermore been somewhat unique in emphasizing the preference as a real feature of the organism as opposed to a useful statistical abstraction merely derived from patterns of behavior. Evolutionary psychologists have generally conceptualized mate preferences as being some form of mental object: for example, "preference mechanisms, at the most general level, may be defined as *psychological processes* that incline or predispose organisms to selectively choose or reject stimuli in their environments" (emphasis added; Buss, 1992, p. 253). Similarly: "Preferences are evolved *psychological mechanisms* that solve survival and reproductive problems. […] They operate as *desires, attractions, and gut-level emotions* that characteristically impel a person toward some mates and repel a person from others" (emphasis added; Buss & Schmitt, 1993). In this view, preferences are psychological adaptations (or their outputs), instantiated in the brain, and built into the mind by selection based on their historical impact on mating behavior. And while preferences are expected to be flexible, adjusting to some degree according to context or experience, they are nonetheless conceptualized as enduring features of the organism designed to guide choice across situations.

This sense of preference contrasts sharply with other popular senses of the construct. For example, economists also make heavy use of a concept of "preference;" however, the word "preference" is used quite differently by economists compared to evolutionary psychologists. Traditionally, in economics, "preferences" refer to rank orderings of options (e.g., Jehle & Reny, 2010; Samuelson, 1948). That is, an individual can be said to have a preference for A over B if, given the opportunity, they actually choose (or would have chosen) A over B. This sense of preference is thus inherently an ordinal relation: one does not have an abstract "preference for A;" rather, one prefers A to something else.

Notably, this traditional economic notion places preferences outside of the head. Economic preferences exist essentially as behavioral phenomena: one has a preference for A over B if one chooses A over B (actually or hypothetically). Though such preferences may be the product of psychological phenomena such as "tastes" (Jehle & Reny, 2010; Samuelson, 1948), and whereas economists do attempt to precisely model the functions underlying preferences, "preferences" themselves in the economic sense are not features contained within an individual's psychology. Rather they are the observable outcome of that psychology interacting with a set of alternatives to yield choice behavior. And although many of the specific assumptions of classical economic theories of preferences have been challenged (Tversky, 1969), the general notion of preferences as being rank orderings of options remains and has been historically influential within some areas of psychology (e.g., Zajonc & Markus, 1982).

These contrasting psychological and behavioral senses of preference offer different advantages and disadvantages. A chief advantage of the behavioral definition of preferences is its clarity: the economic sense of preference affords mathematical transparency as to precisely what a preference is and what it is not (Jehle & Reny, 2010; Samuelson, 1948). However, by placing preferences outside the psychology of the organism, the economic definition of preference renders evolutionary theorizing more challenging. Natural selection cannot create rank orderings over all conceivable options, both because conceivable sets will be infinitely large and because each decision an organism encounters is unique: the precise decision situation, and therefore the rank ordering of options that will be prudent for the organism, has never happened before and will never happen again. Selection cannot possibly endow organisms with rank orderings over options for all decision scenarios it may encounter. Instead, what natural selection can create are decision psychologies that can (1) capture features of the decision situation that map onto recurrent invariances and (2) process those inputs into choice behaviors according to decision rules that historically yielded reproductive success (Cosmides & Tooby, 1995).

By emphasizing preferences as being evolved design features of decision psychology, evolutionary psychologists can more easily leverage the power of evolutionary theorizing to understand human mating. Evolutionary theory can be used to make predictions about the computational design of decision psychology; knowledge of this design and the particulars of a given context can then be used to make predictions about behavior (Cosmides & Tooby, 1995). However, a notable disadvantage of this psychological approach to preferences has been that evolutionary psychologists thus far have generally been less specific than their economist colleagues about exactly what they conceptualize mate preference psychology to be and how they expect it to work. This relative lack of clarity has left room for great heterogeneity among psychologists in the ways that they conceptualize preferences and their relationship to mating behavior. And this heterogeneity has produced confusion over the nature of mating psychology and mate choice.

1.2 Sketching a More Precise Modeling Framework for Mate Preferences

To begin resolving the heterogeneity in preference ontologies, it will be helpful to sketch a framework for modeling the psychology of mate preferences. Doing so makes clear both those aspects of preference theory on which there is widespread agreement and those aspects on which theorists tend to diverge. Creating such a framework requires first identifying the decision-making tasks posed by mate choice.

All sexually reproducing organisms must find mates in order to reproduce. However, for many reasons, individuals cannot pursue every potential mating opportunity they encounter. Most fundamental among these reasons is that time and energy are finite, and any amount of these limited resources dedicated to one mating opportunity must come away from other mating opportunities. This is particularly true for organisms with relatively steep reproductive and parenting costs (Clutton-Brock & Parker, 1992; Trivers, 1972), such as our own species, where mating, reproduction, and parenting are frequently characterized by long-lasting, relatively exclusive bonds (White et al., 1988), lengthy and energetically expensive gestation (Aiello & Wells, 2002), and extended and expensive parenting (Kaplan et al., 2000). Sexually reproducing species therefore experience a fundamental problem of deciding how and to whom they will dedicate their limited mating resources. This is the origin of mate choice.

Mate choices could, in principle, be arbitrary. But across the long arc of evolutionary history, the recurrent reproductive consequences of all possible mate choices are unlikely to have been equal. Some potential mates would inevitably be more successful reproductive partners than others. This dimension of variation, which has been called "mate value" (Sugiyama, 2005), is the critical dimension from the perspective of selection. People with psychologies that allowed them to detect and specially pursue mates high in mate value would, on average, experience greater reproductive success and would better reproduce whatever genes contributed to the development of these psychologies. Iterated over deep time, this would lead to the evolution of mating psychologies more efficiently designed for the detection and pursuit of high mate value partners.

However, here emerges a new problem for sexually reproducing organisms: mate value is invisible. The fitness consequences of pursuing one mate over another are probabilistic future events that no organism can perceive directly. Instead, the probable consequences of pursuing a given mate must be inferred from perceivable cues. These percepts could include enduring traits of the potential mate (e.g., how kind they are), temporary states (e.g., their age), contextual factors (e.g., local marriage norms), dyadic factors (e.g., whether they offer strengths that are complementary to the organism's weaknesses), or other information. Percepts can exist at multiple levels of organization—for example, some are simply objective and directly perceivable features of potential mates (e.g., their physical attractiveness), whereas others are inherently relative (e.g., social status relative to the perceiver). No matter how it is perceived or computed, though, in order for some dimension of variation to be useful to the organism in comparing potential mates, it must be accurately and efficiently perceivable to the organism and it must be reliably correlated with mate value. To the extent that these are recurrently true of some percept across generations, selection can favor the evolution of mating psychologies that make use of that percept in mate choice.

A second challenge encountered in mate choice is that mate value is to some degree multidimensional. Kind mates and intelligent mates would likely make for better reproductive partners. But the kindest mates in the local mating market are not guaranteed to be the most intelligent—nor the highest in reproductive value, resources, fecundity, or health. Reliably pursuing high mate value partners requires not just perceiving potential mates on the individual dimensions of mate value, but also somehow integrating information from across dimensions into some form of overall evaluation that is correlated with true mate value.

To be clear, this evaluation could take on many forms. For instance, a binary sorting of potential mates (e.g., desirable vs. undesirable), a rank ordering of mates reflecting relative appeal or prioritization (akin to the economic sense of "preference"), or a real number estimate of mate value (e.g., the proverbial zero-to-ten desirability scale). In any case, these evaluations are the outputs of some mate evaluation psychology. This psychology takes perceptions of potential mates as input. These perceptions are then subjected to some set of functions which transform the input perceptions into output evaluations. These functions accomplish this transformation using some set of operations (e.g., arithmetic or logical operations), which themselves operate according to some set of parameters (e.g., variables that act in operations as weights, thresholds, exponents, and so on). The output evaluations can then be used to guide pursuit among alternative potential mates.

It is here, within this evaluation psychology, that we find an evolutionary, psychologically, and computationally plausible model of what mate preferences are and how they work (Figure 1). Specifically, we propose that "mate preferences" in the psychological sense are best understood as being the parameters of the evaluation functions underlying mate choice. By acting as weights, thresholds, comparisons, or in other roles, these parameters dictate the shape of evaluation functions across potential mates. That is, the nature of these parameters determines which regions of perception space—which levels of kindness, intelligence, or age—are evaluated favorably vs. unfavorably and thereby guide mate choice toward particular phenotypes. These parameters exist as psychological variables, in the head of the organism rather than as a feature of behavior *per se*. As such, they can be subject to the developmental and evolutionary processes psychologists propose have shaped them. Genes that promote the development of more useful parameter values will yield evaluations more strongly correlated with true mate value and promote more reproductively successful mate choice, increasing their own representation in future generations and causing the evolution of mate preferences as described by biologists, anthropologists, and evolutionary psychologists. The precise values of these parameters could also be calibrated by any number of other psychological mechanisms in response to individual differences, contextual factors, or experience in accordance with psychological hypotheses (e.g., Gangestad et al., 2006; Lewis et al., 2017). Modeling mate preferences as parameters of evaluation functions therefore captures many of the features evolutionary psychologists have proposed preferences possess while also providing mathematical transparency as to what preferences are and how they work.

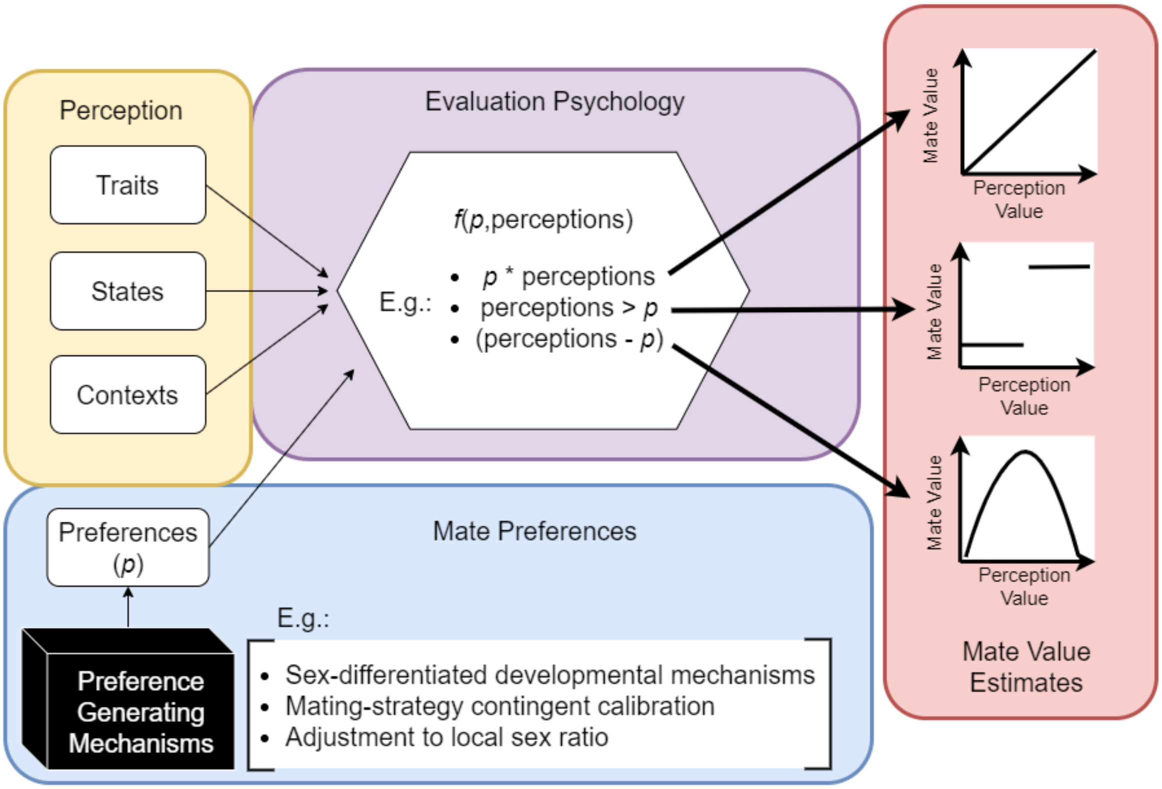

Figure 1. A diagram of the proposed model of mate preferences. Mate preferences act as parameters of evaluation functions that help dictate the shape of mate value estimate curves as a function of input perceptions. Preferences are generated by some number of unspecified preference generating mechanisms and then interact with mate perceptions and mate evaluation functions to yield mate value estimates. The role that preferences play in evaluation functions (e.g., weights, thresholds, or comparisons) dictates the nature of the resulting mate value estimates.

1.2.1. The Nature of Mate Preferences and Mate Evaluation

In light of this model of mate preferences as parameters of mate evaluation functions, two key questions for mate preference researchers become: what is the nature of human mate evaluation functions and what is the nature of the preference parameters within those functions? A review of the mate preference literature with these questions in mind reveals that although researchers appear superficially united in a topic of study, there are manifold assumptions concerning the nature of mate preferences and mate evaluation and few empirical tests among these implicit hypotheses.

Perhaps the most common assumption about the nature of mate value and mate preferences is that mate evaluation functions are linear combinations or weighted sums (Miller & Todd, 1998). Under these models, the more of some desirable feature a potential mate possesses, the higher in mate value they are estimated to be. Preferences act to weight the relative contributions of different dimensions to mate value: preferences are multiplied by trait values, similarly to regression slopes, such that the more preferred a quality is, the more that quality contributes to the overall mate value evaluation.

As with all models of mate preference, this weighted sum model is seldom stated explicitly (although sometimes it is, see Brandner et al., 2020). Rather, the assumption of a weighted sum model must be inferred from the ways in which researchers discuss or measure mate preferences. For instance, Buss (1989)—perhaps the most influential paper on human mate preferences—predicts that "females, more than males, should value attributes in potential mates such as ambition." It is not clear from the text exactly what "value" is intended to mean here. However, when preferences were measured in this study, participants were asked to rank and rate the relative importance of a variety of features in an ideal long-term partner (e.g., "good looks" and "financial prospects"). This mode of measurement suggests a model of mate preferences in which some dimensions are more important than others or carry greater weight in determining overall mate value evaluations than do others.

This implicit model of mate preferences can also be seen in empirical attempts to document mate preferences in the form of moderation effects. For example, some have proposed that for it to be true that men prefer physical attractiveness more than women, it must be demonstrable that physical attractiveness is more strongly correlated with men's evaluations or behaviors than it is for women (e.g. Eastwick & Smith, 2018; Meltzer et al., 2014). Similarly, others have argued that one has a preference for a characteristic to the extent that overall evaluations are correlated with that characteristic (e.g., Wood & Brumbaugh, 2009). These predictions follow directly from an assumption that preferences exert their effect on behavior by acting as slopes in a linear combination function.

This weighted sum model is a common model of mate preferences; but other prominent approaches to studying mate preferences make different assumptions. For example, many theorists propose that preferences act instead as thresholds. In a separate influential paper on preferences, Kenrick et al. (1990) measured many of the same preference dimensions as Buss (1989). But rather than asking about the relative importance of these dimensions, Kenrick and colleagues asked participants to report the minimum and maximum acceptable percentiles for a potential partner on each dimension. This implies that preferences, rather than adjusting the contribution of different dimensions to mate value evaluations, instead define an acceptable range of variation on each dimension. Even more explicit, Miller and Todd (1998) proposed that mate preferences set up a series of aspiration thresholds: potential mates must pass some minimum acceptable value on one preference dimension before being passed on for evaluation on a second. Here the mate value "evaluation" is not a real number estimate of a potential mate's true value, as in the weighted sum approach; rather, it is a binary go/no go signal in that potential mates are pursued only if they pass all of the relevant thresholds.

A third perspective is that mate preferences act as ideal target values to which potential mates are compared. Here mate value evaluations derive from the deviation between a given mate and the ideal value, with smaller deviations being more appealing. The Ideal Standards Model is relatively explicit in proposing such a model of preferences: "a person's partner ideal of 'handsome and warm' represents a personally held ideal that specifies what the individual hopes and desires (the self), describes a hypothetical other (the partner), and specifies what the ideal would be like in an intimate relationship with the self (the relationship)" (Fletcher & Simpson, 2000, p. 102). Under such an approach, preferences identify a hypothetical ideal, and evaluations are a function of the discrepancy between ideal and reality. This is similar to how some evolutionary biologists have conceptualized non-human mate preferences (e.g., Kirkpatrick & Ryan, 1991). That said, while this model of preferences is clear in the stated theory of the Ideal Standards Model, the questionnaires most often used to measure these ideals asks participants to rate the relative *importance* of the different preference dimensions—a measurement more consistent with weight models of preferences than with an ideal value model.

Table 1 summarizes these implicit models of mate preferences and their translation into parameters of mate evaluation functions. Combinations between these ideas occur as well. For instance, Li et al. (2002) appear to blend a summation model with a threshold model in proposing that "creativity should surely make someone more desirable. Yet creativity might be irrelevant if a person is below threshold on attractiveness" (p. 948). Here it seems that the implicit model of mate evaluation is that potential mates must pass some minimum threshold trait level to be evaluated (a threshold model of preferences), but afterwards are evaluated continuously based on the sum of their endowments (a linear combination model). Others have similarly proposed combinations between weighted sum models and discrepancy metrics useful for ideal value models of preferences (Conroy-Beam et al., 2019).

Table 1. A sample of mate preference models from the mate choice literature

Preference Model	Evaluation Function	Examples
Weights	$(p*t)$	Buss, 1989; Eastwick and Smith, 2018
Acceptable Ranges	$(p_{max}>t>p_{min})$	Kenrick et al., 1990
Minimum Thresholds	$(t>p)$	Miller and Todd, 1998
Ideal value	$(p-t)$	Fletcher and Simpson, 2000
Combinations	$p_1*(p_2-t)$ or if$(t>p_1)\{p_2*t\}$ else$\{0\}$	Conroy-Beam et al., 2019; Li et al., 2002

Note: p = preference value, t = mate perception value (e.g., actual trait value)

The key takeaway is that, although different mate preference researchers often appear to be talking about the same construct, when their implicit models of mate preferences are made more computationally precise, the reality is that different researchers actually think about mate preferences in quite dissimilar ways. Even worse, researchers are not necessarily internally consistent in terms of their theories of preferences and their measures of preferences. This unacknowledged heterogeneity creates ambiguity concerning the correct predictions to make on the basis of mate preference theories (Eastwick et al., 2014; Fletcher et al., 2020; Schmitt, 2014), fueling debate but clouding our understanding of human mate preferences.

What, then, is the best way to think about preferences? Attempts to answer this question empirically are rare. The overwhelming majority of the mate preference literature focuses on documenting the content of mate preferences and their variation. There is only a relatively small literature that attempts to explicitly compare models of the psychology of preferences and their computational role in attraction and mate choice decisions (Beckage et al., 2009; Brandner et al., 2020; Conroy-Beam & Buss, 2017). Within even this small literature, the predominant focus has been on comparing models of mate evaluation functions, with less emphasis on the models of mate preferences that these evaluation functions imply.

A noteworthy exception to this is Brandner et al. (2020). In this series of studies, participants reported their mate preferences in a variety of formats including ideal value ratings, minimum acceptable values, and relative importance ratings and rankings. These preferences were used to compare a variety of hypothesized functions for computing attraction to potential mates. The researchers found that the common weighted sum model best predicted participants' attraction decisions, suggesting a weight model of mate preferences is most plausible overall. However, even this study was primarily focused on comparing models of mate evaluation (e.g. weighted sum vs. Euclidean distance) rather than preference models *per se* (e.g., slope vs. ideal vs. threshold). Furthermore, these comparisons were based on choice among hypothetical potential mates in a binary forced choice task. This is an ingenious design in terms of providing experimental control and the ability to compare a broad set of models. However, real mate choice does not generally occur as a binary forced choice—rather, it occurs in mating markets populated by multiple potential mates as well as mating rivals. It is thus unclear the extent to which strategies would generalize from this more controlled context to more complete mating markets.

In the present studies, we attempt to address the gaps in the mate preference literature by comparing both models of mate preferences themselves and mate evaluation functions using a new agent-based modeling technique called couple simulation. Couple simulation attempts to compare alternative models of mate choice by reproducing people's real-world mate choices within simulated mating markets. The method proceeds by sampling real participants who are in real-world relationships and creating avatar agents that inherit the characteristics (e.g., preferences and corresponding traits) of these participants. These avatar agents then enter into a simulated mating market where researchers can experimentally manipulate the decision rules these agents use to make mating decisions. Researchers can then compare the mate choices of the avatar agents to the choices of their real-world counterparts. The core intuition is simple: whatever set of decision rules best approximates those used in real mate choice should tend to cause the avatar agents to make the same decisions as did their yoked participant. Therefore, the more accurately a given set of decision rules tends to reconstruct a given sample of couples, the more likely it is that set of decision rules is approximating realistic features of real human mate choice. Simulation studies indicate that this method can distinguish a population's true model of mate choice from alternatives (for expanded details, see Conroy-Beam, 2021). Here, we first use a series of proof-of-concept agent-based models to demonstrate that this couple simulation method can successfully compare alternative models of mate preferences themselves. We then apply this method to two samples of romantic dyads to evaluate the relative plausibility of a range of models of mate preferences and mate evaluation functions.

2. Proof of Concept Models

To use the couple simulation approach to compare alternative models of the format of preferences, we first have to establish that couple simulation can successfully distinguish among models of preferences in principle. Prior work has established that couple simulation can successfully compare among models of mate choice (i.e., the process by which evaluations lead to choices; Conroy-Beam, 2021); here we assess whether couple simulation can also compare among models of preferences and evaluation. To do so, we conducted a series of proof-of-concept models that apply couple simulation to a series of simulated populations. Each of these simulated populations is composed of agents who choose one another as mates according to a "true model," a simulated mating psychology whose mate preference format and mate evaluation functions are known for a fact. We draw samples of couples from these simulated populations and attempt to reproduce these sampled couples using both the population's true model as well as alternative models that are known to be incorrect. Couple simulation can be said to accurately identify a population's true model of mating psychology to the extent that each population's true model more accurately reproduces the sampled couples than do the alternative models. If couple simulation can accurately identify the true models governing mate choice within these simulated populations, this suggests the method can also be used to compare alternative models of mate choice psychology within real-world mate choice data.

All model scripts and outputs are available on the Open Science Framework (https://osf.io/ep6gf/?view_only=b730ac40dbc442089692f3d1a7b0456a).

2.1. Model Setup

2.1.1. Generating the Agent Population

We followed the model setup procedures detailed in Conroy-Beam (2021). We generated a population of $N = 50{,}000$ agents based on a sample of $n = 1{,}044$ people who were members of $k = 522$ committed, heterosexual romantic relationships. Participants in this sample reported their mate preferences on 16 dimensions in three different formats (see Study 1 for details): (1) ideal values (using 11-point bipolar adjective scales), (2) minimum and maximum acceptable thresholds (using 11-point bipolar adjective scales), and (3) relative importance (using both a ranking and a constant sum allocation rating). These participants additionally rated themselves and their partners on these 16 dimensions using 11-point bipolar adjective scales.

Agents were generated based on these data in a three step process (see Conroy-Beam, 2021 for details). First, we resampled from each dimension up to the desired population size of *N* = 50,000. Second, these values were multiplied by the Cholesky decomposition of the real data's correlation matrix; the Cholesky decomposition is comparable to taking the square root of a matrix and is useful for imposing a realistic correlation matrix on the simulated data. Finally, the simulated trait and preference data was re-scaled to the means, standard deviations, and ranges of the real data. The end result of this process was a population of *N* = 50,000 simulated agents with random traits and preferences whose distributions and correlation matrix closely mimicked that of the real human data.

2.1.2. Generating Agent Couples

Next, these simulated agents were used to generate populations of mated couples that differed only in the format of mate preferences used to generate them. To accomplish this, we first divided the agent population into 100 random subpopulations of *n* = 500 agents each. We then produced three copies of this subdivided population. In each of these populations, agents selected one another as mates within their subpopulations. Each agent did this by first computing the mate value of each potential mate in their local subpopulation based on their own preferences and the potential mates' traits and then selecting mates based on these mate value calculations. This process proceeded identically in each of the three agent populations with the exception of the mate value calculation. Each population used one of three formats of mate preferences and corresponding mate evaluation functions: a weighted sum function, an aspiration threshold function, and a Euclidean integration function.

2.1.2.1. Weighted Sum Mate Value Estimation

Agents in the weighted sum population selected mates on the basis of mate preferences that acted like weights. To compute the mate value of potential mates, these agents computed the sum of each potential mate's trait values, weighted by the agent's own importance rated preferences.

2.1.2.2. Aspiration Threshold Mate Value Estimation

Agents in the aspiration threshold population utilized mate preferences in three formats: rankings, minimum acceptable threshold, and maximum acceptable threshold. Mate value calculation was a multistep process for these agents. First, these agents evaluated all potential mates in their subpopulation against their highest ranked mate preference. On each dimension, the agent checked whether each potential mate's trait value fell both above their minimum preference for that dimension and below their maximum value for that dimension. Any potential mate that did not satisfy either of these conditions was eliminated from consideration. Still eligible mates were passed on for consideration in the next stage of mate value calculation. Here, the agent moved on to their next highest ranked preference and checked their minimum and maximum preferences against the traits of all remaining eligible potential mates. This process repeated until either the agent had used all 16 of their mate preferences or until a given mate preference would, if applied, eliminate all remaining potential mates. This process left the agent with the smallest possible set of potential mates that would be eligible given the agent's mate preferences. Finally, the agent assigned a mate value of 10 to all potential mates left eligible at that point and a mate value of 0 to any potential mate that was eliminated at any point.

2.1.2.3. Euclidean Mate Value Estimation

Agents in the Euclidean mate choice population utilized just their ideal value mate preferences for mate choice. These agents computed the Euclidean distance between their own preferences and the traits of each potential mate. These distances were rescaled such that a potential mate whose traits were the maximum possible distance from the agent's preferences would be assigned a mate value of 0 whereas a potential mate whose trait vector exactly matched the agent's preference vector was assigned a mate value of 10.

2.1.2.4. **Mate Choice**

After estimating the mate value of their potential mates, agents in each population selected their mates according to a resource allocation model of mate choice (Conroy-Beam, 2021). Each agent possessed a set of 10 abstract resources (representing, for instance, time, money, or energy) that could be allocated to potential mates. Each agent initially allocated these resources directly in proportion to each potential mate's estimated mate value. Afterward, agents reallocated resources in proportion to their mutual investment with each potential mate, calculated as the product of investment given and investment received in the prior allocation stage. This reallocation process repeated for 100 steps of courtship. This caused agents to drift from broadly allocating resources across several potential mates to eventually focusing the majority of their resources on 1-2 highly mutually interested partners. At the end of this courtship process, agents were paired with the potential mate in whom they were most highly invested if that potential mate was also most highly invested in the agent. These were the "ground-truth" agent couples upon which couple simulation was based.

2.1.3. Applying Couple Simulation

Finally, to assess the ability of couple simulation to compare among alternative models of mate preferences, we applied the couple simulation method to these populations of agent couples. For this, we drew 100 random samples of agent couples from each of the three populations at each of 7 sample sizes: k = 50, 75, 100, 200, 300, 400, and 500 dyads. Within each of these samples, we applied the couple simulation method attempting to reproduce the sampled agent couples separately using weighted sum mate value estimation, aspiration threshold mate value estimation, and Euclidean mate value estimation. For each model, we calculated the proportion of the sampled agent couples accurately reproduced by couple simulation. If the couple simulation method is able to successfully distinguish among alternative models of mate preferences, each population's true model of mate value estimation should tend to reproduce the greatest proportion of agent couples in couple simulation.

2.2. Model Results

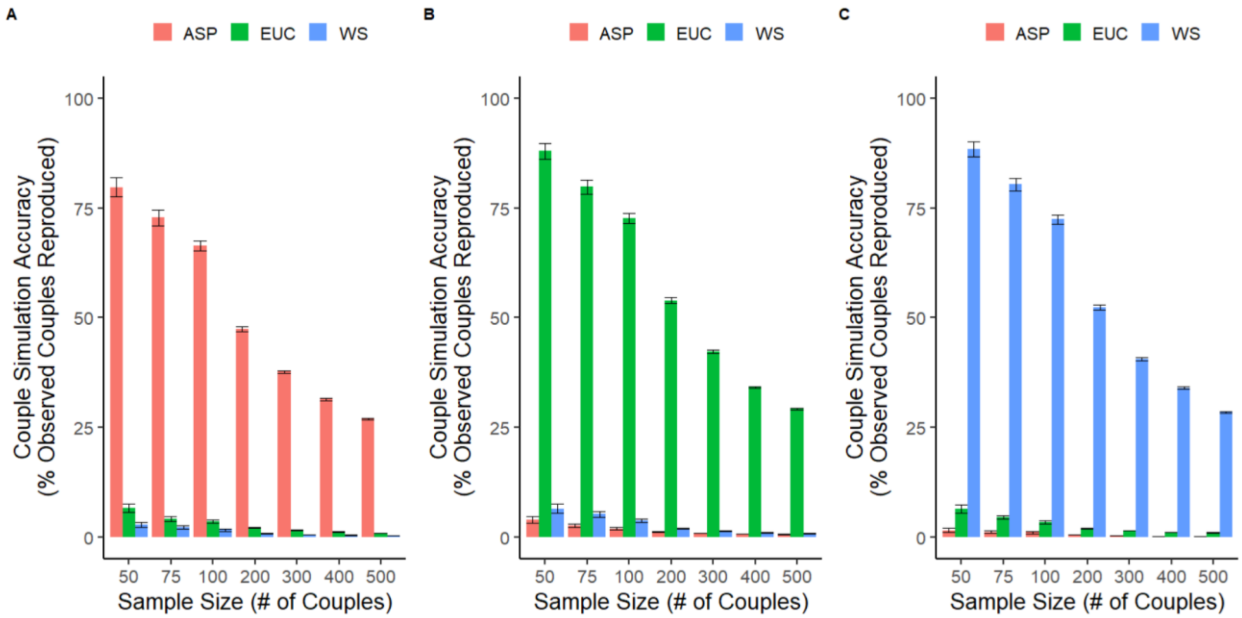

Figure 2. Results from the proof-of-concept models. Couple simulation can successfully identify a population's true model of mate preferences from random samples of couples. A: Results from the population which the aspiration threshold model was the true model of preference psychology; B: Results from the population in which the Euclidean distance was the true model of preference psychology; C: Results from the population in which the weighted sum model was the true model of preference psychology. Error bars represent 95% confidence intervals.

Figure 2 shows the results of the proof-of-concept models. In all three populations, the couple simulation method correctly recovered the population's true model of mate preferences and mate evaluation. When the aspiration threshold method of mate value estimation was the true model of mate preferences and mate evaluation, this model significantly outcompeted the weighted sum and Euclidean models at all sample sizes. The same was true for the Euclidean and weighted sum models. As in Conroy-Beam (2021), we observe that simulation accuracy generally declines with increasing sample size. However, in each population, the true model of mate preferences outcompetes the alternative models in 100% of samples at all sample sizes in all three populations. These results strongly suggest that the couple simulation method can indeed be used to empirically compare among alternative models of mate preference and mate evaluation.

Given how strongly couple simulation performed in distinguishing among these models, we conducted a further series of proof-of-concept models to further "stress test" couple simulation's abilities to compare among models of preferences and mate evaluation. This series of proof-of-concept models worked identically to the first. However, we changed the set of mate evaluation functions tested across the populations. These were limited to similarity metrics and as such all used a model of mate preferences in which preferences act as ideal values.

The comparison set included three populations in which mate evaluation was based on distance metrics: the Euclidean distance, the Manhattan distance, and the Minkowski distance with a power term of 1.5. If one imagines a "preference space," an abstract space in which each dimension represents a single mate preference, the Euclidean distance represents the straight-line distance, as the crow flies, between ideals and potential mates whereas the Manhattan distance represents the "city block" distance—the distance when going up and over between ideals and potential mates rather than cutting across the space. The Manhattan distance is equivalent to the total absolute deviation between preferences and potential mates. As such, in terms of comparing preferences to potential mates, the Manhattan distance allows for large deviations on some dimensions to be compensated for by small differences on other dimensions, whereas the Euclidean distance promotes pursuing partners who minimize large deviations from preferences on any dimension. Both the Euclidean and Manhattan distance are special cases of a broader metric known as the Minkowski distance. The Minkowski distance can take on any of an infinite number of forms based on the value of a power term. The Euclidean distance is the Minkowski distance with a power term of 2; the Manhattan distance is the Minkowski with a power term of 1. The third distance metric used here, the Minkowski distance with a power term of 1.5, is an intermediate form between the Euclidean and Manhattan distances and represents a curved line connecting preferences and potential mates.

We additionally included a population in which mate value was calculated based on the cosine similarity (see Conroy-Beam, 2018). The cosine similarity is a separate commonly used similarity metric that represents the cosine of the angle formed by ideals, preferences, and the origin of the preference space. This is highly similar to the profile correlation between preferences and potential mate traits. Evaluating potential mates according to a cosine similarity promotes pursuing potential mates whose overall trait configuration matches one's preference configuration (i.e., partners who are relatively high on those dimensions are relatively highly preferred) but does not minimize the direct deviation between preferences and partner characteristics. Finally, we included a population that blended ideal value and weight models of preferences using a weighted Euclidean model: in this population, mate value was computed as a Euclidean distance between an agent's preference vector and a potential mate's trait vector. However, the contribution of each dimension to the overall distance was weighted by the agent's importance-typed preferences, meaning that deviations on important dimensions were considered more negative than deviations on less important dimensions.

These similarity metrics are collectively more similar to one another than were the mate evaluation functions used in the first proof-of-concept models in that they are using the same preference format and computing values that reflect deviations between preferences and partner characteristics. This therefore provides a stricter test of couple simulation's ability to compare among models of mate preferences.

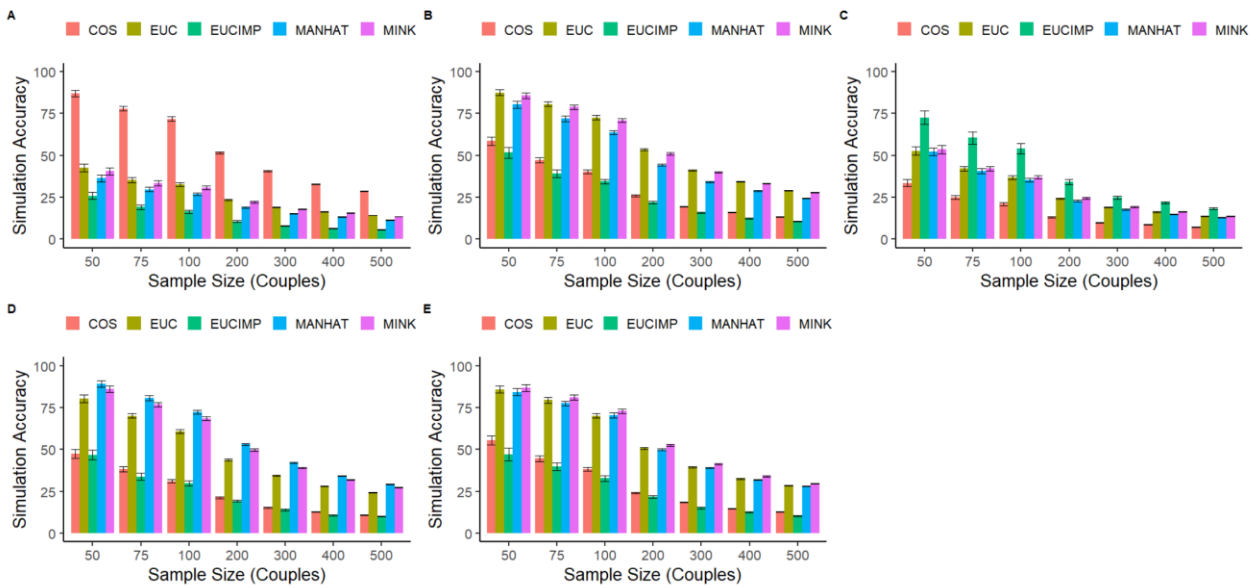

Figure 3. Results from the second series of proof-of-concept models. These tests compare a more similar set of mate preference models overall. Nonetheless, couple simulation can successfully identify a population's true model of mate preferences on average and in the majority of samples. A: Cosine similarity population; B: Euclidean population; C: Weighted Euclidean population; D: Manhattan population: E: Minkowski population. Error bars represent 95% confidence intervals.

Figure 3 presents the results of this second set of proof-of-concept models. Simulation accuracies were generally closer to one another in this second model than they were in the primary model. However, even here, in each population the true model of mate preferences significantly outcompetes the others on average across samples by the time the sample size was k = 300 dyads.

Although the correct model of mate preferences outperformed the alternatives on average across samples, Figure 4 shows that the proportion of samples in which couple simulation recovered the correct result was more complex. Whereas couple simulation identified the population's true model of mate evaluation in more than 80% of samples by the time *k* was greater than 400 for the cosine similarity, Manhattan distance, and weighted Euclidean models, the method had slightly more difficulty distinguishing among the Manhattan distance, Euclidean distance, and Minkowksi distance methods. The Minkowski distance was correctly identified in only 71% of samples even when the sample size was *k* = 500; the Euclidean distance model was correctly identified in only 78% of samples at the same sample size. This relatively low resolution should be unsurprising as these distance metrics are very similar to one another in terms of both the format of mate preferences that they use and the way in which they convert mate preferences into mate value estimates. Overall, the couple simulation method can clearly distinguish between highly distinct models of mate evaluation. However, its ability to distinguish among the relatively similar distance metrics is slightly lower in resolution.

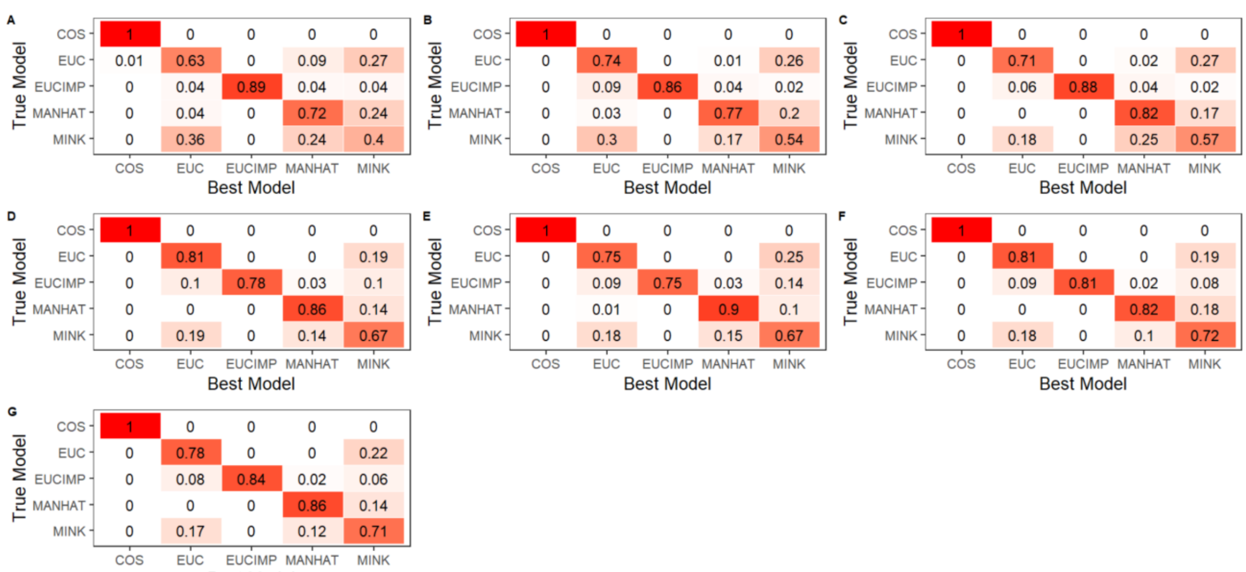

Figure 4. Confusion matrices from the second series of proof-of-concept models. With sufficient sample size, couple simulation does identify the true model of preferences and evaluation in the majority of samples. However, distinction between the relatively similar distance metrics is more challenging. Panels A-G represent sample sizes from k = 50, 75, 100, 200, 300, 400, and 500 dyads respectively.

2.3. Discussion

Overall, the results of this series of proof-of-concept modeling indicate that couple simulation can clearly distinguish between models of mate preference and mate evaluation when the models are as distinct from one another as are, for example, threshold and weighted sum models. That is, if a population's true model of mate evaluation is a weighted sum, weighted sum models of mate choice will outperform the alternative models tested here when reproducing couples sampled from that population; conversely, if the population's true model is an aspiration threshold procedure, aspiration threshold models will outcompete alternatives. Couple simulation can even clearly distinguish among alternative similarity metrics such as distance metrics and cosine similarity metrics. However, when the models of mate evaluation are highly similar, as are the various distance metrics in the family of the Minkowski distance, couple simulation results remain accurate in the long run across samples, but are less precise on a sample-to-sample basis in that no one sample is as likely to correctly identify the population's true model of mate choice. For this reason, we omitted Minkowski distances from future comparisons and interpret the differences between the Manhattan distance and Euclidean distance cautiously.

3. Study 1

The proof-of-concept models establish that couple simulation can in principle distinguish between alternative models of mate preference and mate evaluation. That is, when alternative models of mate preferences and mate evaluation are challenged to reproduce couples sampled from a population, the model that best reflects the population's true model of mating psychology tends to perform best in reproducing sampled couples on average and across samples. As such, in Study 1 we apply couple simulation to a sample of real-world couples to empirically compare alternative models of mate preferences. Here we ask: which combination of mate preference formats and mate evaluation functions maximally reproduced the observed couples in simulated mating markets?

3.1. Methods

3.1.1. Participants

Participants were n = 1,052 people who were members of k = 526 committed, romantic dyads. The target sample size was k = 500 dyads. A total of k = 738 dyads completed at least some part of the survey, however of these k = 212 were eliminated for failing at least one of two attention checks, yielding the final sample size of k = 526. Participants were recruited using Qualtrics's survey panel service; survey criteria were heterosexual U.S. participants, in romantic relationships, and cohabitating with their romantic partner. Participants were M = 56.89 years old on average (SD = 13.95). Participants were in their relationships for Mdn = 27.83 years and relationship lengths ranged from 1 years to 64 years. Most participants described themselves as married (n = 977, 93.58%), followed by dating seriously (n = 34, 3.26%), and dating casually (n = 14, 1.34%). The number of married participants is odd because the partners of three married participants opted to write-in a description of their relationship status rather than select the "married" option from the relationship status question; however, each of these partners left their relationship status blank. Nineteen participants opted to write in a separate description of their relationship status, these included “cohabitation”, “been together 15 years not married”, “committed relationship”, “divorced but together”, “domestic partner”, “living together”, “partner”, and three declined to report as described above.

3.1.2. Materials

3.1.2.1. Mate Preferences

In order to compare models of preferences, we needed to be able to measure mate preferences in a wide range of hypothesized formats within the same participants. Although a variety of mate preference questionnaires exist in common use within the literature (e.g. Buss, 1989; Fletcher & Simpson, 2000; Li et al., 2002), these questionnaires are generally designed to measure mate preferences in just one or two formats. In particular, several mate preference questionnaires exist and can provide guidance for measuring mate preferences in the form of relative importances; few validated questionnaires exist for measuring preferences in terms of thresholds or ideal values. For this reason, we used an act nomination procedure to develop and validate a novel mate preference questionnaire that could be used to measure mate preferences across formats within the same participant. The final scale contained three 31-item subscales for measuring ideal preferences, minimum preferences, and maximum preferences. Each subscale had one item representing age and two items for each of 15 other mate preference dimensions: affectionateness, ambition, artistic ability, disposition, family support, health, humor, intelligence, kindness, parenting, physical attractiveness, religiosity, sexiness, and status (see supplementary materials, section S1 for details).

Using these scales, participants reported their ideal (i.e., most preferred value) as well as their minimum acceptable and maximum acceptable values for each trait in a potential partner. For these ratings, participants used the 11-point Likert scale developed in Study 1, with scale labels presenting the relative standing information in frequency format. Participants additionally rated themselves and their romantic partners on these same items using the same scale, with the exception of age which was self-reported in years.

Participants reported the relative importance of the mate preference dimensions in two different ways. The first was a ranking procedure. Participants were presented with the 16 mate preference dimensions. These were presented instead of the 31 paired items that composed the dimensions in order to minimize the number of comparisons participants had to make. Partially inspired by Brandner et al. (2020), each item was phrased in terms of a difference dimension, for example "Kind or not," and participants were asked to order these differences in terms of their relative importance in distinguishing desirable partners from undesirable partners. In addition to this ranking task, participants also completed a forced-sum rating task, partially inspired by Li et al. (2002). Here, participants were asked to rate how important each dimension was on a 10-point scale ranging from "Extremely unimportant difference" to "Extremely important difference" with "Moderately important difference" as the midpoint of the scale. However, participants were forced to make their ratings sum to a total of 80 points. This allowed participants to rate all 16 dimensions as "Moderately important" (i.e., a 5 on the 10-point scale); however, in order to rate one dimension as more important than the others, participants were required to also rate another dimension as less important. The complete mate preference questionnaire can be found in the supplementary materials (S4).

3.1.2.2. Relationship quality

As measures of relationship quality, participants completed the Quality Marriage Index (QMI; *a* = .97; Norton, 1983), the Perceived Relationships Quality Components Inventory (PRQC; subscale *a*s range from .88 - .97; Fletcher et al., 2000), and the cognitive subscale of the Multidimensional Jealousy Scale (MJS; *a* = .96; Pfeiffer & Wong, 1989).

3.1.3. Procedure

Participants completed the questionnaires in a somewhat random order. Participants first completed the ideal preference, self, and partner ratings in random order with items randomized within block; this was followed by the QMI. Participants then completed the minimum preference, maximum preference, and preference importance ratings in randomized order, with items randomized within block as well. Each of these was paired with subsections of the PRQC and the preference ranking and rating tasks were split by the cognitive subscale of the multidimensional jealousy scale. This presentation order was chosen to mitigate participant fatigue. Ratings were paired so as to interleave the relationship quality reports with the mate preference reports in order to reduce perceived redundancy.

3.1.4. Data Processing

Measures from participants were used to parameterize agents for couple simulation. For each participant, we created one avatar agent that inherited that participant's mate preferences, in all formats, as well as the average of the participant and their partner's ratings of the participant's traits. These agents were entered into simulated mating markets in which agents selected each other as mates based on their mate value calculations and the resource allocation model as described in the proof-of-concept models.

Specifically, agents were simulated in 19 simulated mating markets that varied in the format of preferences and the evaluation function that agents used to estimate mate value. Table 4 reviews the combinations of mate preference models and evaluation functions. In each market, all agents in that market computed the estimated mate value of each potential mate to them according to their preferences, that potential mate's traits, and the mate evaluation function used in that mating market. These estimated mate values were used as the basis of mate choice according to the resource allocation model (using alternative models does not appear to qualitatively change the results; see supplementary section S2). The simulation accuracy of a given model was computed as the proportion of the real-world couples accurately reproduced by a given mating market; 95% confidence intervals on simulation accuracy were estimated by bootstrapping from the model's couple-wise vector of simulation accuracies (i.e., the binary simulation accuracy of the model for each sampled couple). The relationship between simulation accuracy and relationship quality was assessed with multilevel models. We predicted relationship quality for each participant using the simulation accuracy for their couple as well as random intercepts for couple to account for non-independence of dyad members. Because simulation accuracy was a binary variable at the level of couples (accurate vs. inaccurate), relationship quality measures were standardized prior to analysis so that regression slopes can be interpreted comparably to Cohen's *d* values.

Table 4. Summary of mate preferences and evaluation functions modeled.

Preference Format	Evaluation function	Description

Ideal value	Euclidean Distance	$-1 * \sqrt{\sum (p_{id} - t)^2} + \sqrt{\sum (10)^2}$
Ideal value, weight	Weighted Euclidean Distance	$-1 * \sqrt{\sum p_w * (p_{id} - t)^2} + \sqrt{\sum p_w * (10)^2}$
Ideal value	Manhattan Distance	$-1 * \left(\sum \lvert p_{id} - t \rvert\right) + 160$
Ideal value, weight	Weighted Manhattan Distance	$-1 * \left(\sum p_w * \lvert p_{id} - t \rvert\right) + p_w * 10$
Ideal value	Cosine Similarity	$\left(1 + \left(\sum p_{id} * t\right) / \left(\sqrt{\sum p_{id}} * \sqrt{\sum t}\right)\right)$
Ideal value	Mahalanobis Distance	$-1 * \sqrt{\sum (p_{id} - t)^T * cov(t) * (p_{id} - t) + \sqrt{\sum (10)^T * cov(t) * (10)}}$
None	Sum	$\sum t$
Weight	Weighted Sum	$\sum p_w * t$
Minimum, maximum, weight	Aspiration (Range)	In decreasing order by p_r and while > 1 mates remain: $\begin{cases} 10, p_{max} > t > p_{min} \\ 0, otherwise \end{cases}$

Minimum, weight	Aspiration (Minimum)	In decreasing order by p_r and while > 1 mates remain: $$\begin{cases} 10, t > p_{min} \\ 0, otherwise \end{cases}$$
Maximum, weight	Aspiration (Maximum)	In decreasing order by p_r and while > 1 mates remain: $$\begin{cases} 10, p_{max} > t \\ 0, otherwise \end{cases}$$
Minimum, maximum, weight	Aspiration (Range; Continuous)	In decreasing order by p_r and while > 1 mates remain: $$\begin{cases} mv + 1, p_{max} > t > p_{min} \\ 0, otherwise \end{cases}$$
Minimum, weight	Aspiration (Minimum; Continuous)	In decreasing order by p_r and while > 1 mates remain: $$\begin{cases} mv + 1, t > p_{min} \\ 0, otherwise \end{cases}$$
Maximum, weight	Aspiration (Maximum; Continuous)	In decreasing order by p_r and while > 1 mates remain: $$\begin{cases} mv + 1, p_{max} > t \\ 0, otherwise \end{cases}$$
Minimum, maximum	Aspiration (Range; Total)	$$\sum p_{max} > t > p_{min}$$
Minimum	Aspiration (Minimum; Total)	$$\sum t > p_{min}$$
Maximum	Aspiration (Maximum; Total)	$$\sum p_{max} > t$$

Ideal value	Exceed (Ideal)	$\sum \begin{cases} t - p_{id}, t > p_{id} \\ 0, otherwise \end{cases}$
Minimum	Exceed (Minimum)	$\sum \begin{cases} t - p_{min}, t > p_{min} \\ 0, otherwise \end{cases}$

Note: p_w = importance rated preference; p_{id} = ideal value preference; p_r = importance ranked preference; p_{min} = minimum preference; p_{max} = maximum preference; *t* = mate trait value. All mate values were scaled to a 0-10 range prior to couple simulation; scaling terms are omitted here for simplicity.

3.2. Results

Figure 5 presents the simulation accuracy for Study 1. Overall, the best performing models were those that utilized preferences exclusively in ideal value format. The Mahalanobis distance (accuracy = 30.651%, 95% CI [26.820, 34.674]) and cosine similarity (accuracy = 32.567, 95% CI [28.544, 36.590] models performed similarly. These were each outperformed by the Euclidean distance model (accuracy = 37.356%, 95% CI [33.333, 41.571]. However, in contrast to prior research, the Euclidean distance model was outperformed by the Manhattan distance model: accuracy = 40.996, 95% CI [36.782, 45.211]. A paired permutation test indicated that this difference was statistically significant, $p = .014$. In contrast to its popularity within the mate preference literature, the weighted sum model performed surprisingly poorly in reproducing the real-world couples with an accuracy of 5.747%, 95% CI [3.831, 7.854]. The aspiration threshold models performed poorly as well, with the Aspiration (Minimum; Total) performing best of all threshold models with an accuracy of 9.579%, [7.088; 12.261].

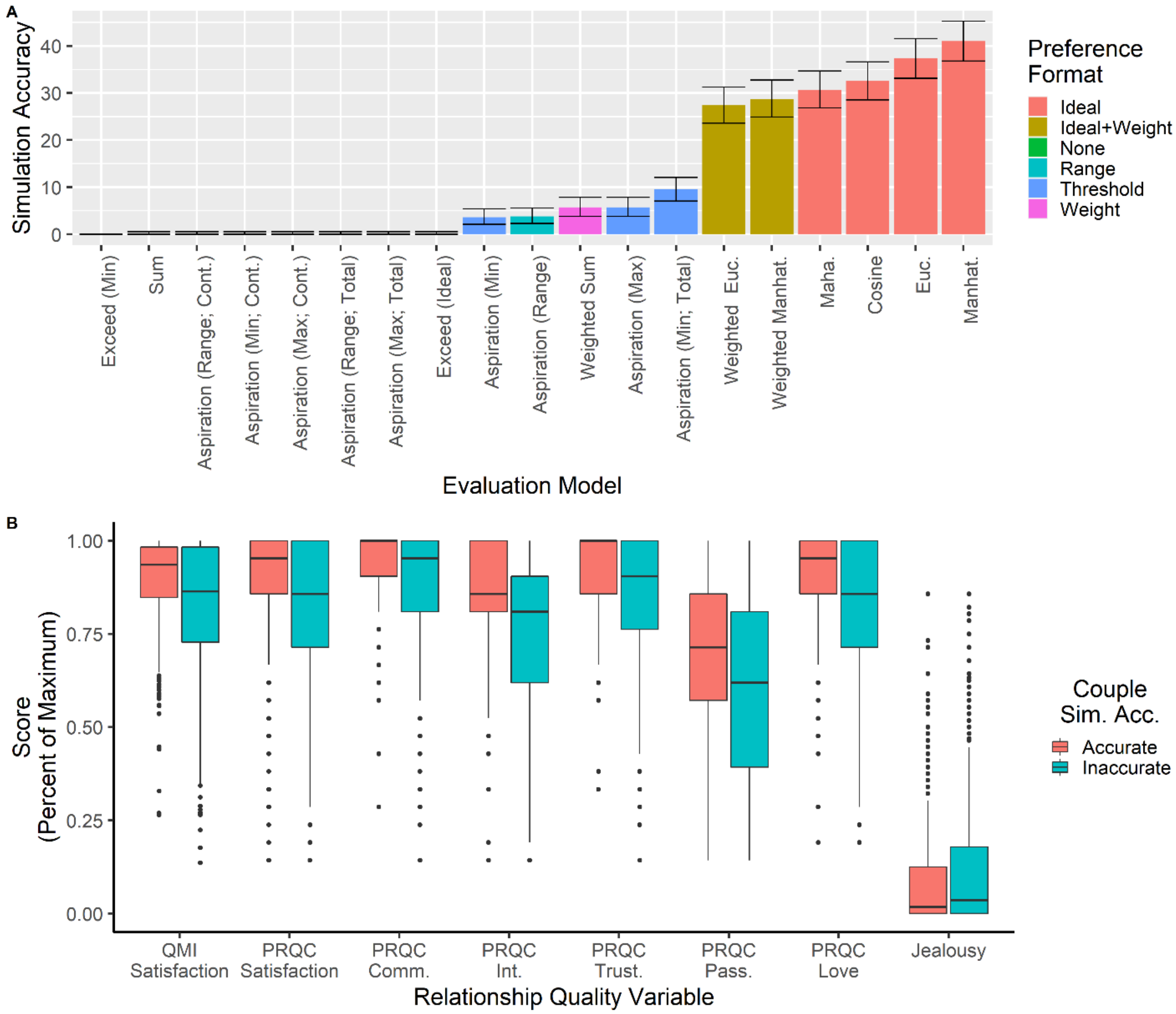

Figure 5. Couple simulation accuracy from Study 1. A: Simulation accuracy as a function of preference format and integration model. Ideal preferences outcompete all other preference formats. B: Relationship quality as a function of Manhattan distance simulation accuracy. Participants whose relationships were accurately reproduced by the Manhattan distance model reported greater relationship quality across all dimensions.

Furthermore, consistent with Conroy-Beam (2021), these models not only accurately reproduce real-world couples at above-chance levels, they also attain power to discriminate between couples on overall relationship quality. Figure 5 shows the difference in relationship quality between participants whose relationships were accurately reproduced by the Manhattan distance model and those whose relationships were inaccurately reproduced. Participants whose relationships were accurately reproduced by the Manhattan distance model reported higher levels of relationship quality across dimensions; multilevel models predicting relationship quality from simulation accuracy with random intercepts for couples indicate that all of these differences were statistically significant (largest p = .014, for jealousy).

3.2.1. Exploratory Analyses of Importance

The poor performance of the weight models of preferences creates somewhat of a theoretical puzzle. The notion of mate preferences reflecting relative importance of alternative dimensions has been a dominant model of preferences within the human mating literature. Working within this framework, preference researchers have discovered several robust empirical phenomena that appear to align with theoretical principles. For example, the well-documented, cross-culturally robust sex differences in preferences for age, physical attractiveness, and financial prospects predicted on the basis of sex-differentiated adaptive problems experienced throughout human evolutionary history (Buss, 1989; Zhang et al., 2019). Our results would appear to pose a question for this classic area of research: if mate preferences in the sense of relative importance have no connection to mating behavior, why would they still be sex-differentiated in a theoretically predicted manner?

One potential answer to this question comes from research on individual differences in preferences and the change in preferences over time. Prior research has found that higher mate value individuals tend to have higher preference standards (Buss & Shackelford, 2008; Conroy-Beam et al., 2019). Such a correlation could emerge if preferences are adjusted in response to differential experiences on the mating market. Indeed, prior research has found that when people are rejected in the mating domain, they tend to increase the flexibility of their mate preferences (Beckage et al., 2009; Charlot et al., 2020) and that changes in mate preferences over time track changes in perceived mate value (Bredow & Hames, 2019). If rejection by potential mates motivates downregulation of preferences, and if high mate value people experience less frequent rejection, this could partially explain why high mate value people set higher preference standards.

How does this relate to preferences as relative importances? Although adjusting preferences in response to experience on the mating market may be a sensible strategy, mate preferences could in principle be adjusted in multiple ways. For example, in response to romantic rejection, one could downregulate all mate preferences equally, or one could strategically downregulate some less important preferences (e.g. for artistic ability) in order to maintain high standards on other, more important dimensions (e.g. kindness). This is akin to Li (2002)'s notion of "necessities" and "luxuries" in mate choice—however, rather than importance reflecting necessities in what potential mates *possess*, importances may reflect necessities in what is *preferred* in ideal value terms. Such a distinction could explain what is being measured when participants report on the relative importance of alternative preferences. Rather than relative importance factoring into how potential mates are evaluated, the relative importance of a preference dimension could instead reflect how sensitive ideal preferences are to experience.

Study 1's data allow for an indirect, exploratory test of this hypothesis. For this, following prior research, we computed the overall mate value of each participant as proportional to the Euclidean distance between their own trait composites and the average ideal preferences of the opposite sex. We then explored the interaction between mate value and preference importance ratings in predicting ideal value preferences. Figure 6 displays these results. A multilevel model, with preferences nested within participants and a random intercept term, confirms a significant interaction between mate value and preference importance in predicting ideal preferences, $b = -.051$, $SE = .006$, $p < .001$. Consistent with the hypothesis that importance ratings reflect the sensitivity of ideal preferences to experiences on the mating market, we see that ideal preferences are indeed correlated with mate value but this correlation is stronger for preferences that are *less* important to participants. This suggests that attributing high importance to a preference dimension reflects an unwillingness to adjust that preference in response to experience whereas low importance reflects greater flexibility.

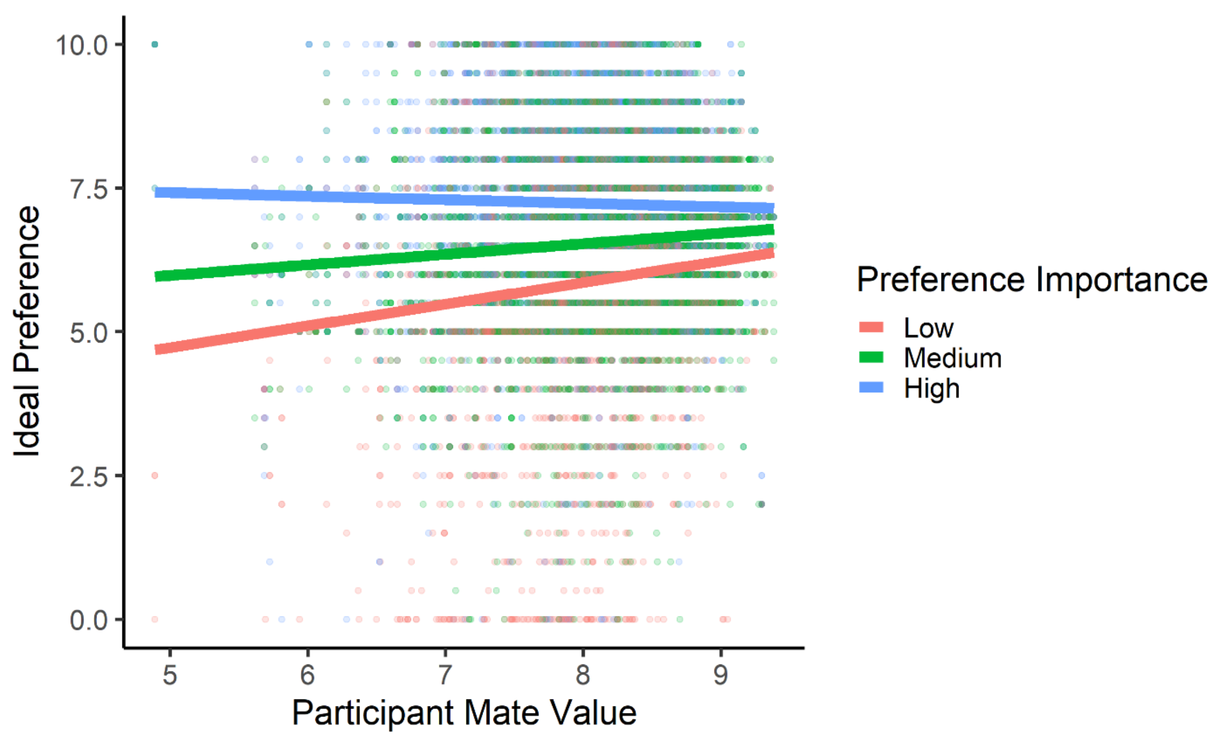

Figure 6. The relationship between mate value and preference importance in predicting ideal preferences across all 16 preference dimensions. Across dimensions, higher mate value people tend to set higher ideal preferences, but this relationship is particularly true for preferences people find to be less important. For highly important preferences, all people maintain high standards relatively independent of their mate value. Dots represent individual observations; lines represent predicted values from the multilevel model.

3.3. Discussion

In Study 1, we applied the couple simulation method to compare among alternative models of mate preferences and mate evaluation. We found that the couple simulation method does indeed discriminate among a set of 19 possible models and specifically identifies ideal values as being the most plausible model of mate preferences and distance metrics as being the most plausible models of mate evaluation. Within these, the single best performing model was the Manhattan distance model. Weighted distance functions performed next best overall, followed by the weighted sum and aspiration models of mate evaluation. Overall, from Study 1, it appears the best supported model of mate preferences is that of ideal values, not unlike the model proposed by Ideal Standards Theory (Fletcher & Simpson, 2000).

However, Study 1 does have some noteworthy limitations. Particularly, the couples used as the basis for couple simulation in Study 1 were quite established, with a median relationship length of 27.83 years. The individuals in these relationships are quite distant in time from when they made the actual mate choices responsible for their relationships. It could be that these results would differ for individuals in more nascent relationships.

Furthermore, the strong performance of the distance metrics especially as compared to the weighted sum is somewhat surprising both because of the relative popularity of the weighted sum model and because this result conflicts somewhat with some prior research. For example, Brandner et al. (2020) found that the weighted sum model performed best of all in their task, followed closely by the sum and Euclidian distance models whereas here the distance metrics outcompeted both sum models. Additionally, the strong performance of the Manhattan distance is surprising both in light of prior research finding that the Euclidean distance outperforms the Manhattan distance in predicting attraction to hypothetical potential mates (Conroy-Beam & Buss, 2017) and because there are some theoretical reasons to expect a Euclidean distance integration model might perform better than a Manhattan distance. Namely, the Manhattan distance does not distinguish between large deviations on a few dimensions and small deviations across several dimension—for instance, a Manhattan distance might treat a sadistic but handsome partner as equivalent to partner who is only slightly attractive and a little grumpy. A Euclidean distance, on the other hand, favors minimizing deviations across all dimensions and does not tolerate large deviations from preferences on any dimension . While not impossible, it does seem unlikely that selection would favor an attraction psychology that would allow vicious or lethally infectious partners to fully compensate for these deficits by being sufficiently attractive or funny. Additionally, the proof-of-concept results suggest that couple simulation estimates of the relative accuracy of different distance functions might be somewhat unstable.

For each of these reasons, we conducted a follow-up study in which we assessed the robustness of these results by attempting to replicate them in a separate sample of couples who were in less established relationships.

4. Study 2

The purpose of Study 2 was to replicate the results of Study 1 using a separate sample of participants in more nascent relationships, both to establish the robustness of these results and assess their generalizability to newer relationships.

4.1. Methods

4.1.1. Participants

Participants were 590 members of 295 ongoing, committed, heterosexual dyads. Participants were $M = 25.87$ ($SD = 5.00$) years old. Participation was limited to participants who had been in a relationship for less than 5 years; the median relationship length was $Mdn = 3$, with a range of 0 to 5 years and an interquartile range of 2 to 4 years.

4.1.2. Materials

Participants completed a subset of the materials from Study 1. This included the ideal preference ratings, the forced-sum preference importance ratings, and the self and partner trait ratings. Participants additionally completed the QMI, PRQC, and the complete MJS as measures of relationship quality. These were interwoven with measures intended for other studies that are not analyzed here.

4.1.3. Procedure and Data Analysis

Measurement scales appeared in a similar order as in Study 1. Data processing occurred identically as well, with evaluation models limited to those that apply ideal value or weight preference models. This included the Euclidean, weighted Euclidean, Manhattan, weighted Manhattan, cosine similarity, sum, and weighted sum models.

4.2. Results

Figure 7 presents the simulation accuracy results for Study 2. The results are broadly similar to Study 1 in that the models that incorporate preferences as ideal values outcompete those models that incorporate mate preferences as weights. Within these, the models that integrate preferences according to a distance function outcompete the cosine similarity. However, unlike Study 1, the Euclidean distance and Manhattan distance models now perform similarly, with the Euclidean distance achieving a barely higher simulation accuracy (accuracy = 27.189%, 95% CI [22.034%, 32.203%]) compared to the Manhattan distance (accuracy = 26.780%, 95% CI [21.695%, 31.864%]). This difference was not statistically significant in a paired permutation test, $p = .505$. As Figure 7 also reveals, Study 2 also replicated the relationship quality findings of Study 1. Couple simulation accuracy according to the best performing model (in this case, the Euclidean distance model), again significantly predicted all dimensions of relationship quality (largest $p = .023$ for jealousy).

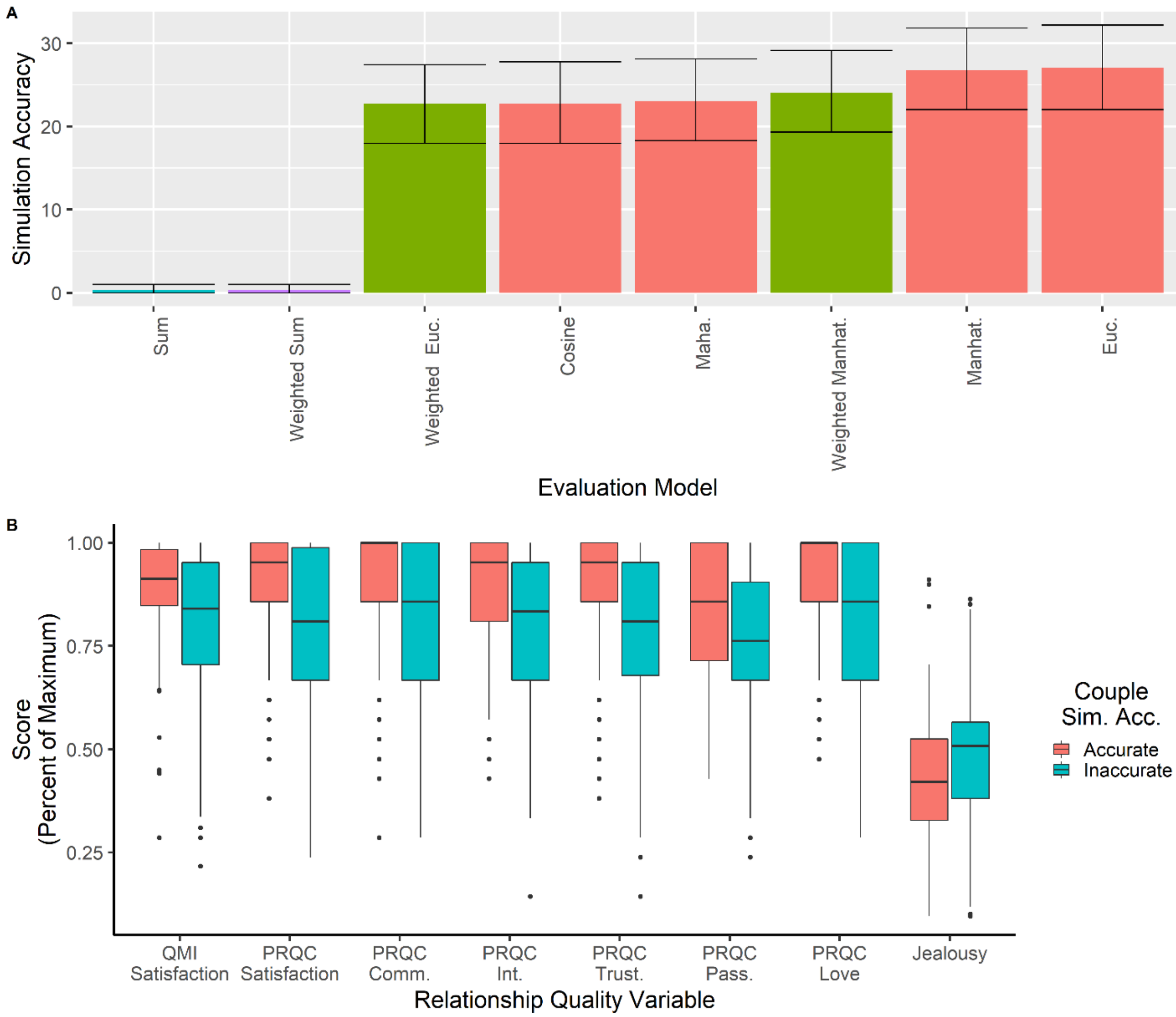

Figure 7. Couple simulation accuracy from Study 2. A: Simulation accuracy as a function of preference format and integration model. Ideal preferences outcompete all other preference formats. B: Relationship quality as a function of Euclidean distance simulation accuracy. Participants whose relationships were accurately reproduced reported greater relationship quality across all dimensions.

Notably, although Study 2 broadly replicated the relative accuracy findings of Study 1, the overall accuracy was much lower in Study 2. For example, the Manhattan distance model accurately reproduced 40.996% of couples in Study 1 but just 26.780% of couples in Study 2.

This decrease in performance is especially surprising given that, on average, couple simulation accuracy tends to *increase* for smaller samples (Conroy-Beam, 2021).

The reasons for this decline in accuracy are not perfectly clear. One possibility is that the couple simulation method is more effective for reproducing more established relationships than it is for reproducing more nascent relationships. A second possibility is that Study 2 presents a more challenging classification task simply because the sample was, by design, more homogenous owing in particular to the narrower age range. To compare among these alternative possibilities, we conducted a third round of couple simulation by iteratively blending the samples from Studies 1 and 2. We entered each couple from Study 2 into a random sample of 294 couples from Study 1 and conducted couple simulation, using the Euclidean distance model, on each of these 295 blended samples. This provided samples that were of the same sample size as Study 2 but were as heterogenous as the sample from Study 1. We then assessed the simulation accuracy for the Study 2 couples across these 295 blended samples.

Across these blended samples, 55.256% of the Study 2 couples were accurately reproduced. This compared to an average simulation accuracy of 42.765% for the Study 1 couples across the 295 blended samples. This suggests that, all else equal, the couple simulation method was actually *more* accurate in reproducing the relatively nascent relationships compared to the more established relationships sampled in Study 1. The lower on-average simulation accuracy in Study 2 is therefore more likely attributable to the more homogenous nature of the sample owing to the more restrictive sampling criteria.

Finally, as Figure 8 illustrates, Study 2 similarly replicated the relationship between mate value, preference importance, and ideal preferences found in Study 1. A multilevel model again confirms a significant interaction between mate value and preference importance in predicting ideal preferences such that mate value is less strongly associated with ideal preferences for relatively important dimensions but has a stronger positive association with ideal preferences for relatively unimportant dimensions.

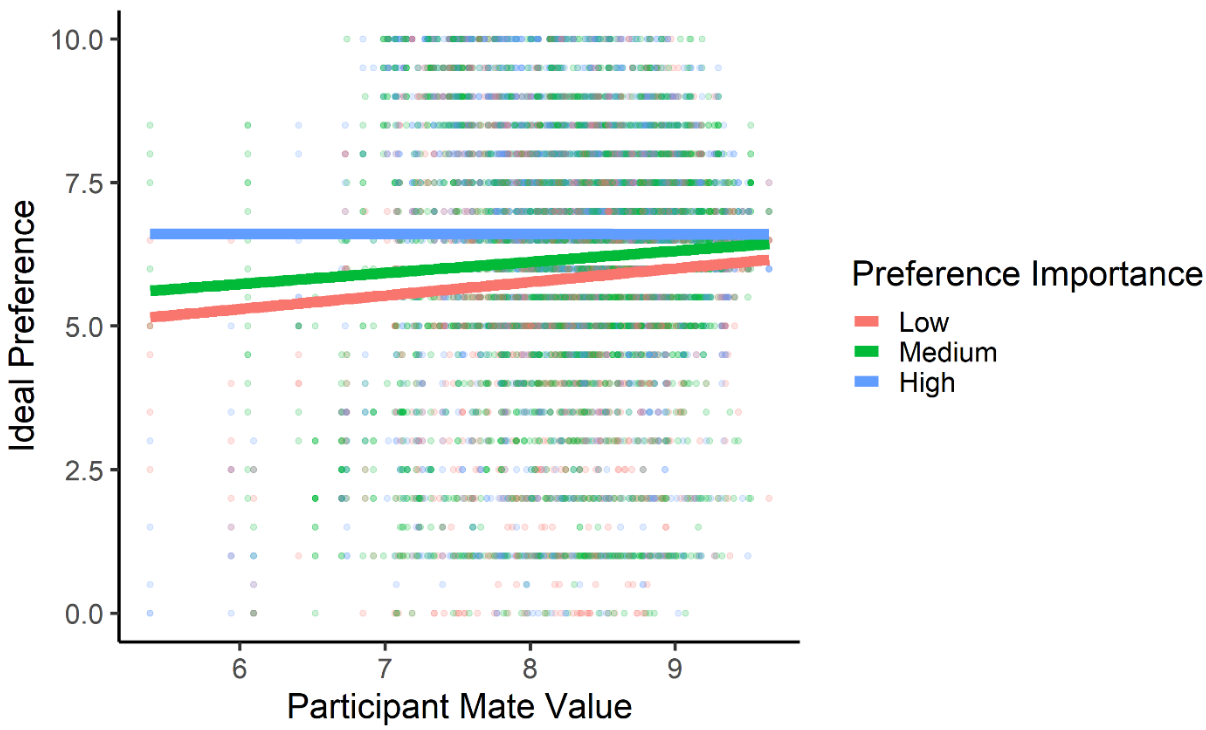

Figure 8. The relationship between mate value and preference importance in predicting ideal preferences. Higher mate value people tend to set higher ideal preferences, but this relationship is particularly true for preferences people find to be less important. For highly important preferences, all people maintain high standards relatively independent of their mate value. Dots represent individual data points; lines represent predicted values from the multilevel model.

4.3. Discussion

Study 2 broadly replicated the results of Study 1. Mate choice models that incorporate mate preferences as ideal values outcompete those that incorporate preferences as weights and those that model mate evaluation as a distance function outcompete other similarity metrics.

Furthermore, couples accurately reproduced by the most accurate mate choice model report higher levels of relationship quality across several dimensions. However, consistent with the conceptual models, comparisons among alternative distance metrics appear to be less precise in that, unlike Study 1, the Euclidean distance model now performs comparably to the Manhattan distance model. Why exactly this occurred is unclear. This could simply reflect sampling error and the relatively small difference between the two models; it could also reflect theoretically interesting differences between the mate preferences or mate choice of relatively nascent vs. established couples. Ultimately, clearer evidence would come from larger samples of even more nascent couples—or even better, longitudinal studies that are able to follow-up on the mate choices of originally single participants (e.g., as in Campbell et al., 2016; Gerlach et al., 2019). Nonetheless, overall the results of this study suggest that couple simulation results can generalize to less-established couples, however comparisons among highly similar models such as alternative distance metrics are more difficult.

5. General Discussion

Mate preference research has become a cornerstone of evolutionary and social psychological research. Psychologists have worked for decades to chart both the contents of human preferences as well as to document their variation across sex/gender (Buss, 1989), context (Kenrick et al., 1990), and culture (Eagly & Wood, 1999; Gangestad et al., 2006). This work has been invaluable in advancing our understanding of human mating psychology. However, somehow lost in this literature is a more fundamental question: what is a mate preference? What aspect of the mind does “mate preference” refer to?

Here we offer a computational definition of mate preferences: mate preferences are parameters of evaluation functions that help to shape mate value estimates as a function of perceptions of potential mates. This definition places mate preferences in the head, rather than as a property of decision sets or behaviors, consistent with prior evolutionary psychological conceptions of preferences (Buss, 1992). This definition furthermore can accommodate the multiple different models of preferences that psychologists have historically assumed: mate preferences as weights, thresholds, ranges, or ideal values.

The question now becomes: which of these models of mate preferences is most plausible overall? Here we present evidence that the couple simulation method can be useful for answering this question. By representing members of real-world couples in simulated mating markets, we can assess the power of alternative models of mate preferences to reproduce people's real-world mating decisions. Our proof-of-concept models demonstrate that this simulation accuracy metric can identify a population's true model of mate preferences, especially when the comparison set of models of preference and evaluation are relatively dissimilar. In the long run, a population's true model of mate preferences and mate evaluation will tend to reproduce a greater proportion of sampled couples within a couple simulation framework.

In light of this, we applied this couple simulation approach to two samples of real-world couples. Across both samples, we find that the best performing model of mate preferences is one of mate preferences as ideal values: templates of ideal mates to which potential mates are compared. This is particularly true when mate preferences are integrated with one another and with potential mate information according to distance metrics such as the Manhattan and Euclidean distance, which compute mate value as the distance between a potential mate and an ideal mate through a multidimensional preference space. These models outcompeted a wide range of alternatives, including several that are more complex and make use of more participant information (e.g., the weighted distance models and the aspiration models). These results are generalizable across both highly established and relatively nascent romantic relationships. Replicating prior work (Conroy-Beam, 2021), they also attain power to discriminate between couples in terms of relationship quality in that people whose relationships are accurately reproduced by these models of mate choice report higher quality romantic relationships across several dimensions including satisfaction, commitment, intimacy, trust, passion, love, and jealousy.

Overall, these results contribute toward answering a long-overlooked question: how are mate preferences represented within the mind? Our data suggest that, despite the popularity of weight and threshold models—but consistent with the theoretical perspective of the Ideal Standards Model (Fletcher & Simpson, 2000)—mate preferences are best conceived of as serving as ideal representations of potential mates. This has several implications for human mating and relationships research. For instance, our results suggest a need to disentangle priorities—in the sense of relative importances—from preferences themselves. Many theories of human mating treat these as though they are interchangeable—for instance, asking participants to rank the relative importance of traits as measures of mate preferences. However, results of our exploratory analyses suggest that priorities have a role in determining the value of preferences but do not have a role in determining actual mate choice. That is, priorities govern preferences whereas preferences govern choice.

These results also have implications for measurement of mate preferences. Regardless of theoretical perspective, the modal method for measuring mate preferences is by asking about preferences in terms of their relative importance. However, in couple simulation, models that treat mate preferences as relative rankings or ratings of importance perform poorly in reproducing actual mate choices. This suggests that future research on mate preferences would be better served by measuring preferences as ideal values rather than as relative importances. This is a potentially important observation in light of ongoing debate concerning the power of mate preferences to predict real choices. Several studies have found inconsistent relationships between stated mate preferences and actual mate choices (e.g., Joel et al., 2017; Kurzban & Weeden, 2007; Li et al., 2013; Todd et al., 2007). However, these studies predominantly measure mate preferences in terms of relative importance, which our results indicate have only an indirect relationship with real mate choice. This measurement issue could thus account for some of the apparent inconsistency within this literature.

This exploratory finding also suggests a need for further research on the ontogeny of preferences. With some notable exceptions (e.g., sex differences: Buss, 1989; cultural factors: Eagly & Wood, 1999; mating strategy: Kenrick et al., 1990), human mating research has been largely agnostic as to how individuals come to adopt their specific set of preferences. What research does exist largely focuses on contextual factors and neglects the development of preferences within a person over time. Our results suggest that the ideal preferences a person holds are at least partly a function of their mate value—and the mating experiences this affords—and the relative importance of different mate value dimensions to them. The exact process by which these factors interact to structure the development of preferences over time is worth modeling in and of itself. This hypothesis—that ideal preferences are calibrated based on experience and according to their relative importance—also leaves ambiguous what exactly determines the relative importance of different preference dimensions. An appealing hypothesis is that many of the individual difference and contextual factors that have been studied as determinants of preferences (e.g., sex and mating strategy) are really determinants of relative priorities and these priorities, in interaction with mate value, dictate the ideal trait values people prefer. However, this is just one possibility that we leave to future research to test.

Despite these important insights, this research is not without limitations. Some of these limitations pertain to the application of the couple simulation method itself. For example, as we are applying it here, couple simulation is necessarily retrospective: we are attempting to reproduce mate choices participants already made in the past. In light of this, it is impossible to know the extent to which people are adjusting their preferences to match the choices they have made. While there is some evidence that preferences remain somewhat stable across the lifespan (e.g., Bredow & Hames, 2019), other evidence suggests preferences shift somewhat toward chosen partners as people initiate relationships (e.g., Gerlach et al., 2019). Such changes can be accounted for within couple simulation if one has a model of how preferences adjust over time. We did this here based on estimates from the prior literature (Gerlach et al., 2019; see supplementary materials section S3). The effect of adjusting for potential changes in preferences was relatively minor, with the exception of improving the performance of minimum threshold models. Nonetheless, these analyses were based on change estimates from just a single study and provide only imperfect proxies of the change of individual participants' preferences over time. Ultimately, the strongest evidence concerning the nature of mate preferences will come from methods that apply the couple simulation method prospectively to assess the relative predictive power of preferences measured prior to the initiation of romantic relationships.

Furthermore, couple simulation requires simulating participants as members of a single, shared mating market. However, our participants were sampled from a national population and are thus virtually guaranteed to not personally know one another. Our proof-of-concept models suggest that this does not prevent accurate couple simulation—the method can still be fruitfully applied even when couples are sampled from distinct subpopulations. Nonetheless, stronger tests of mate preference models would come from applying couple simulation to samples of couples from relatively closed mating markets, where each participant is known to have actually selected among the other participants in the sample.

For simplicity, our models also assume limited individual differences at the level of mating psychology. That is, while each participant is allowed their own mate preferences, all participants are assumed in each model to have preferences in the same format. Nonetheless, it is possible in principle that different participants hold different types of preferences—for example, some participants holding ideal-type preferences whereas others having preferences that act as thresholds. At an even further level of granularity, it is possible that different preference dimensions exist in different formats. The space of possibilities is large, which is why we made the simplifying assumption that all preferences and all people share a common preference format. However, future research could develop and test hypotheses concerning variability in preference formats across people or across preference dimensions. This could include identifying contextual or individual difference variables that predict under what circumstances people employ different types of preferences (e.g., perhaps people occupying larger mating markets are more likely to adopt threshold-style preferences to increase search efficiency). Such hypotheses would be easily testable in a couple simulation framework by generating agents that inherit these contextual or individual variables from their corresponding participants and decision rules that deploy the correct preferences for the agent's context.

The relationship between simulation accuracy and relationship quality remains somewhat mysterious in that it is not clear what information couple simulation is using to separate higher-quality relationships from lower-quality relationships. Prior research has found that this relationship is not mediated by any of a variety of lower-level variables (e.g., mate preference fulfillment, mate value, mate value discrepancies, etc. Conroy-Beam, 2021). Further research is needed to determine what exactly separates accurately reproducible couples from inaccurately reproducible couples in terms of their satisfaction, commitment, love, jealousy, and so on. The binary nature of simulation accuracy applied here likely also belies subtler relationships between simulation accuracy and relationship quality. That is, here each couple was either accurately reproduced by a given model or was not, and so relationship quality can only be predicted in a binary fashion. There may exist more continuous relationships, however, wherein more predictable couples have higher relationship quality than less predictable couples and these continuous relationships may be more useful for determining what information couple simulation is capturing to discriminate on relationship quality. Such continuous relationships could be identified by, for example, iteratively running couple simulation and forbidding incorrect pairings from each prior iteration. The number of iterations required to accurately pair a given couple can provide a continuous measure of simulation accuracy that may reveal more nuanced relationships with overall relationship quality.

Other limitations concern more theoretical issues. For example, here we focused on modeling actual mate choice using a resource allocation model. This model was chosen because it was previously shown to outcompete several other candidate models in reproducing real mate choices (Conroy-Beam, 2021). However, this is just one, incomplete model of human mate choice. Other, more accurate models are sure to be discovered in time and these superior models may interact differently with the models of mate preference and integration considered here.

Additionally, although we considered a somewhat large set of possible models of mate preference and mate evaluation, this set is surely not exhaustive. The possibilities considered here are special only insofar as they represent hypotheses that have been popular within the prior human mating literature. However, other possibilities could surely be conceived, some of which may perform better than even the ideal value and distance function models. The models we have applied here could also be implemented in alternative ways. For example, for the aspiration threshold models, we prevented agents from eliminating all possible partners—agents instead pursued the smallest non-zero set of threshold satisfying partners. This is a slight deviation from prior conceptualizations of this model but was intended to improve model performance. If agents were allowed to eliminate all partners, the overwhelming majority of agents would in many cases have no viable partners (e.g., just 1% of possible partners have a non-zero mate value in the aspiration range model if agents are allowed to eliminate all partners compared to 13.70% in the chosen operationalization). Nonetheless, future researchers could consider alternative implementation of these and all of our models that may perform in unexpected ways.

In general, in evaluating models of mate choice, it is helpful to remember the aphorism: "all models are wrong, but some models are useful." We have identified a subset of mate choice models that have performed relatively well. But this does not mean that these models should be accepted as accurate representations of the ground truth nature of human mate choice psychology. Rather, they are hopefully valuable steps in a long-term process of hill-climbing toward more accurate and more useful models of mate choice overall. Iteratively improving on these models must be a continued goal of future research—and further couple simulation, mixing new models of mate preferences, mate evaluation, and mate choice, can be one valuable tool for achieving this cumulative progress.

It must also be stressed that although distance functions performed well here in reproducing the sampled couples, that does not necessarily mean that the mind actually uses distance functions like the Manhattan distance to evaluate potential mates. This is a possibility, but it could also be that the mind uses simpler heuristics that either use less information, use fewer parameters, or both but are still able to approximate the performance of more complex distance functions. If future research were able to specify such heuristics, they could be tested against the functions modeled here using a couple simulation approach as well. Furthermore, it is not necessarily the case that the mind uses all 16 dimensions of mate preferences measured here (and surely uses some that were not measured here). Couple simulation could be used to narrow down the set of preferences under consideration by iteratively testing models that assume smaller sets of preferences and retaining only the smallest set that is required for high simulation accuracy. In general, the couple simulation approach we have developed here has no inherent penalty for model complexity; yet all else equal, simpler models should be preferable to more complex models. Determining how to balance rewarding models for their simulation accuracy while also penalizing them for their complexity is a worthwhile goal beyond the scope of this paper. However, developing more accurate as well as more parsimonious models must be parallel goals for future research.

Finally, our results contrast somewhat with those of some other recent studies—most notably Brandner et al. (2020). While both studies found that distance models perform relatively well, Brandner et al.'s results suggest better performance for weighted sum and sum models whereas these models performed relatively poorly in our studies. This inconsistency is curious and in need of explanation. An obvious candidate explanation is the difference in the underlying task: whereas Brandner et al. (2020) asked participants to choose a hypothetical mate among pairs of options, we reconstructed the mate choices of real people within complete simulated mating markets. These different tasks impose different demands on decision makers, likely contributing to the difference in performance of the models we considered in common.

However, the distinct nature of these tasks might also reveal a sense in which these results could be more complementary than they initially appear. Thus far, we have discussed mate choice as though it is a relatively singular decision. But in reality, mating decisions happen at multiple scales. While it is true that, when choosing a mate, a person is in principle choosing that mate from among all of the people they know in their social network, it is also true that in any given moment a person is likely choosing among a narrower set of options. That is, while when choosing a mate, Emma may in the grand scheme compare Charles's mate value against all of her potential mates, at the same time, when choosing with whom to spend an hour of her day, Emma can only choose among the potential mates immediately available to her. We have modeled mate choice more in terms of this prior, broader task whereas Brandner et al.'s task may better emulate the latter, moment-to-moment decision tasks inherent to mate choice. It is possible that different forms of preferences are involved in regulating decisions at different scales, with weight preferences regulating moment-to-moment decisions so as to achieve choices consistent with ideal value preferences at broader decision scales. Testing this hypothesis will require developing computational models that can integrate models of mate choice across different decision scales, specifying how smaller, day-to-day decisions add up to broader overall decisions.

Overall, these results take an important step toward answering a long-overlooked question: what exactly is a mate preference? We offer a computationally plausible description of what mate preferences represent in the mind: parameters of evaluation functions that generate mate value estimates. We furthermore present across two dyadic studies evidence that these parameters are most plausibly conceived of as ideal values rather than as weights or thresholds. This suggests the need for important revisions to both the nature of theorizing and measurement concerning mate preferences and provides an important step further toward a more unified, thorough, precise, computational model of human mating.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 1845586.

References

Aiello, L. C., & Wells, J. C. K. (2002). Energetics and the Evolution of the Genus Homo. *Annual Review of Anthropology*, *31*, 323–338. https://doi.org/10.2307/4132883

Beckage, N., Todd, P. M., Penke, L., & Asendorpf, J. B. (2009). Testing sequential patterns in human mate choice using speed dating. *Proceedings of the 2009 Cognitive Science Conference*, 2365–2370.

Berscheid, E., & Walster, E. (1974). Physical Attractiveness. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology* (Vol. 7, pp. 157–215). Academic Press. https://doi.org/10.1016/S0065-2601(08)60037-4

Brandner, J. L., Brase, G. L., & Huxman, S. A. J. (2020). “Weighting” to find the right person: Compensatory trait integrating versus alternative models to assess mate value. *Evolution and Human Behavior*. https://doi.org/10.1016/j.evolhumbehav.2020.05.001

Bredow, C. A., & Hames, N. (2019). Steadfast standards or fluctuating fancies? Stability and change in people’s mate criteria over 27 months. *Personality and Social Psychology Bulletin*, *45*(5), 671–687. https://doi.org/10.1177/0146167218794643

Buss, D. M. (1989). Sex differences in human mate preferences: Evolutionary hypotheses tested in 37 cultures. *Behavioral and Brain Sciences*, *12*(01), 1–14.

Buss, D. M. (1992). Mate preference mechanisms: Consequences for partner choice and intrasexual competition. In *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 249–266). Oxford University Press.

Buss, D. M., & Barnes, M. (1986). Preferences in human mate selection. *Journal of Personality and Social Psychology: Personality Processes and Individual Differences*, *50*(3), 559–570. http://dx.doi.org/10.1037/0022-3514.50.3.559

Buss, D. M., & Schmitt, D. P. (1993). Sexual Strategies Theory: An evolutionary perspective on human mating. *Psychological Review*, *100*(2), 204–232. https://doi.org/10.1037/0033-295X.100.2.204

Buss, D. M., & Shackelford, T. K. (2008). Attractive women want it all: Good genes, economic investment, parenting proclivities, and emotional commitment. *Evolutionary Psychology*, *6*(1), 134–146.

Campbell, L., Chin, K., & Stanton, S. C. E. (2016). Initial evidence that individuals form new relationships with partners that more closely match their ideal preferences. *Collabra: Psychology*, *2*(1). https://doi.org/10.1525/collabra.24

Charlot, N. H., Balzarini, R. N., & Campbell, L. J. (2020). The association between romantic rejection and change in ideal standards, ideal flexibility, and self-perceived mate value. *Social Psychology*, *51*(2), 116–126. https://doi.org/10.1027/1864-9335/a000392

Clutton-Brock, T. H., & Parker, G. A. (1992). Potential Reproductive Rates and the Operation of Sexual Selection. *The Quarterly Review of Biology*, *67*(4), 437–456.

Condon, J. W., & Crano, W. D. (1988). Inferred evaluation and the relation between attitude similarity and interpersonal attraction. *Journal of Personality and Social Psychology*, *54*(5), 789–797. https://doi.org/10.1037/0022-3514.54.5.789

Conroy-Beam, D. (2018). Euclidean mate value and power of choice on the mating market. *Personality and Social Psychology Bulletin*, *44*(2), 252–264. https://doi.org/10.1177/0146167217739262

Conroy-Beam, D. (2021). Couple Simulation: A Novel Approach for Evaluating Models of Human Mate Choice. *Personality and Social Psychology Review*, 1088868320971258. https://doi.org/10.1177/1088868320971258

Conroy-Beam, D., & Buss, D. M. (2017). Euclidean distances discriminatively predict short-term and long-term attraction to potential mates. *Evolution and Human Behavior*, *38*(4), 442–450. https://doi.org/10.1016/j.evolhumbehav.2017.04.004

Conroy-Beam, D., Buss, D. M., Asao, K., Sorokowska, A., Sorokowski, P., Aavik, T., Akello, G., Alhababha, M. M., Alm, C., Amjad, N., Anjum, A., Atama, C. S., Duyar, D. A., Ayebare, R., Batres, C., Bendixen, M., Bensafia, A., Bizumic, B., Boussena, M., … Zupančič, M. (2019). Contrasting Computational Models of Mate Preference Integration Across 45 Countries. *Scientific Reports*, *9*(1), 16885. https://doi.org/10.1038/s41598-019-52748-8

Cosmides, L., & Tooby, J. (1995). From evolution to adaptations to behavior: Toward an integrated evolutionary psychology. In *Biological perspectives on motivated activities* (pp. 11–74). Ablex Publishing.

Eagly, A. H., & Wood, W. (1999). The origins of sex differences in human behavior: Evolved dispositions versus social roles. *American Psychologist*, *54*(6), 408–423. https://doi.org/10.1037/0003-066X.54.6.408

Eastwick, P. W., & Finkel, E. J. (2008). Sex differences in mate preferences revisited: Do people know what they initially desire in a romantic partner? *Journal of Personality and Social Psychology*, *94*(2), 245–264. https://doi.org/10.1037/0022-3514.94.2.245

Eastwick, P. W., Luchies, L. B., Finkel, E. J., & Hunt, L. L. (2014). The predictive validity of ideal partner preferences: A review and meta-analysis. *Psychological Bulletin*, *140*(3), 623–665. https://doi.org/10.1037/a0032432

Eastwick, P. W., & Smith, L. K. (2018). Sex-differentiated effects of physical attractiveness on romantic desire: A highly powered, preregistered study in a photograph evaluation context. *Comprehensive Results in Social Psychology*, *3*(1), 1–27. https://doi.org/10.1080/23743603.2018.1425089

Fletcher, G., Overall, N. C., & Campbell, L. (2020). Reconsidering "best practices" for testing the ideal standards model: A response to eastwick, finkel, and simpson (2018). *Personality and Social Psychology Bulletin*, 0146167220910323. https://doi.org/10.1177/0146167220910323

Fletcher, G., & Simpson, J. A. (2000). Ideal standards in close relationships: Their structure and functions. *Current Directions in Psychological Science*, *9*(3), 102–105.

Fletcher, G., Simpson, J. A., & Thomas, G. (2000). The measurement of perceived relationship quality components: A confirmatory factor analytic approach. *Personality and Social Psychology Bulletin*, *26*(3), 340–354. https://doi.org/10.1177/0146167200265007

Gangestad, S. W., Haselton, M. G., & Buss, D. M. (2006). Evolutionary foundations of cultural variation: Evoked culture and mate preferences. *Psychological Inquiry*, *17*(2), 75–95.

Gerlach, T. M., Arslan, R. C., Schultze, T., Reinhard, S. K., & Penke, L. (2019). Predictive validity and adjustment of ideal partner preferences across the transition into romantic relationships. *Journal of Personality and Social Psychology*, *116*(2), 313–330. https://doi.org/10.1037/pspp0000170

Greenwood, J., Guner, N., Kocharkov, G., & Santos, C. (2014). Marry Your Like: Assortative Mating and Income Inequality. *American Economic Review*, *104*(5), 348–353. https://doi.org/10.1257/aer.104.5.348

Hill, R. (1945). Campus values in mate selection. *Journal of Home Economics*, *37*(554), 269.

Jehle, G., & Reny, P. (2010). *Advanced Microeconomic Theory* (3rd edition). Pearson.

Joel, S., Eastwick, P. W., & Finkel, E. J. (2017). Is romantic desire predictable? Machine learning applied to initial romantic attraction. *Psychological Science*, *28*(10), 1478–1489. https://doi.org/10.1177/0956797617714580

Kaplan, H., Hill, K., Lancaster, J., & Hurtado, A. M. (2000). A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology: Issues, News, and Reviews*, *9*(4), 156–185. https://doi.org/10.1002/1520-6505(2000)9:4<156::AID-EVAN5>3.0.CO;2-7

Kenrick, D. T., & Keefe, R. C. (1992). Age preferences in mates reflect sex differences in human reproductive strategies. *Behavioral and Brain Sciences*, *15*(1), 75–91. https://doi.org/10.1017/S0140525X00067595

Kenrick, D. T., Sadalla, E. K., Groth, G., & Trost, M. R. (1990). Evolution, Traits, and the Stages of Human Courtship: Qualifying the Parental Investment Model. *Journal of Personality*, *58*(1), 97–116. https://doi.org/10.1111/j.1467-6494.1990.tb00909.x

Kirkpatrick, M., & Ryan, M. J. (1991). The evolution of mating preferences and the paradox of the lek. *Nature*, *350*(6313), 33–38.

Kurzban, R., & Weeden, J. (2007). Do advertised preferences predict the behavior of speed daters? *Personal Relationships*, *14*(4), 623–632. https://doi.org/10.1111/j.1475-6811.2007.00175.x

Lewis, D. M. G., Al-Shawaf, L., Conroy-Beam, D., Asao, K., & Buss, D. M. (2017). Evolutionary psychology: A how-to guide. *American Psychologist*, *72*(4), 353–373. https://doi.org/10.1037/a0040409

Li, N. P., Bailey, J. M., Kenrick, D. T., & Linsenmeier, J. A. (2002). The necessities and luxuries of mate preferences: Testing the tradeoffs. *Journal of Personality and Social Psychology*, *82*(6), 947–955. https://doi.org/10.1037/0022-3514.82.6.947

Li, N. P., Yong, J. C., Tov, W., Sng, O., Fletcher, G. J., Valentine, K. A., Jiang, Y. F., & Balliet, D. (2013). Mate preferences do predict attraction and choices in the early stages of mate selection. *Journal of Personality and Social Psychology*, *105*(5), 757.

Mare, R. D. (1991). Five decades of educational assortative mating. *American Sociological Review*, *56*(1), 15–32. https://doi.org/10.2307/2095670

Meltzer, A. L., McNulty, J. K., Jackson, G., & Karney, B. R. (2014). Sex Differences in the Implications of Partner Physical Attractiveness for the Trajectory of Marital Satisfaction.

Journal of Personality and Social Psychology, *106*(3), 418–428. https://doi.org/10.1037/a0034424

Miller, G. F., & Todd, P. M. (1998). Mate choice turns cognitive. *Trends in Cognitive Sciences*, *2*(5), 190–198.

Norton, R. (1983). Measuring marital quality: A critical look at the dependent variable. *Journal of Marriage and Family*, *45*(1), 141–151. JSTOR. https://doi.org/10.2307/351302

Pfeiffer, S. M., & Wong, P. T. P. (1989). Multidimensional Jealousy. *Journal of Social and Personal Relationships*, *6*(2), 181–196. https://doi.org/10.1177/026540758900600203

Ryan, M. J., Fox, J. H., Wilczynski, W., & Rand, A. S. (1990). Sexual selection for sensory exploitation in the frog Physalaemus pustulosus. *Nature*, *343*(6253), 66–67. https://doi.org/10.1038/343066a0

Saegert, S., Swap, W., & Zajonc, R. B. (1973). Exposure, context, and interpersonal attraction. *Journal of Personality and Social Psychology*, *25*(2), 234–242. https://doi.org/10.1037/h0033965

Samuelson, P. A. (1948). Consumption Theory in Terms of Revealed Preference. *Economica*, *15*(60), 243–253. https://doi.org/10.2307/2549561

Schmitt, D. P. (2014). On the proper functions of human mate preference adaptations: Comment on Eastwick, Luchies, Finkel, and Hunt (2014). *Psychological Bulletin*, *140*(3), 666–672. https://doi.org/10.1037/a0036225

Sugiyama, L. S. (2005). Physical attractiveness in adaptationist perspective. In *The handbook of evolutionary psychology* (pp. 292–343). John Wiley & Sons Inc.

Symons, D. (1979). *The Evolution of Human Sexuality*. Oxford University Press. https://repository.library.georgetown.edu/handle/10822/782278

Thibault, J. K., & Kelley, H. (1959). *The social psychology of groups*. New York: John Wiley.

Todd, P. M., Penke, L., Fasolo, B., & Lenton, A. P. (2007). Different cognitive processes underlie human mate choices and mate preferences. *Proceedings of the National Academy of Sciences*, *104*(38), 15011–15016. https://doi.org/10.1073/pnas.0705290104

Trivers, R. (1972). Parental investment and sexual selection. *Sexual Selection & the Descent of Man, Aldine de Gruyter, New York*, 136–179.

Tversky, A. (1969). Intransitivity of preferences. *Psychological Review*, *76*(1), 31–48. https://doi.org/10.1037/h0026750

Vandenberg, S. G. (1972). Assortative mating, or who marries whom? *Behavior Genetics*, *2*(2), 127–157. https://doi.org/10.1007/BF01065686

Walter, K. V., Conroy-Beam, D., Buss, D. M., Asao, K., Sorokowska, A., Sorokowski, P., Aavik, T., Akello, G., Alhabahba, M. M., Alm, C., Amjad, N., Anjum, A., Atama, C. S., Atamtürk Duyar, D., Ayebare, R., Batres, C., Bendixen, M., Bensafia, A., Bizumic, B., … Zupančič, M. (2020). Sex differences in mate preferences across 45 countries: A large-scale replication. *Psychological Science*, *31*(4), 408–423. https://doi.org/10.1177/0956797620904154

White, D. R., Betzig, L., Mulder, M. B., Chick, G., Hartung, J., Irons, W., Low, B. S., Otterbein, K. F., Rosenblatt, P. C., & Spencer, P. (1988). Rethinking Polygyny: Co-Wives, Codes, and Cultural Systems [and Comments and Reply]. *Current Anthropology*, *29*(4), 529–572. https://doi.org/10.1086/203674

Wood, D., & Brumbaugh, C. C. (2009). Using revealed mate preferences to evaluate market force and differential preference explanations for mate selection. *Journal of Personality and Social Psychology*, *96*(6), 1226–1244. http://dx.doi.org.proxy.library.ucsb.edu:2048/10.1037/a0015300

Zajonc, R. B., & Markus, H. (1982). Affective and Cognitive Factors in Preferences. *Journal of Consumer Research*, *9*(2), 123–131.

Zhang, L., Lee, A. J., DeBruine, L. M., & Jones, B. C. (2019). Are Sex Differences in Preferences for Physical Attractiveness and Good Earning Capacity in Potential Mates Smaller in Countries With Greater Gender Equality? *Evolutionary Psychology*, *17*(2), 1474704919852921. https://doi.org/10.1177/1474704919852921