Relationship Foraging: Does Time Spent Searching Predict Relationship Length?

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Animals foraging for resources often need to alternate between searching for and benefiting from patches of those resources. Here we explore whether such patterns of behavior can usefully be applied to the human search for romantic relationships. Optimal foraging theory (OFT) suggests that foragers should alter their time spent in patches based on how long they typically spend searching between patches. We test whether human relationship search can be described as a foraging task that fits this OFT prediction. By analyzing a large, demographically representative data set on marriage and cohabitation timing using survival analysis, we find that the likelihood of a relationship ending per unit time goes down with increased duration of search before that relationship, in accord with the foraging prediction. We consider the possible applications and limits of a foraging perspective on mate search and suggest further directions for study.

Public Significance Statement
The longer individuals search for a romantic relationship, the longer their subsequent relationships and future searches. This effect is stronger in high-commitment relationships like marriage than in low-commitment relationships like cohabitations. This study shows that optimal foraging theory can be repurposed to make testable hypotheses in human mate choice.

Keywords: optimal foraging theory, relationship dissolution, romantic relationships, relationship duration, survival analysis

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Most relationships do not last. Moreover, few people have the luxury of jumping immediately from one relationship into another that is already waiting in the wings—instead, there is usually a gap between the end of one relationship and the start of the next. Thus, many people spend a good chunk of their lives switching between periods of being in a relationship and periods of being unattached. Given that people have some control over how long they are in a relationship and how long they are searching or waiting before the next one, are there observable patterns that exist regarding how long relationships last and the time spent between them and, if so, how can they be explained?

People presumably get something out of being in relationships, such as companionship, emotional attachment, financial support, intellectual stimulation, children, family connections, status, stability, improved health and well-being, and so on. Whatever they get, if people are (or perceive they are) getting more of those things while in a

relationship than while single, then we can think of the mate search process—repeatedly seeking a relationship, getting something from it, leaving the relationship, and seeking another—as a form of foraging. A rich body of theory known as optimal foraging theory (OFT; Stephens & Krebs, 1986) predicts how organisms should evolve to make the trade-offs between seeking resources ("exploring") and making use of them ("exploiting"). In this article, we consider whether mate search can be usefully studied from the perspective of foraging and how mating opportunities may be distributed as a patchy resource and then focus on a specific example, assessing patterns of human relationship and singlehood duration in terms of some of the ideas of OFT.

Modeling Mate Search as Patchy Foraging

OFT has examined how individuals allocate their time as they search for various resources. In many environments, resources (e.g., food, information) are clustered in dense patches across the landscape (e.g., berry bushes, web pages) rather than being randomly distributed. Foragers in such environments must find patches (exploring, during between-patch time), locate and use resources within each patch (exploiting, during within-patch time), and decide when to leave the current patch and start looking for another (switching). Once a forager enters a patch, it typically finds initial resources to consume rapidly, but as these easy-to-obtain resources are depleted, the forager's rate of resource accumulation decreases. Foragers are expected to behave in ways that are sensitive both to this rate of return and to search costs for exploring, exploiting, and switching. In particular, an "optimal" forager should leave a patch when the marginal rate of return from that patch is less than the mean rate of return expected from the environment at large, as indicated by the marginal value theorem (Charnov, 1976).

Common assumptions for OFT models include two nonoverlapping phases of activity (e.g., exploration and exploitation of resources), the consumption of some resource(s), and, for patch-based models, a patchy resource distribution with a decreasing rate of return within each patch as the resources there are used up (Stephens & Krebs, 1986). Does mate search meet these assumptions, and if so, what predictions does OFT make about this domain?

One way that mate search can be analyzed as patch-based foraging is if the potential mates being sought are found in clusters, and each mate found counts as a resource. This can occur for species where polygamous males search for females that are themselves clustered in groups, for instance, around other resources such as food (Hutchinson & Halupka, 2004; Parker, 1978). Males first spend time finding these patches (whether that be at a feeding site, a dating website, in a social clique, etc.) and then pursuing individual females there. The number of available mates in a patch is depleted over time as the foraging male mates with each female. Such mate foraging has been demonstrated in male parasitoid wasps in an artificial environment consisting of "patches" of multiple females tethered in a confined area, where males alter their patch residence time based upon the number of fertile females available (e.g., Martel, Wajnberg, & Boivin, 2008), indicating resource-sensitive foraging in patchy mate search. But the assumption of consuming resources (mates) with a decreasing rate is unlikely to be met for females or monogamous males when they do not benefit from multiple matings in a patch (but see Hutchinson & Halupka, 2004, for a model where mate seekers can search through prospects in a patch, decreasing the number of unexamined options before choice).

Relationships as Patches

In contrast, for species that engage in lengthier monogamous relationships, each of those relationships could be considered a patch that provides some exploitable mix of the benefits mentioned earlier (many of which relate to fitness). From this perspective, the time spent between relationships, whether actively exploring for another or merely waiting until a good-enough one comes along, is the "travel time" between patches. Individuals switch between searching through the environment for patches (i.e., potential relationships) and accruing the resources from being in the current relationship patch—meeting the common OFT assumption of two phases of foraging activity. With respect to the OFT assumption of decreasing rates of resource intake over time in a patch, dyadic levels of many possible relationship-oriented resources can decrease with greater time spent in a relationship (at least for relationships that end; Sprecher, 1999): There are rapid initial

increases in feelings of love and satisfaction in early relationships (Rusbult, 1983), followed by decreasing or stabilizing relationship quality as the relationship leaves the "honeymoon" or infatuation stage and individuals perhaps stop "display[ing] their best selves" over their "true, flawed selves" (Rusbult, 1983, p. 113; see also Byers, 2005; Huston & Vangelisti, 1991; Sprecher, 1999). Relationship quality also often declines with the number of children (Twenge, Campbell, & Foster, 2003), which itself grows at a declining rate (Christensen, 1963).

When considering relationships as a patchy resource that people search for, the foraging framework suggests three important aspects of this search to be studied: How do people explore for relationships and decide when to enter into one? What do people gain (exploit) from their relationships, and how do they decide when to leave them? And how are time and effort allocated between exploring for new relationships and exploiting (benefiting from) the current relationship? We touch on each of these topics in turn.

Exploring for and Starting Relationships

Opportunities to enter into new relationships will be distributed in time and possibly in space. How people search for and find these opportunities has been studied mostly in terms of what they are looking for and how they behave in different modalities (e.g., at bars, while speed-dating, during online dating), rather than in terms of how people allocate their time to different potential patches of opportunities across modalities. How people decide when to pursue a *particular* opportunity has been studied from a search perspective, often in terms of optimal stopping problems. From the optimal stopping perspective, mate search consists of encountering a sequence of potential mates, each of whom has some quality, and making a decision when to stop this search and enter into a relationship in such a way that a mate is found with the highest possible quality. As optimizing in a real-world context such as mate choice is typically not possible, people may approach this problem using simpler heuristic search mechanisms that can find a good-enough mate. These heuristics include satisficing strategies that set a threshold quality level that the individual uses to search, stopping the search as soon as a

person is found above that threshold (Beckage, Todd, Penke, & Asendorpf, 2009; Miller & Todd, 1998). The particular heuristic used can depend on the influence of the two-sided search in the particular mating context (where both parties must agree for a relationship to start), which differs from a one-sided search in many food foraging contexts.

If there are multiple types and qualities of relationships that a searcher could enter into, another set of OFT models becomes applicable: diet breadth models, which posit that the decision to include a particular item type in one's diet is based on its relative energy value and its handling time, that is, how much time and effort are required to process the item so it can be used (Stephens & Krebs, 1986). In terms of relationship foraging, this could be applied to how people decide what quality or type of relationships to pursue given the available distribution of relationship quality and how they take "handling time" in the form of courtship costs into account.

Choosing what items to pursue can also be influenced by competition among foragers, which again can have different effects on foraging for food (where individuals can share patches; Giraldeau & Caraco, 2000) versus foraging for mates (where patches interpreted as relationships are typically not shared but can be in some cases). In the mate search case where choice is mutual (different from food search), the way that competing males or females search for mating opportunities with one another can also be affected by the sex ratio (Simão & Todd, 2003). A further difference between relationship foraging and food foraging is that the search for new relationship opportunities can continue even while in a current relationship (e.g., via "back burner" interactions; Dibble & Drouin, 2014), while such simultaneous exploring is unlikely when exploiting a food patch.

Exploiting and Leaving Relationships

From an optimal stopping perspective, exploring for relationships culminates in finding one and staying in it thereafter, but from a broader foraging perspective, a relationship can also be benefited from (exploited) for some amount of time and then left, possibly returning to another round of exploration. Once we consider an individual searching for a succession of

relationship patches, other types of predictions from OFT become applicable. In particular, the point at which an individual should leave a relationship can be predicted on the basis of the marginal value theorem (Charnov, 1976) in terms of when (if ever) the resources gained in a relationship are lower than can be expected by leaving this relationship and seeking others. (Ongoing monitoring of other opportunities, including the "back burners" mentioned above, can contribute to the estimate of expected resources in other relationships; see also Rusbult, 1983, for a related cost/benefit analysis of relationship satisfaction.) This approach has been used to model divorce in birds (McNamara & Forslund, 1996), accounting for how females may decide to stay with their current male partner for another breeding season or "divorce" him to find a new mate, depending on the likely viable offspring produced with him versus with other mates: "For the basic model the threshold rule is analogous to the marginal value theorem and requires a female to divorce a male if and only if the reproductive success on next breeding with him is less than the average future lifetime success per breeding attempt [with other males] if she divorces" (p. 610). (Whether or not to enter a given relationship in the first place can also be considered within this framework based on an initial estimate of the relationship's potential quality.)

Given the typical assumption of the marginal value theorem that resources decline with time spent in a patch, applying such models to human relationship foraging requires measuring whether various possible relationship-based resources (e.g., love, commitment, trust, enjoyment, children, income) do show diminishing returns over time in a given relationship. Once such declining resources have been identified, their changing rate of return can be compared to the expected level of that resource from relationships in general to predict when an individual would be likely to leave that relationship—specifically, when the resource would be more plentiful on average outside of this relationship than in it, including those periods between relationships when the resource could be largely absent. (From the romantic relationship literature, interdependence theory posits that individuals should leave a relationship when its outcomes fall below a particular threshold that one

might expect from other potential relationship partners; Kelley & Thibaut, 1978.)

Some more or less objectively defined aspects of relationships such as reproduction, sexual access, and health could be analyzed via a variety of large representative data sets that are freely available to researchers: The Married and Cohabiting Couples survey contains measures of health, children, relationship quality, and duration of various phases of the relationship at both the individual and couple level (National Center for Family and Marriage Research, 2010), while the National Couples Survey also includes duration of relationship phases, fecundity, reproductive attitudes, and detailed sexual histories (Grady, Billy, Klepinger, Cubbins, & Tanfer, 2009). Preliminary results (Cohen & Todd, 2017) suggest that levels of some more subjectively assessed relationship resources, including love, trust, and satisfaction, may change over time (such as depleting toward the end of dissolved relationships) in ways that are consistent with a foraging analysis, although results were mixed. Additional sources of longitudinal relationship data that are longer term and of higher temporal resolution are needed to test such hypotheses further and to study specific cognitive mechanisms that could underlie decisions to leave.

Trading Off Between Relationship Exploration and Exploitation

Foraging effectively for a patchy, depletable resource requires appropriate balancing of the time spent exploiting and depleting found patches, as well as exploring and finding those patches in the first place. OFT predicts that the time spent exploiting a given patch should depend on the relative quality (resource level) of that patch and also the travel time between patches (Stephens & Krebs, 1986). The effect of travel time is one of the most commonly tested and supported predictions in animal food foraging—specifically, the longer the expected time to be spent exploring between patches without receiving rewards, the longer one should stay in each patch accruing rewards (Krebs, Stephens, & Sutherland, 1983). From the perspective of foraging for romantic relationships, the predicted pattern would be that people who face longer search times between relationships stay in each particular relationship for longer on

average. There are different ways that individuals could "know" that they face longer search—they could learn about their own search time between relationships, or they could observe the search time of others, or they could infer their likely search time given their mate qualities and those of their competitors. If we simply assume that the actual search times that individuals experience provide a reasonable basis for their expectation of the search times they face, then the foraging-based prediction becomes more specifically that longer times spent searching for relationships lead to longer times spent in subsequent relationships.

Interestingly, previous research in the close romantic relationship field leads to a different (although not exactly contradictory) prediction. In that tradition, duration has mostly been studied in terms of how it is affected by relationship quality—particularly for predicting when a relationship will end. Not surprisingly, individuals exiting relationships reported decreased satisfaction, commitment, and love (Sprecher, 1999). Following a relationship, most individuals enter a period of distress and possibly elevated sadness (Sprecher, Felmlee, Metts, Fehr, & Vanni, 1998), which can interfere with or delay subsequent relationship search. Furthermore, individuals exiting longer, more committed relationships tend to have greater distress or negative affect (Simpson, 1987), which could delay search longer. Such distress could even lead to an aversion to reenter that same type of relationship again: Following the dissolution of a marriage, many individuals do not marry again and instead cohabitate with new partners (de Jong Gierveld, 2004). Consequently, relationship duration could be expected to alter postbreakup behavior, leading to longer searches after longer relationships, which contradicts another assumption of the marginal value theorem that "the length of time between patches should be independent of length of time the predator hunts within any one (although the reverse statement is not true)" (Charnov, 1976, p. 131). Thus, past relationship research could lead to a second prediction of longer (or even abandoned) search after longer relationships that does not follow from OFT.

We next test both the foraging-based and the romantic research–based predictions in two separate analyses as an example of foraging-inspired research about romantic relationships.

Specifically, we investigate how people may balance the explore/exploit trade-off with regard to the duration of time spent searching for relationship patches and the time spent within those patches. While there are many other considerations that can go into a foraging-inspired investigation of mate search as described above (including mutual choice, the importance of patch relationship quality, individual differences in preferences and strategies, and changes in those preferences and strategies across the life course), our aim in this initial study is to abstract away those details and assess whether there is an overarching foraging-related pattern in how people spend time in and between relationships.

Method

We analyze one set of data about two types of human relationships to examine how relationship duration relates to search duration between relationships. The majority of data on relationship length and dissolution concerns married couples, so this serves as a natural starting point. But marriage has significant social, financial, and legal repercussions that may distort the time spent in and between such relationships. Further, because marriages tend to be lengthy, each individual has relatively fewer of them than other types of relationships, impacting analysis. We therefore also analyze cohabitations, which are typically less stable and shorter than marriages, often either ending or transitioning to marriage within 5 years (Bramlett, Mosher, & National Center for Health Statistics, 2002).

Data Set: Centers for Disease Control and Prevention National Survey for Family Growth

For marriages and cohabitations, we used publicly available data from the Centers for Disease Control and Prevention (CDC) in their 2013–2015 National Survey for Family Growth (NSFG; National Center for Health Statistics, 2016). This data set, focusing on American women's reproductive outcomes, has accumulated data from a large representative sample of women and men since 1973 primarily through confidential interviews (see https://www.cdc .gov/nchs/nsfg/about_nsfg.htm). It contains considerable individual detail, including the presence of children in the home (number, age,

and parentage), wealth, race, number of reproductive partners, date of first sexual intercourse and menarche, and the date and amount of sexual education. Most importantly for our purposes here, it also includes the dates of the beginning and end of marriages and cohabitations.

Participants. In total, 10,205 individuals (female = 55.8%) were included in the sample we analyzed, ages 15–45 years (M = 28.6 years, SD = 8.5), with 67.4% White, 21.4% Black, and 11.1% other races. As a whole, 60.7% had never married, 0.3% were widowed, 28.5% were currently married, and 10.4% were currently divorced, separated, or annulled. Over half (52.0%) of the sample had cohabited with at least one partner outside of marriage, and 39.3% of the sample had been married at least once. We limited relationship duration analyses to the first marriages and cohabitations for men and women, which were much more common than later relationships. First marriages where the relationship ended by spousal death (n = 38) and first cohabitations ending in marriage (n = 2,002) were not included in the analysis. We also excluded the 15.5% of the sample who never had sexual intercourse.

Measures. Our analyses use the date (month and year) of the beginning and end of cohabitations and marriages, including how the relationships ended, and the date of critical behaviors such as moving out or divorce finalization. A cohabitation was defined as a live-in, specifically sexual, romantic partnership.

We define the search (or travel) time before a given relationship as follows: For the first search period leading up to the first marriage, we use the number of months between the individual's first sexual intercourse and the date of his or her first marriage. In the case of individuals who said that they had first sex within one month of first marriage (n = 414 people), this length was coded as 0; individuals reporting having first sex later than 1 month into the first marriage (n = 59) were excluded. We call this the first "marriage gap," that is, the time spent as a sexually active searcher for a committed relationship. (This gap could also be defined as starting at one's 18th birthday or menarche for women; using these definitions did not produce meaningful differences in the results.) The subsequent "marriage gaps" are defined as the length of time one is between marriages (where the du-

ration is the difference in months between the earlier of either the date when divorce was finalized or the spouses stopped sharing a home and the date of the subsequent marriage). Across analyses, any negative durations (e.g., individuals whose first sexual experience was after the second cohabitation) were excluded.

We also computed the completed cohabitation duration (from move-in to move-out month date for finished cohabitations) and cohabitation gaps (calculated analogously to marriage gaps) for each cohabiter. Because the primary focus of the NSFG survey is on the reproductive lives of women, women reported their earliest four cohabitations, but men only reported their first cohabitation and are thus only included here in analyses involving the first cohabitation length (in addition to the marriage analyses).[1]

Results

At first glance, to analyze the connection between time spent in and out of relationships, one might look at the correlations between duration of dissolved relationships and their associated search times. However, correlation does not tell the whole story, because it fails to take into account the influence of successful relationships that do not end. After all, many individuals never leave their first marriage (or cohabitation). The correlation approach omits the data of individuals who have chosen their partner well (or got lucky) and are in a relationship that is still ongoing at the end of the data collection period but could end in the future (these are referred to as *censored* data points). We incorporate these additional data by using *survival analysis,* which tells us about how likely a particular state is to survive (or, conversely, to end) at each point over some period of time. Here the

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[1] Individuals' search for cohabitation partners and marriage partners may overlap. Given this, we also excluded from the first cohabitation gap analysis those individuals (436) who had married before entering their first nonmarital cohabitation, which would generate a misleadingly long first cohabitation gap. An additional 293 individuals in the second cohabitation gap analysis were excluded if their order of cohabitations was unclear or missing or if the individual married before entering another cohabitation (i.e., when the second cohabitation gap ended). We did not exclude from the marriage gap analysis those individuals who cohabitated prior to marriage, because cohabitation frequently precedes marriage as a part of the evaluation period, while the opposite is not true.

states we are interested in are being in a relationship (or being single). Specifically, within the CDC data, we can analyze the survival likelihoods of marriages and cohabitations over time, based on observation of those relationships that ended through divorce, annulment, or separation in the case of marriages or through a partner exiting a shared nonmarital cohabitation. The duration for ended relationships is calculated as described earlier, while the duration of relationships that have not yet ended is calculated as the difference between their start date (either the month of marriage or of moving in together for cohabitations) and the date the participant was interviewed (in century months). (Note that the NSFG data set uses imputed values for some missing values.) By analyzing the proportion of relationships that reach a certain duration without the relationship end-event occurring, we can estimate the likelihood of exiting a romantic relationship at any duration.

The likelihood of a relationship (or search period, i.e., marriage gap or cohabitation gap) ending after a particular duration is called the *hazard rate* of relationship (or gap) dissolution. A number of factors may differentially affect this hazard rate at various lengths of relationship duration in addition to that duration itself. To find out what factors may affect relationship dissolution over time, we use a Cox proportional hazards survival regression analysis (Cox, 1992).[2] In this analysis, the hazard rate λ of an end-event occurring at time t is calculated as follows:

$$\lambda(t) = \beta_0(t) \exp (\beta_1 x_1 + \beta_2 x_2 + \ldots)$$

where each of the beta coefficients β_i is weighting a corresponding variable factor x_i. If a beta coefficient is positive, this means the corresponding factor increases the hazard rate (e.g., of a relationship ending over time), and if it is negative, the corresponding factor decreases the hazard rate. An increased hazard rate of relationship dissolution goes along with relationships ending sooner (being shorter), while a decreased hazard rate goes with relationships ending later (lasting longer).

We run two separate analyses to test how several factors impact the likelihood of a relationship ending (for the foraging-based prediction) or remaining single (for the romantic research–based prediction). We focus on two

factors: the length of search periods (as dictated by our foraging hypothesis) and the age of one's first sexual intercourse. We include the latter primarily as a control for age- and experience-related impacts upon one's mate search. The age of first sexual intercourse can be considered a proxy for when one entered the mating market, as well as an indicator of desirability, such that earlier sexual encounters indicate greater attractiveness (Rhodes, Simmons, & Peters, 2005). It also serves as an indicator of life history strategy, with earlier sexual encounters indicating faster strategies and therefore an expediting of the entire reproductive cycle (Chisholm et al., 1993). Individuals with earlier sexual encounters may also be more likely to have unstable pair bonds (Belsky, Steinberg, & Draper, 1991). Age of first sexual intercourse is thus likely to be a strong predictor of relationship timing patterns, making it important to include in our model. Both factors were incorporated as integer covariates (months for search duration and years for age) and normalized within each subsample used in the individual analyses. (Other factors are included in an expanded model in the online supplemental materials, where intact family during childhood, attitudes toward the acceptability of divorce, and success of marriages of acquaintances also have a limited impact on relationship dissolution but do not appreciably change the impact of the two factors considered here.)

To test for the effect of previous search time on relationship length, we fit the marriage and (separately) cohabitation survival data to a Cox proportional hazard model predicting relationship dissolution based simultaneously on the first search gap duration and age at first sexual intercourse. For the marriage model, these variables were available for 3,916 individuals who were currently married to their first spouse or whose first marriages had ended in divorce, separation, or annulment. The mean first marriage gap for these individuals was 85.4 months ($SD = 66.2$); the mean first marriage length was 83.7 months ($SD = 66.4$). For the cohabitation

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[2] The Python *lifelines* module was used for primary analysis (Davidson-Pilon, 2016), and the R *OIsurv* library (Therneau & Grambsch, 2000) was used for additional, noncontinuous covariate analysis and assumption checks (e.g., proportional hazard assumption). All covariates passed this test unless otherwise noted.

model, these variables were available for 2,669 individuals currently in their first cohabitation or who had ended that cohabitation (without immediately marrying that cohabiting partner). The mean first cohabitation gap for these individuals was 65.8 months ($SD = 54.6$), and the mean first cohabitation length was 36.9 months ($SD = 41.9$).

The impact of these variables on the likelihood of a relationship ending is shown in Table 1. Censorship within the data indicates the marriage or cohabitation continuing rather than dissolving. Because we exclude cases with widowing, the two possible relationship outcomes are dissolution ("death") and maintenance ("life"). Participants were limited to ages 15–45, which capped relationship duration.

In line with our foraging-based prediction, longer search periods before first marriage led to a decreased likelihood (hazard risk) of the first marriage ending over time (suggesting longer first marriage duration). Older age at first sexual intercourse similarly decreased the hazard rate of first divorce (according to the model, the risk is halved by each year one waits before having sex, indicated by e^β being close to 0.5). Both patterns also held for cohabitations (at marginal significance for prior cohabitation gap) but with weaker effects on the hazard rates. One measure of the predictive usefulness of this kind of model, concordance, is the proportion of pairs of individuals in the data set for which the individual with the predicted higher hazard rate for relationship dissolution actually had his or her relationship end sooner than the relationship

of the other individual with the lower predicted hazard rate (so the chance level is 0.5). The concordance for the marriage model was 0.650, in line with typical levels of agreement in survival analysis; the concordance of the cohabitation model was 0.529, barely above chance. The fit of each model was compared to chance performance with the likelihood ratio test, which uses a null model without any covariates. The marriage model fit the data significantly better than the null model, $\chi^2(2) = 366.3$, $p < .001$, but for cohabitation, the improvement was more modest, $\chi^2(2) = 32.8$, $p < .001$.

To test the second, nonforaging-based prediction that one would search longer after a longer relationship, we analyzed the hazard rate of the second relationship search period ending (i.e., the end of the second marriage gap or cohabitation gap) based on the previous relationship duration as well as the duration of the first search period and the age at first sexual intercourse (see Table 2). For this subsample, the mean first marriage gap was 79.9 months ($SD = 58.2$), the mean marriage duration was 56.7 ($SD = 49.1$), and the mean second marriage gap was 66.4 months ($SD = 53.2$). For the marriage model, one factor, prior marriage duration, failed the test of proportional hazards (i.e., the effect of that covariate on the hazard function was not constant) and so the analysis was run without it. The resulting model produced a concordance of 0.550, not much above chance but fitting significantly better than the null model (likelihood ratio test, $\chi^2(2) = 10.0$, $p = .00673$). Both prior search period and age at first

Table 1
Results of Cox Proportional Hazards Survival Regression Analysis of Effect of Search Duration and Age at First Sexual Intercourse on Hazard Rate of Dissolution of First Marriage or Cohabitation

Predicted event: End of . . .	Events/observations	Concordance	Variable	β Coefficient	e^β	[95% CI] on β coefficient
First marriage	1,434/3,916	.650	Prior search period (first marriage gap)	−.289	.749***	[−.3558, −.2212]
			Age at first sexual intercourse	−.696	.499***	[−.7699, −.6212]
First cohabitation	1,990/2,669	.529	Prior search period (first cohabitation gap)	−.048	.953†	[−.0967, .0006]
			Age at first sexual intercourse	−.132	.877***	[−.1777, −.0860]

† $p < .07$.   *** $p < .001$.

Table 2

Results of Cox Proportional Hazards Survival Regression Analysis of Effect of Relationship Duration, Previous Relationship Gap Duration, and Age at First Sexual Intercourse on Hazard Rate of End of Second Marriage Gap or Cohabitation Gap (i.e., Length of Search After First Marriage or Cohabitation Ends)

Predicted event: End of . . .	Events/observations	Concordance	Variable	β Coefficient	e^{β}	[95% CI] on β coefficient
Second marriage gap	544/1,434	.550	Prior search period (first marriage gap)	−.160	.852**	[−.2682, −.0514]
			Age at first sexual intercourse	−.117	.890*	[−.2212, −.0128]
Second cohabitation gap	359/988	.612	Prior search period (first cohabitation gap)	−.370	.691***	[−.5069, −.2322]
			First cohabitation duration	−.126	.881*	[−.2493, −.0031]
			Age at first sexual intercourse	−.325	.722***	[−.4431, −.2075]

Note. The second cohabitation gap analysis only includes women who began at least two cohabitations uninterrupted by marriage. See Note 1.
* $p < .05$.   ** $p < .01$.   *** $p < .001$.

sexual intercourse mildly decreased the risk of one's second marriage gap ending, indicating that search lengths before and after marriage may be correlated but not allowing us to test the predicted connection between marriage length and subsequent search length. This analysis was repeated with corresponding variables for the second cohabitation gap search period, including the cohabitation duration variable (as indicated earlier, data about subsequent cohabitations were only available for women, so this analysis only includes women). The mean first cohabitation gap was 56.4 months ($SD = 46.3$), the mean first cohabitation length was 32.9 months ($SD = 33.5$), and the mean second cohabitation gap was 44.6 months ($SD = 47.9$). Longer first cohabitation durations only weakly decreased the subsequent search hazard (suggesting slightly longer search durations), not providing much support for the nonforaging-based hypothesis. As for marriages, longer first cohabitation gap search periods decreased the subsequent search hazard (again suggesting correlated search durations), as did older age at first sexual intercourse. This model had a higher concordance (0.612) and greater improvement in fit over the null model (likelihood ratio test, $\chi^2(3) = 50.9$, $p < .001$).

Discussion

People decide when to enter into romantic relationships and when to leave them, presumably motivated by what they may get out of those relationships over time. This is analogous in some ways to how many types of foraging animals decide to enter and leave patches of food, which suggests a range of questions regarding whether similar cognitive mechanisms are used in the two domains. To assess one aspect of whether people forage for relationships as animals forage for patches of food, we analyzed a large data set of human marriages and cohabitations asking how the duration of search before a relationship is related to the duration of that relationship, construed as a patch. We tested a prediction of OFT that longer search for a relationship patch should result in longer time spent in each relationship, as well as an independent prediction from romantic relationship research that longer time in a relationship patch should lead to longer time spent searching again after that relationship.

Using hazard rate regression modeling, we found that longer search periods (and later age of first sexual intercourse) before the first marriage was significantly associated with reduced risk of the first marriage ending at any particular

point and hence likely to be associated with longer marriages as indicated by the foraging-based prediction. This only weakly held for cohabitations. But with respect to the second prediction, we found that greater relationship length (specifically for cohabitations; marriages could not be tested) does not lead to meaningfully longer search subsequently, as the romantic relationship literature suggests—although longer prior search does increase the likelihood of a longer second search, pointing to consistency in relationship search intensity within individuals. These results offer modest initial support for relationship foraging akin to food foraging (along with indicating some other moderately strong influences related to life history theory on the patterns of relationship and search timing—see also online supplemental materials). There remain, though, a number of caveats and other directions that need to be explored in order to judge the plausibility and usefulness of the idea of relationship foraging.

If we are to use OFT to guide studies of mate choice, we must consider the discrepancies between the assumptions of foraging for food and the realities of searching for mates. As indicated earlier, the psychology of long-term mate search may not match the assumption in OFT for depleting patchy resources that foragers will switch back and forth between periods of exploration and periods of exploitation. While people presumably expect that they will have multiple short-term relationships before marriage, once they get to the long-term marriage stage, they may search as though they expect to find their one marriage and stick with it. For example, in a sample of 137 individuals getting marriage certificates, none estimated they would get a divorce (Baker & Emery, 1993). In this case, more appropriate models of search could include the optimal stopping perspective described earlier, consisting of an extended period of exploration followed by one switch to final exploitation (Todd & Miller, 1999); in this case, longer search and longer relationship length could be correlated if individuals use a higher threshold for stopping, meaning they will search longer to find above-threshold mates and then could stay longer with those mates because they are of higher quality. Similarly, mate foraging could be consistent with the "sit-and-wait" foraging strategy of, for example, web-building spiders (Beachly, Stephens, & Toyer, 1995), with long exploration followed by long exploitation

and the ongoing possibility of switching to another better patch to exploit. These long-exploitation strategies better fit the notion of relationships as nondepleting patches where resource levels do not fall over time (see Cohen & Todd, 2017).

Alternatively, it could still be that early life relationship search does align with depleting patch foraging but that we cannot see this in data about marriages and cohabitations, where there can be external forces (including children, homes, and legal structures) that may influence people to stay in those relationships longer than they might otherwise choose to. To assess this possibility, further research should consider data sets capturing the durations of relationships among individuals who are dating but not cohabiting (nor married) and so may face fewer extrinsic constraints on their decisions to enter into and dissolve their relationships. Neither of these perspectives highlight the mutual choice aspect of human mate search, where both partners must agree to start a relationship but either one can end it, which could strongly affect the subsequent search behavior of the other person; future studies should also gather data on who ended the relationship and how search proceeded for both parties.

Another factor that could impact relationship foraging is the extent to which a forager can affect the search time between relationships. Certainly, individuals could make that time longer, for instance, by not actively searching, but they could also make it shorter by lowering their acceptance threshold for the next mate. According to OFT, the time spent exploring between patches should depend on the distribution of patch quality and the forager's quality aspiration level (Stephens & Krebs, 1986). A mate forager facing higher search costs could then lower its standards—for instance, female sticklebacks swimming across strong currents accept lower quality mates (Milinski & Bakker, 1992)—which could in turn result in shorter exploration time between accepted mates. The extent to which this applies to human mate searchers could affect predictions about the connections between relationship and search durations. Finally, there are also positive aspects and resources obtained during the search phase itself (i.e., while single), including independence, short-term mating opportunities, and so on, that could change the way decisions are made about switching between relationships and singlehood. Relat-

edly, many of the resources one could potentially gain within a relationship could also be obtained elsewhere (e.g., happiness, life satisfaction), violating the assumption that resources can only be gained within a patch and also potentially affecting switching behavior.

Even if predictions arising from applications of OFT to human "relationship foraging" are supported, this does not imply that humans have specifically evolved to search for, as well as begin and end, relationships in the same way that animals forage for food in patches. While this may be a possibility, it could also be that mechanisms that arose for some other purpose are "borrowed" for the mate search domain. There is evidence that cognitive mechanisms that evolved to guide food foraging have been repurposed in species, including humans (whether through exaptation—Todd & Miller, in press—or modification by individual learning) for use in other domains that bear some structural similarity to patchy resource environments. This appears to be the case for mechanisms used to search for information and other goods in online environments (Pirolli, 2007) or for concepts in memory (Hills, Jones, & Todd, 2012), among others, several of which have also been illuminated from the perspective of OFT (see Hills et al., 2015, for an overview). We are currently agnostic as to the origins of the possible cognitive search mechanisms that may be employed in relationship search.

For now, the applicability of ideas from OFT to understanding patterns of human relationship search, formation, and dissolution remains largely untested. To make progress, we would need to advance from assessing whether relationship search behavior is predictable in terms of optimal foraging to studying the cognitive mechanisms that generate those behaviors. Further work should also examine whether there is evidence for relationship foraging for all relationships, only for less serious (e.g., premarital) relationships, or for none. More generally, the approach we have used here, analysis of large readily available relationship data sets via statistical packages for finding patterns over time, should be increasingly useful in testing predictions that arise from the evolutionary behavioral sciences.

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