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Coevolved Cognitive Mechanisms in Mate Search

Making Decisions in a Decision-shaped World

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SEARCHING FOR A SPACE

*I*magine that you are driving to a movie theater to watch a film. You look for a place to park as you approach the cinema, and show time is coming up. You feel some time pressure not to miss all the previews, and you are motivated to try to minimize your total travel time, including driving and then walking from wherever you park. What is the best strategy to follow in this case? Should you park in the first space you come to? Or should you immediately drive all the way to the theater, then turn around and take the first space you find as you head away again? But what if everyone else driving to the movies does the same thing? How should you choose a parking space in the face of everyone else's choices so as not to have to skip buying Raisinettes before the film starts?

The search for a parking space did not present much of a concern to our ancestors in the course of human evolution, but this modern trial illustrates a common aspect of the situations that challenged our evolving minds: The problem here and in many other social domains is how to make decisions in

environments that are shaped by the decisions of ourselves and others. What makes such tasks particularly tricky is that whatever decision mechanism we use must work within some rather stringent bounds. For instance, in this setting, we have limited time to make the parking choice as we drive along; we have limited knowledge of what spaces may lie ahead, perhaps some prior expectations and perhaps we can see a few upcoming spots, but not beyond the next parked SUV; and we have limited cognitive capacity to put together our current experience of who is parking where with our past expectations to come up with a decision about whether to take an empty spot we find or to keep driving and hope that a better one turns up later. And even if we did have Total Information Awareness satellites to tell us that, indeed, the spot right in front of the theater is still empty right now, that could change by the time we drove there—so in this dynamic, uncertain, self-creating environment, more information would not necessarily be better.

How, and how well, can decision makers operate in the face of such challenges? In this chapter, I will show how some simple strategies can allow individuals to behave adaptively even in complex domains, focusing specifically on the important adaptive task of choosing a mate. Part of the power of these decision mechanisms comes from their fit to the structure of information in their particular environment. But because individuals actually change their environment—and the environment faced by others—through the decisions they make, their strategies must be fit to the structure of that changed, individual-constructed environment. This coadaptation or coevolution of decision mechanisms and environment structure leads to distinct strategies being most appropriate for different problems. Many of these problems, such as mate choice, involve strategic interactions where individuals alter the environment of other individuals in their own social network, putting this topic at the center of social psychology; and yet, despite the complexity of the interactions involved, simple decision heuristics can lead to good outcomes, contrary to common assumptions in social cognition research (e.g., Nisbett & Ross, 1980).

THE BIG PICTURE: ECOLOGICAL RATIONALITY

We will first consider the big picture within which this research fits, driven by the following big question: How can good decisions be made by real minds operating in an uncertain world? This is a mystery, because humans and other animals must make decisions within the rather severe bounds that our minds and the world impose on us. As mentioned earlier, these bounds include the limited time that we have to make decisions before an opportunity may be gone, the limited and uncertain information we can access within that time, and the limited ability we have to process that information, owing to constraints of memory, processing speed, and the amount of complexity we can deal with.

To work within these bounds and still behave adaptively, agents can rely on

simple "fast and frugal" heuristics (Gigerenzer & Goldstein, 1996; Gigerenzer, Todd, & the ABC Research Group, 1999)—decision rules that use a small amount of time, information, and processing to come up with what are usually good choices, when they are employed in the proper environments. This use in appropriate environments is key to the heuristics' successful application, because it allows them to exploit the fact that information in the world is typically structured in useful ways. For example, if you ask what authors, or places, or products are widely recognized in a given society, you will find systematic patterns relating recognition knowledge to the publication rate, or population size, or prevalence of those things, rather than a random or uniform distribution of what is recognized (Gigerenzer et al., 1999; Goldstein & Gigerenzer, 2002). This structure can then be capitalized on by simple heuristics that employ recognition as a cue in making choices, for instance what paper to cite or what brand to buy. In fact, by counting on certain information structures to be present in the environment, decision heuristics can be correspondingly simpler, effectively letting the world do some of the work for them.

Using simple heuristics in environments to which they fit can enable decision-making agents to achieve what Herbert Simon (1990) called *bounded rationality*. In contrast to the largely unachievable dream of unbounded rationality, which assumes optimal processing of all available information without concern for computational or informational costs, Simon saw humans as exhibiting a bounded form of rationality emerging from the interaction of two forces: the cognitive capabilities of the agent and the structure of the task environment. These two components should fit together like the two blades of a pair of scissors for adaptive, or boundedly rational, behavior to be produced—that is, mind and environment should be closely matched if decision outcomes are to be useful. This perspective aligns well with that of evolutionary psychology, which adds the assumption that the close mind–environment fit has been achieved by evolution honing the former to match the latter. This chapter in turn focuses on how minds shape their own environments, particularly in social domains, so that the adaptive forces flow in both directions between the organisms and their world.

Gigerenzer and colleagues (1999) have taken up the challenge of identifying the particular decision mechanisms that can produce bounded rationality in the presence of particular structures of information in the environment. They call this research program *ecological rationality*, to emphasize the importance of considering both environmental information structure and psychological information-processing mechanisms, and how the former enables and constrains the latter to yield adaptive decisions. Their strategy for studying the ecological rationality of particular decision mechanisms proceeds through a sequence of steps that largely follows the research plan for evolutionary psychology set out by Cosmides and Tooby (1987), including analysis of the environment, simulation of proposed heuristic mechanisms, mathematical analysis of the information structures in which they will and will not work well, and empirical investigation

of when people actually use these heuristics (see Todd, 2000, for more connections).

But so far the focus of this work has been on environments whose structure could be specified independently of the decision makers acting in it. This is a simple starting point, but often the world does not work this way, and does not oblige us with such independence or stability. In many real situations instead, the environment is shaped by the decisions of the agents acting in it. This was the case in the initial example of the parking situation—the pattern of occupied and free spots, that is, the structure of the environment, is created just through the action of the decision makers who have arrived before you. Imagine introducing a burr or bump onto the "agent" blade of Simon's scissors—over time it will carve a matching channel in the environment blade, shaping the environment to fit the agents' cognitive mechanisms more closely. And in turn the bump on the cognitive blade will be worn down by the counteracting force of the environment blade—so both the cognitive system and the environment can coadapt or coevolve to shape each other. (See Gangestad & Thornhill, chapter 3, this volume, for examples of coadaptation when the cognitive system belongs to a signal-perceiver and the environment comprises a target signal-producer.)

Examples of the coconstruction of decision mechanism and environment can be found in different classes of heuristics. For instance, repeated recognition-based decisions, such as when large numbers of scholars choose whom to cite in a paper or shoppers decide what music to buy based on what they recognize, can result in some things in the world, such as some authors or bands, becoming much more recognized, and chosen, than others (Todd & Heuvelink, 2006). The repeated application of the recognition heuristic can lead the world to become J-shaped in the sense of a power-law describing the rates of choices among options. This environment structure in turn can affect the efficacy of the recognition heuristic itself, making it more beneficial to use. Such strategic interactions have long been the province of game theory, but here we take a more psychologically-oriented approach to looking at the particular information-processing mechanisms that interacting individuals may adaptively use. We next turn to the case of sequential decision heuristics, focusing on the domain of mate choice, for a particular example of how decision mechanisms can change their environments, and how those changes can correspondingly influence which decision heuristics may function well in the newly-altered environments.

SEQUENTIAL DECISION MAKING IN MATE CHOICE

The task of mate choice can be broadly thought of as incorporating three steps: First, assessing the relevant cues of mate quality of an individual (see Gangestad & Thornhill, chapter 3, this volume, for several such cues), then processing those cues somehow into an overall judgment of the individual's mate quality, and finally using that judged quality in the process of searching through a sequence of

individuals to decide whom to court and whom to pass by. Decision heuristics involving limited cue processing can be used in the first and second steps; here we will assume that the outcome of these two steps is that all cues have been collapsed into a single criterion value of mate quality. What heuristics can be used to guide mate search through a sequence of potential mates with different mate quality values?

The mate choice domain for humans has a particular constellation of features, which can vary somewhat from culture to culture, not to mention from other species. But there are some typical basic underlying commonalities that are also found in other forms of sequential search (Schotter & Braunstein, 1981). In many search domains where there is competition for specific alternatives, such as searching for a mate, buying unique items like antiques or houses, or looking for a job or job candidate, once you have passed by an alternative and decided not to pick it, there may be no chance of changing your mind and returning to that alternative later, because someone else will have bought the house you rejected or married the person you spurned. Also in such situations, you probably will not know the range of possible alternatives ahead of time so that you have to learn about this distribution as you search.

To find out what kind of approach is appropriate for searching in such an environment, we begin with a problem of this form that has been well-studied in probability theory, where it is known as the secretary problem in the job search domain, or the dowry problem in the mate search domain (Ferguson, 1989). As the dowry problem, it goes like this: A sultan wishes to test the wisdom of his advisor, who is seeking a wife. The sultan arranges to have 100 women from the kingdom brought before the advisor in succession, and all the advisor has to do is to choose the woman with the highest dowry. If he chooses correctly, he gets to marry that woman and keep his job with the sultan. The advisor can see one woman at a time and ask her dowry; then he must decide immediately if he thinks she is the one with the highest dowry out of all 100 women, or else let her pass by and go on to the next woman. He cannot return to any of the women he has already seen—once he lets a woman go by, she becomes unavailable. Moreover, the advisor has no idea of the range of dowries before he starts his search. What strategy can he use to have the greatest chance of selecting the one woman with the highest dowry?

For such challenging search problems, Simon (1990) suggested the *satisficing* approach of setting an aspiration level somehow and then searching until an option is encountered that exceeds it. The optimal way to set an aspiration level in the dowry problem is to search through the sequence of options for some time without making any final choice, so that enough information can be gathered about the available values to make a good decision, but not so long that the highest value is passed by in this initial information-gathering stage. The length of initial search that optimizes this balance is to look at N/e of the available alternatives, where N is the number of alternatives and $e \approx 2.718$ is the base of the natural logarithm system, which comes out to 37% of the sequence of

alternatives (Ferguson, 1989). In other words, the optimal approach is to follow the 37% rule: In Phase 1 of search, look at 37% of the alternatives; then set the aspiration level to equal the highest value seen among all those alternatives; and then continue search in Phase 2 until an alternative is found that exceeds the aspiration level. Note that this type of strategy has minimal cognitive and information requirements: There is no need to remember a distribution or calculate statistics over multiple values; in fact, the searcher only needs to remember a single value as the aspiration level, and make a simple comparison between it and every currently-perceived value in succession. But this optimal rule, while it is the best possible under the circumstances, still does not do that well—the chance of picking the highest dowry is only about 1 in 3, which means there is a good chance that the sultan's advisor ends up single and jobless.

Luckily, real human mate choice is seldom like this, and instead our outcome criteria are usually a bit more lenient—rather than having to find the one best, a more reasonable version of this scenario would say the advisor just has to live with whatever choice he makes, and so he should aim to maximize the expected mean value of the dowry he stops at. To do this, he only needs to look at nine women, rather than 37, and set his aspiration level to the highest among those nine before stopping search at the next woman who exceeds that aspiration (Todd & Miller, 1999). If no other dowry exceeds that aspiration, then he settles with the last woman he encounters. This best performing rule can be seen in the top line in Figure 9.1, which shows the length of search in Phase 1 before setting the aspiration level, along the x axis, plotted against the mean dowry value
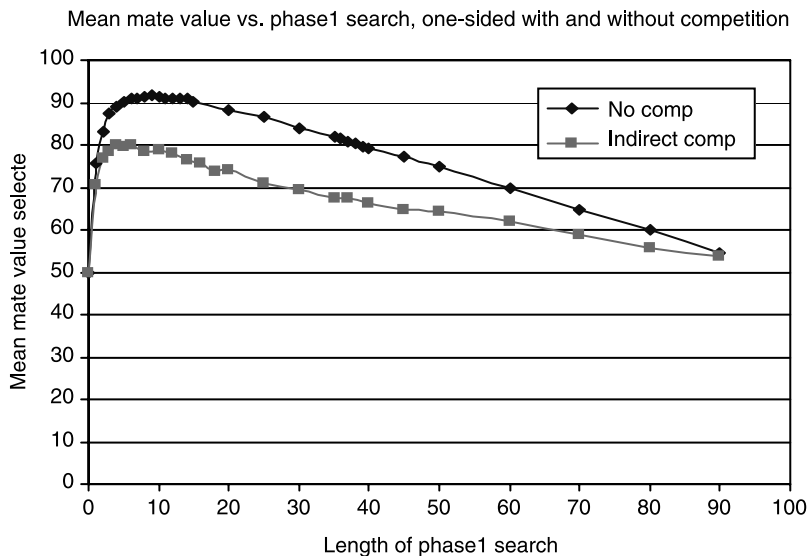

FIGURE 9.1 Performance in Terms of Mean Mate Value Selected (Out of 100) Versus Length of Phase 1 Search for Two One-sided Sequential Search Rules.

selected, assuming dowries from 1 to 100, along the y axis. The best performance reached yields a mean selected value of 92. Searching through less than nine initial samples does not give enough information to set quite as good an aspiration level, while going through more than nine candidates before turning to the second phase of search increases the chances of missing a high dowry in the initial phase.

So setting an aspiration level after seeing just nine options in this scenario is a strategy that is appropriate for a lone searcher to use, living in the adolescent male fantasy world of one man and 100 available partners. But of course, real life is seldom like this simple lone-searcher scenario—other people come along and mess things up. This leads back to our central question: What happens when the decisions of others (and oneself) affect the structure of the world? In particular, we can ask how the best strategy in this scenario changes when competition is introduced. Now, rather than one wise man advisor, imagine 100 wise women, each searching through the same set of 100 male candidates, trying to select the best one according to some criterion. If every woman was looking for exactly the same thing in a man, then the best any of them could do would be to take the first man they see, and hope they get lucky—so much direct competition creates a zero-sum game where the best average payoff comes from making a random (and fast, if there are time costs) selection. But in real mate choice, people's criteria differ to a greater or lesser extent. So to make things somewhat more realistic and easier for everyone, we can go to the opposite extreme and give all the women a different, independent and uncorrelated, criterion to search for. Thus wise woman 1 is looking for the man with the bluest eyes, wise woman 2 seeks the man with the longest ears, etc. Hence, while they are all competing for someone among the same pool of candidates, they are each looking for something different. In this situation of *indirect* competition, how should each woman search to maximize the criterion she alone seeks?

In the bottom line in Figure 9.1, we see that even indirect competition makes things more challenging for the individual searchers: To maximize the mean value that they select, they have to act more quickly than before when there was no competition, now checking out only three or four potential mates in Phase 1 search before setting their aspiration level. If any searcher takes longer than this, then someone else is more likely to take the candidate that she is most attracted to. And this competition also means that the searchers' overall performance falls—the highest mean value they can hope for is around 80, instead of around 92 before. Again, in actual mate search, there will certainly be some correlation among people's preferences, so a more realistic scenario would fall between this case and the full direct competition case where everyone has the same preferences. This indicates that an even shorter Phase 1 search would be called for.

Thus, as the search problem is made more complex by taking into account the decisions being made by others, the most appropriate strategy is to use a satisficing mechanism that sets its aspiration level after shorter amounts of initial

Phase 1 search—in fact, less than half as much search as is appropriate for a lone searcher. While the direction of this strategy change is not surprising, the magnitude was unexpected. But even greater, and qualitative, changes in strategy are called for when we take into account the other half of the decisions made in the mating domain that have been missing in this scenario.

STRATEGIES FOR MUTUAL MATE SEARCH

Those other decisions are being made not by our competitors, but by those individuals that we are searching through. In some evolutionarily-important search domains, the options that people are searching through have little choice themselves as to whether or not they will be chosen, such as in habitat choice or food-patch selection. The challenge in mate choice though is that few of us are sultans, able to line up a selection of potential mates and one-sidedly declare which one we will have. For most of us, mate choice is two-sided, and mate search is mutual, which means that searchers are being searched at the same time. The empirical manifestations of such a mutual process, as it operates in human mate choice at least, is that most people find a mate who is typically somewhat matched to them on attractiveness and other dimensions (Kalick & Hamilton, 1986) after a reasonably short search. What simple decision algorithms can create such outcomes given the decisions that everyone else is making, competitors and choosy potential mates alike?

To find out, we can turn to computer simulations, which allow us to test how different decision strategies would work when employed by a population of individuals searching for partners. Such simulation studies are useful for testing the implications of proposed psychological mechanisms and for generating testable predictions about the behaviors they would lead to, forming "runnable thought-experiments" that can bolster our understanding of possible social interactions (as in mutual mate search) that are beyond our intuitive abilities to predict. We set up a simulation similar to a classroom demonstration called the Pairing Game (Ellis & Kelley, 1999) in which two sets of individuals with numbers on their foreheads must wordlessly find their numeric match from the other set (see Fletcher & Overall, chapter 12, this volume, for more details on this game, and for further consideration of how individuals can find, or end up with, similar partners). In this model (Todd & Miller, 1999), we simulate 100 males and 100 females, each with some attractiveness value drawn from a uniform distribution from 0 to 100. As in the Pairing Game and in real life, individuals do not innately know their own attractiveness value, but they can see the values of all potential mates they encounter. Individuals meet in male–female pairs, assess each other, and decide somehow whether or not to make a proposal to each other. This meeting and assessing process happens in two phases. In the first "adolescent" phase, proposals and rejections do not result in actual pairing. But they can be used to set or adjust an aspiration level that will determine to

whom later proposal offers are made. In the following "adult" phase, the aspiration level set during the adolescent phase is fixed and used to make decisions during the rest of the search. These proposal and rejection decisions are now "real," in that mutual proposals result in a pair being made and that couple leaving the simulation. It is this necessity for mutual agreement that makes this scenario different from the one-sided case described above—the decisions of potential mates play a critical role here in determining one's mating fate, so one's decision strategy should take this into account. The degree of competition is also different from the one-sided search cases. Here, as before, everyone shares the same assessment of the attractiveness of others, which is an indication of direct competition. But because everyone is different in terms of their own attractiveness, and must find a mate who also wants them, everyone's goals are by definition different—so the level of competition here is somewhere between a direct and an indirect situation.

How well do different search strategies fare in this setting? A simple strategy that only uses half of the available information, ignoring the decisions made by potential mates, is the one-sided strategy discussed in the previous section, now applied in the mutual setting. In this case, each individual goes through the adolescent period and just sets his or her aspiration level at the highest mate value seen among the potential mates that he or she meets. What happens when this "ignorant" strategy is used in the mutual search case is that most everyone quickly ends up with very high aspiration levels, and thus only those with very high mate values will find willing mates—who must also have very high mate values. As a consequence, unrealistically very few pairs are formed using this strategy with anything other than an extremely short Phase 1 search. This is shown in the bottom line in Figure 9.2, plotting the mean number of pairs formed in the population against the adolescent learning period of Phase 1 search used by this ignorant strategy. These pairs *are* well-matched, in terms of having small within-pair differences in mate value, but that is because only the very high-valued individuals find mates. So ignoring the decisions made by others, and trying to get the best mate possible without regard for one's own attractiveness on the market, results in unrealistically poor outcomes for most searchers.

In contrast, if individuals magically knew their own mate value and used that as their aspiration level, then most of the population could quickly find a well-matched partner. But as mentioned earlier, the problem here is that individuals do not have built-in knowledge of their relative ranking in the current mate market, so if they wanted to use it in their decisions, they must infer it or learn it. A reasonable approach to this problem could be to use the assessments that others make about oneself as a cue about one's own mate value, which, after all, the others can see. So one could raise one's self-appraisal, and hence one's aspiration level, every time an offer is received and lower it after every rejection. This also fits with intuitions about how romantic successes and failures can induce self-esteem to go up and down, which in turn can affect how high or low people aim in their next romantic endeavors. (Another potential source of
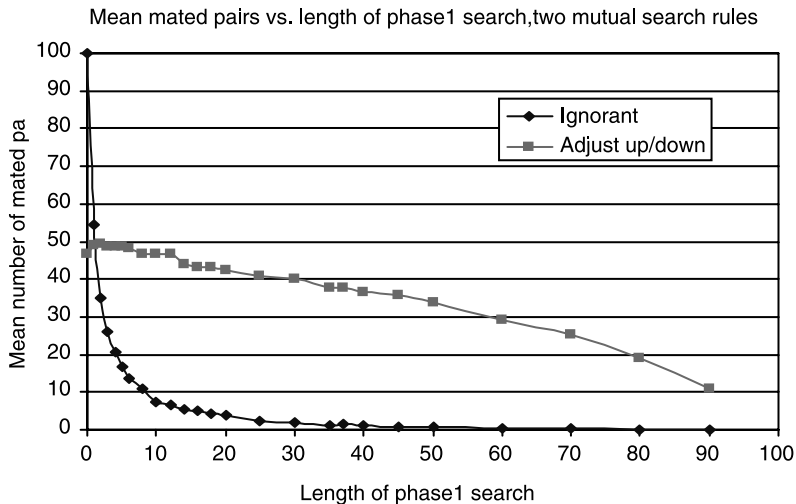
Mean mated pairs vs. length of phase1 search, two mutual search rules

FIGURE 9.2 Number of Mated Pairs Formed (Out of 100) Versus Length of Phase 1 Search for Two Different Mutual Search Rules

information which we do not include here is feedback from, and comparisons to, one's competitors.) To specify a decision mechanism in more detail, all individuals start with an initial aspiration level of 50, which corresponds to assuming oneself to be just average. Then, during the adolescent learning period, for every proposal from someone more attractive than one's current aspiration level, raise one's aspiration level to be partway to the other's attractiveness value. Any proposals from someone less attractive that one's aspiration level are somehow to be expected, and so will not have any effect. Just the reverse happens for rejections: For every rejection from someone below one's current aspiration level, lower the aspiration level toward the other's attractiveness. As each individual's aspiration level changes over the course of the adolescence period, they also influence the learning of everyone else's aspiration levels via the combined effect of the proposals and rejections made.

   With this simple rule, taking into account all of the decisions made by others, many more pairs are formed, at least if the adolescence period is not too long (top line, Figure 9.2). The within-pair attractiveness difference is also smaller for this rule than for the ignorant rule, meaning closer matches for the same amount of search. This simple rule's performance does not exactly meet the observed realities of human mate search, particularly because too few pairs are formed (e.g., here only around half of the population finds a mate). However, it goes in the right direction, and modifications of this type of mutual search rule can come much closer to human behavior (Simão & Todd, 2003).

   What forms of empirical evidence can we find to assess whether or not people are actually using such simple sequential search mechanisms when

looking for a mate? A variety of indirect evidence is at least consistent with these aspiration-adjustment mechanisms. For instance, individual self-esteem goes up and down with dating success or failure, and this could be the basis of an aspiration level for further search (Kenrick, Groth, Trost, & Sadalla, 1993; Kirkpatrick & Ellis, 2001). People searching for a match in an online dating setting want a small set of potential dates to look through (even though they may profess ahead of time that they want many options—Lenton, Fasolo, & Todd, 2005). In addition, the behavior of these proposed search mechanisms can be assessed against population-level outcome measures. For instance, demographers have long puzzled over a frequently-observed skewed-bell shape pattern in the distribution of ages at which people first get married (Coale, 1971). When we created an agent-based demographic model of a population of males and females looking for marriage partners by using the mutual sequential search heuristics described earlier, we found that the "ages" at which the individuals got married basically matched the observed demographic data (Todd, Billari, & Simão, 2005).

The most compelling evidence regarding mechanisms being used, though, would come from direct observation of the sequential mate search process as it transpires. The challenge is that this search typically takes an extended period of time, happening over months and years, which would require a detailed longitudinal study. What would be very handy is a way to watch the sequential mate search process that people go through, somehow distilled down into an easily-observable sped-up version of reality. Just such an opportunity is afforded by the phenomenon of speed dating: a commercially-sponsored occasion in which several men and women seeking dates sequentially meet and assess each other within the span of an evening. Researchers have begun using speed dating as a source of data about the mate choices that people make (Kurzban & Weeden, 2005), and we are using data from events conducted by the FastDating firm in Germany to explore the decision mechanisms involved. What happens at these events is that 20–25 men and an equal number of women gather in a large room one evening, and all the women sit down at separate tables. Each man then sits down across from a particular woman, and the pair get to talk for 5 minutes about whatever they want. At the end of this time, the organizer rings a bell and all the men and women circle a response on a card they are carrying to indicate whether or not they would like to interact further with this person they have been talking to. Then all the men stand up and shift to the next woman in line at the next table, and the process repeats. After everyone has talked to every member of the opposite sex in this way, the organizer compares everyone's cards to see which pairs expressed mutual interest in each other, and the members of those pairs are sent each other's contact information.

This speed dating setup is quite similar to sequential mate search situation we have been exploring, because everyone sees a succession of potential dates without knowing exactly who is coming later, and must decide after each 5-minute meeting whether or not they are interested in that person. However,

there are also a number of differences from the dowry-problem scenario (and, presumably, from much of real mate search): Here, the men and women gathering for the evening's event actually have some time before it starts to mill around and meet each other initially, and thus to get an idea of the range of potential dates that they will be talking to; and the decisions that are made after talking with someone can be erased and changed later in the evening after meeting more candidates. (Of course, the other major difference is that in the dowry problem, only a single choice can be made, while here, individuals can indicate interest in as many others as they wish, which will modify the search mechanism used somewhat.) To address some of these differences and create a scenario that is closer to the extended, low-knowledge situation in real mate search, we are developing our own new speed dating setup in which men and women will be kept isolated from each other until their appointed 5–minute meeting, and must make their decisions on the spot without the possibility of changing them later. We also hope to gather data throughout the evening about how each individual's aspiration level changes as a consequence of their experience and feedback in each minidate, to help identify what cognitive mechanisms are being used to decide on dating interest given the decisions of everyone else.

SUMMARY AND CONNECTIONS

To summarize the above results on how sequential mate search must be adjusted to take into account the decisions made by others, a solo searcher (who has no others to account for) looking to maximize his or her mean selected mate value should set an aspiration level to the highest value seen during an initial short trial period. When indirect competition is introduced, so that there are multiple searchers seeking different things among the same set of options, each searcher should adjust for the decisions being made by his or her competitors by making a quicker choice, shortening the length of the initial trial period. And when mutual choice is included, so that searchers must also be sought in order to succeed, searchers should adjust their aspiration level during adolescence toward the mate value of the successive potential mates they encounter, conditional on their current aspiration level and on getting a proposal or rejection. In this case, rather than just switching to a new behavior based on the fact that others are also making choices, individuals can actually use some of the decisions made by others to inform and adjust their own decision-making strategies.

The impact of other mutual mate searchers can be seen not only in the sequential search strategies individuals use, but also in their weighting and processing of the separate cues of the quality of potential mates they encounter (the first two steps of the mate choice task indicated earlier). Again, if a solo searcher had no competition to contend with, he or she could set an aspiration level for traits such as wealth and status, physical attractiveness, and degree of parental investment as high as desired. But in mutual mate choice, one's aspirations must

be tempered by what one has to offer in return—someone with a portfolio of only low trait values who nonetheless demands high values in a mate will end up disappointed and alone. Buston and Emlen (2003) found evidence for exactly this sort of self-sensitive aspiration setting, in that individuals who had higher overall self-appraisals (created by summing their self-reported levels on 10 traits of mate quality) had choosier preferences for mates (again found by summing the preferred values of the same 10 traits). There is currently some disagreement as to how the trait values of self and other are ultimately processed to yield an overall judgment of attractiveness—whether individuals seek mates with the same trait levels as themselves, as indicated by Buston and Emlen's questionnaire data, or seek mates with complementary values such as male status against female attractiveness, as indicated by evolutionary theory (Buss, 1989) and data from actual choices made in the speed-dating context described earlier (Todd, Penke, Fasolo, & Lenton, 2005; see also Fletcher & Overall, chapter 12, this volume, on what traits people use and how). But in either case, to be successful individuals must adjust their mate choice strategies to fit with how others are choosing.

Finally, what of parking? After all, once one has found a mate, and a job, and a place to live, finding a good parking place may be one of the most challenging sequential—and social—choice problems left to tackle. Do any of the search strategies we may have evolved for use in other domains find application in this modern task? Parking is not so much like mutual mate search, in that parking spaces cannot veto our decisions and tell us we cannot park there. But parking search *is* similar to the one-sided search situation we described earlier. Imagine a long road leading to a destination, with cars parked along one side of it, so that as we drive toward the destination we encounter a sequence of possible parking spaces. As in other forms of sequential search, we do not know what opportunities lie ahead, and, while we can turn around a go back to a spot we passed before, we cannot be certain that it will still be available. One unique aspect here is that the parking spaces we encounter keep getting better in quality over time as we drive toward the destination, which is not usually the case for other forms of search (though it might be, if the search can be focused on more productive options over time).

So now what sorts of rules might be appropriate for the parking search problem, able to find spaces close to the destination preferably without turning around? Our discussion earlier of one-sided search suggests the satisficing approach: Set an aspiration level, and take the next better option encountered after that. In this case, that means passing by some fixed number of parking spots, whether they are empty or occupied, and then taking the first available space we come to thereafter. This type of fixed-distance rule is in fact the optimal approach for an infinite parking lane filled with a constant density of spaces (MacQueen & Miller, 1960). But our interest here is in what strategies work well when the pattern of spaces is not necessarily constant, but rather is created by the decisions of other drivers parking. To find out, we put evolution to work,

allowing a variety of parking-search strategies to compete and evolve over time in a simulated version of the single-lane world described above (Hutchinson, Fanselow, & Todd, 2005). We used different types of distance-based strategies (such as the fixed-distance satisficing rule) along with density-based ones (such as rules that take the next available parking space as soon as enough of the last few spots passed have been occupied). Those strategies that found closer parking places on one day's worth of parking were used more often in the population of drivers on the next parking day, and slight mutations were introduced into the evolutionary process to allow the full space of strategies to be explored.

After just a few generations of evolving parking strategies, only two rules emerge as the winners in a mixed equilibrium: the fixed-distance heuristic, used by about 80% of the population, and a density-based linear-operator heuristic, used by the rest. Thus, while it is best for everyone to use the same fixed-distance heuristic if they are all in a static environment that they cannot affect, this is not the best option when the environment is created by the drivers themselves—in that case, some individuals do better by using a density-based mechanism, which can take advantage of the environment structure created by the fixed-distance users. Whether or not such a mixed strategy is used by real drivers, and whether it is also appropriate in other domains such as mate search, remains to be explored.

Many other questions about the decision mechanisms that are best suited to environments they themselves shape are also open for exploration. In addition to developing models of such mind–environment coadaptation in other domains and looking for evidence of the process in operation, the most important questions center on whether we can develop a theory of the principles underlying such coadaptation that will allow us to predict when it will occur and what form it will take in different domains. Doing so will require a three-way focus: on the constraints and structure of the information-processing mechanisms that individuals bring to bear on the environmental challenges they face, on the constraints and structure that the environment imposes on the information available to individuals, and the on way these two sets of constraints interact with and shape each other over time.

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