MATE CHOICE PATTERNS IN SOCIAL AND NON-SOCIAL DECISION-MAKING DOMAINS

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Humans are a fundamentally social species, and an individual may have social ties of many flavors. One social domain, mate or romantic partner choice, has been thoroughly examined, but others remain relatively understudied. How do our choice patterns vary between different social domains? In this work, I argue that although choice constraints vary between social domains (e.g. a collaborator, spouse, friend, mentor, or dodgeball teammate), the fundamental patterns of choice are ultimately similar. In this dissertation, I present studies of three different choice areas.

First, I compare the search for non-social resources such as food (i.e. Optimal Foraging Theory; OFT) with that for a romantic partner to produce a theory-driven framework for mate choice as a foraging problem. Mate foragers demonstrated sensitivity to search costs as predicted by OFT, where those searching longest for their first marriage (but not cohabitations) had a decreased risk of relationship dissolution. However, periods of relationships and search also covaried in ways unexpected by OFT.

Next, I tested for the presence of two common patterns in romantic partner choice: positive assortment (e.g. homophily) and the stated-revealed preference gap (inconsistency between one's stated preferences and the actual traits of a chosen partner). I demonstrated these patterns in two social domains: academic collaborator choice and companion animal choice.

I tested whether homophily was the best predictor of academic collaborations forming. I held three academic speed-networking events, a modified form of speed-dating. Pairs were assigned experimentally based on the similarity of academics' current research and complementarity of desired vs current knowledge. These manipulations did not significantly impact collaboration rates; rather, *believing* a partner's research was similar was predictive of collaboration, suggesting homophily has a nuanced role in collaboration formation.

I then examined dog choice in animal shelters. Comparing the traits of a newly adopted dog to the stated preferences of their adopter, adopters perceived their dog to fulfill their stated preferences at above-chance rates. These adopter-dog pairs also exhibited weak positive assortment of personality. I summarize the implications of exapting choice mechanisms which are appropriate for one adaptive domain to novel social domains with different choice constraints.

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Introduction

If Hollywood is any indication, the most important decision in life is choosing one's

romantic partner. Surprisingly, the scientific literature of social choice exhibits the same narrow

focus on mates. This abundance of research has provided a rich theoretical background for

understanding our social world but ignores the plethora of interaction outside the bounds of

romantic love. We are constantly exposed to many potential social partners: friends, business

partners, collaborators, ultimate frisbee teammates, and so on. How do choice strategies occur in

these other social domains? Are these patterns unique to social choice problems?

In this dissertation, I test the hypothesis that humans exhibit similar patterns of choice

best known in mate choice in several types of social partner choice, in addition to within non-

social search problems. I begin by providing a brief description of the patterns of interest in

romantic partners and a portion of the existing evidence that these patterns generalize to several

types of social partners.

1.1   Patterns of Interest in Romantic Partners

In general, choice problems involve picking from several options (the choice set) which

vary on several dimensions or traits. *Social choices*—that is, the choice of a social partner, rather

than choices made socially—are unique in the choice domain, because of the complexity of the

stimulus (consider the choice of peanut butter at the grocery store and the choice of a life

partner) and the consequences of the decision (e.g. divorce). Unlike non-social choice, typically

both potential partners must choose one another (*bi-directionality*), resulting in competition,

especially when only one such social partner can be had at a time (*exclusivity*), and this may

produce or amplify patterns at a population level absent in non-social searches (e.g. gambles or

consumer choice), such as self-perceptions of one's quality as a partner influencing choice behavior.

Of the social domains, romantic partner choice (also referred to in this work as mate choice) has been studied the most extensively across species and the human life course, providing a large breadth of theory that can be used as a starting foundation for studying newer or lesser-studied types of social choice. I focus on two patterns studied over several relationship phases: assortative mating and the stated-revealed preference gap.

1.1.1 Assortative Mating and Homophily

> *"If you would marry suitably, marry your equal."*
>
> –Ovid

One of the most consistently described patterns in mate choice is that romantic pairs generally show remarkable similarities in their trait levels (e.g. Vandenberg, 1972). This process is exhibited by numerous species beyond humans (Crespi, 1989). The non-random coupling based on one or more characteristics is known as *assortative mating*.

Assortative mating describes several patterns based on some aspect of similarity, including the amount of overlap on the same trait (*character-specific assortment*) or similar levels on different traits valued equally (*cross-character assortment*). Assortment can be positive (i.e. common overlap on a trait, e.g. birds of a feather flock together) or negative (i.e. varied levels of a trait, e.g. opposites attract). Marriage to a similar partner is known as *homogamy*, while attraction to and relationship formation with similar others is known as *homophily*. In this dissertation, I use assortment to describe the pattern of similarity between existing social partners and homophily to refer to a preference or strategy to approach or interact with similar others.

Positive assortative mating in spouses, engaged couples, and long-term romantic relationships has been shown on a number of traits, including the highly valued (e.g. physical attractiveness, kindness) and the less critical (e.g. ear lobe length), and ranging from demographic (e.g. age, socioeconomic status, religion, ethnic background) to behavioral factors (e.g. personality, intelligence, desire for children; see Vandenberg, 1972; Buss & Barnes, 1986; Watson et al., 2004). Other traits exhibit a specific type of cross-character assortment, "potentials attract" (Buston & Emlen, 2003), such that individuals "exchange" matching relative levels on different traits which are valued equally by one's potential dating pool (Todd, Penke, Fasolo, & Lenton, 2007, in contrast to Buston & Emlen's (2003) finding).

The extent of assortative mating in existing pairs is impacted by initiating, maintaining, and ending romantic relationships. The greatest influence on the resemblance of partners comes from initial similarity (*selection*): humans tend to select partners who resemble them at the time of choice (McPherson, Smith-Lovin, & Cook, 2001). This may be the product of homophily: both attraction towards potential social partners and a stronger aversion to dissimilar individuals (e.g. Singh, Teoh, & Boon, 1999). In online dating, similarity on idiosyncratically valued traits is predictive of messaging behavior, suggesting a specific search for similar individuals (Hitsch, Hortaçsu, & Ariely, 2010; Fiore & Donath, 2005; Shaw Taylor, Fiore, Mendelsohn, & Chesire, 2011).

Of course, while some individuals may actively exhibit homophily initially, positive assortment can also be the end-product of a non-homophilic strategy (Burley, 1983). That is, individuals may not be actively seeking a similar partner, even if their preferences imply it, and this strategy can still produce positive assortment as a byproduct of who reciprocates their interest. This is especially true for traits where a particular value is universally preferred. For

example, if all individuals seek out the most attractive partner, setting a minimum standard of their own attractiveness, non-reciprocity of interest by potential partners who are more attractive will result in positive assortment in the final pairs (Kalick & Hamilton, 1986). In online dating, messaging often exhibits a pattern of "aspirational mating" on vertically preferred traits (that is, traits where the highest value is the most preferred as opposed to a similar value, e.g. physical attractiveness), where the most attractive individuals are messaged regardless of one's personal value, but the average similarity of attractiveness increases in potential pairs as messaging continues (Hitsch et al., 2010; Kreager, Cavanagh, Yen, & Yu, 2014).

Once a partnership has formed, similarity can also change through *convergence* as well as divergence, where individuals' non-fixed characteristics change over the course of the relationship (e.g. switching religions). Several studies have found minimal effects of convergence over time in married couples, controlling for both the length of marriage and courtship (Watson et al., 2004; Eyseneck & Wakefield, 1981, but see also Davis & Rusbult, 2001 for a contrary finding in dating couples). Assortment amongst ties can also grow by ending relationships with dissimilar others (*deselection*), which may be mediated by dyadic factors such as relationship satisfaction (Eysenck & Wakefield, 1981; Le, Dove, Agnew, Korn, & Mutso, 2010; Richard, Wakefield, & Lewak, 1990, but see also Watson et al., 2004).

Individuals may be surrounded by similar others not just by active desire for a similar partner (choice homophily) but also because most of the available partners are similar (induced homophily; Kossinets & Watts, 2009; McPherson & Ranger-Moore, 1991; McPherson et al., 2001). In a world where humans are distributed randomly, as humans form relationships with similar others through even a weak preference, the network structure slowly changes. The average similarity of individuals' nearby potential partners (in terms of network distance) will

increase. Family members (who share numerous genetic traits, values, and experiences) strengthen induced homophily because they generally reside in the same household initially and then do not marry far from their birthplace (Spuhler & Clark, 1961). Neighborhoods are also more homogenous that expected as a result of both constraints such as similar housing prices as well as choice homophily (Schelling, 1971). Heightened proximity to these similar others also increases the likelihood of attraction (e.g. Segal, 1974), meaning induced and choice homophily interact and strengthen homophily as a whole (Kossinets & Watts, 2009; McPherson & Ranger-Moore, 1991), kept in check by weak ties between non-homogenous areas of a social network (Granovetter, 1983; Kossinets & Watts, 2009). This interaction effect means that when attempting to isolate the effects of active choice producing homophily, researchers must take into account the relative levels of trait variation within the sample compared to a population as a whole.

1.1.1.1   Benefits of Assortment

Given how widespread positive assortment is across the animal kingdom, the pattern is assumed to be beneficial, whether one takes a relationship (individual and dyadic) or evolutionary viewpoint. At the individual level, there appears to be evidence for this claim. Sharing traits with another reinforces the legitimacy of one's values and traits, improving self-esteem and possibly feelings of social acceptance; similar others may also be easier to evaluate as a partner and their behavior easier to predict using one's own experiences (Huston & Levinger, 1978; Kossinets & Watts, 2009). At a dyadic level, shared experiences ease initial bonding as well as tie maintenance through shared social experiences, interactions, and tasks (e.g. Dainton & Stafford, 1993; McPherson et al., 2001). These outcomes can both prevent deselection and lead to opportunities for partner convergence.

Taking an evolutionary perspective, though it is often proposed, there is no clear consensus that positive assortment increases individual reproductive success in terms of "genetic compatibility" (Tregenza & Wedell, 2000), although perhaps it can increase the fitness of one's offspring by passing on traits that will attract high-quality mates for their children (e.g. sexy sons). At an ultimate level, assortative mating could be beneficial for promoting greater genetic homozygosity in family members up to a level that avoids inbreeding depression, thereby increasing inclusive fitness (Thiessen & Gregg, 1980). To review the entirety of the biological literature on assortment is beyond the scope of this dissertation, but both positive and negative assortment in mating pairs manifest under a vast number of environmental conditions (see review in Burley, 1983; Jiang, Bolnick, & Kirkpatrick, 2013).

Outside of the mating domain, homophily could be a mechanism to promote kin selection. Kin selection proposes that since relatives share a portion of one's genetic code, it is adaptive to contribute to their fitness—an original explanation for how altruism was stabilized in populations. Others who look and act similar may also share genetic traits, and it could be beneficial to form supportive relationships with them in terms of inclusive fitness. However, this perspective (genetic similarity theory, Rushton, Russel, & Wells, 1984; or extended inclusive fitness theory, Jaffe, 2016) is flawed in several respects. Whether individuals demonstrate stronger or weaker positive assortment on more heritable traits is debatable (e.g. Thiessen & Gregg, 1980; Rushton & Bons, 2005). Genetic similarity is also not necessary for homophily to impact fitness: repeated interacting with others of similar strategies or cooperative values is enough to stabilize mutually-beneficial behaviors such as repeated cooperation or altruism (Axelrod & Hamilton, 1981; Bowles & Gintis, 2011; Robinson et al., 2017; Trivers, 1971), which would be directly advantageous to individuals drawn to similar others. Finally, these

theories cannot explain why social partners with far lower genetic similarity are sometimes preferred. In non-human companion animals, for example, which always have a lower genetic relatedness to a human than would a fellow human social partner, some individuals will develop stronger attachment or closeness to their pet than their own kin (Barker & Barker, 1988) or would save a family pet over a fellow human (Cohen, 2002).

Positive assortment is not always beneficial to relationships. Similarity to others also engenders social comparison, which can result in feelings of inadequacy, lack of unique identity, competition, and negative self-evaluation, particularly if the traits shared are not viewed positively (e.g. Brewer, 1991; Schimiel, Pyszczynski, Greenberg, O'Mahen, & Arndt, 2000). Taking on a heterogenous member to a group can also increase the group's performance through the introduction of new skills and specialized labor (Hong & Page, 1998; Lambert, 2016), emphasizing the necessity to consider the unique constraints of different social relationships when assessing the generalizability of positive assortment.

1.1.2 The Stated-Revealed Preference Gap

"Saying and doing are two very different things."

–Folk saying

When individuals are asked to describe their preferences for a social partner explicitly to researchers (for similarity or other patterns), the resulting data are referred to as *stated preferences*. However, it is unclear whether individuals actually incorporate these statements into their search, as shown by the qualities of the social partner they choose in experiments or real-world environments, which are referred to as *revealed preferences*. Neither stated nor revealed preferences are necessarily the true (*normative*) preferences of an individual—for example,

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individuals may be unable or unwilling to accurately articulate their preferences to an experimenter (e.g. Nisbett & Wilson, 1977), and competition with others and other real world constraints could lead to the option one prefers being unavailable (Beshears, Choi, Laibson, & Madrian, 2008). The size of the discrepancy between the stated preferences of an individual and the qualities of the partner they desire is known as the *stated-revealed preference gap*.

This particular phenomenon is actually best studied in economics, a (generally) non-social choice domain. Consumer choice researchers often use stated, revealed, or combined models of preferences to examine the choice of non-social resources (e.g. Murphy, Allen, Stevens, & Weaterhead, 2005; Levitt & List, 2007). Within economics, the near-synonymous term for the stated-revealed preference gap is hypothetical bias, a tendency to overstate willingness to pay a particular price for an item in a hypothetical scenario compared to when given the chance to actually buy it (a review of hypothetical bias in economics is outside the scope of this dissertation; see Murphy et al., 2005). How might hypothetical bias apply to mate choice?

When considering romantic partners, willingness-to-pay is similar to how one values a mate relative to others, meaning a stated-revealed preference gap would incorrectly predict which mate will be chosen under rational choice. This has generally not been the focus of study in economics—rather, work has focused on how the *same* product is valued differently in a survey compared to a consumer setting, rather than how a *set* of options is relatively valued. That these patterns occur in purely consumer domains with no social component or competition suggests that the stated-revealed preference gap may be more dependent on choice constraints or environment, rather than on evolutionary relevance.

In social partner choice, the stated-revealed preference gap is seen, for instance, in dating events where individuals report romantic preferences beforehand that do not match the traits of the partners in whom they express interest (e.g. Todd et al., 2007). Like assortative mating, the cause of the gap is unclear: are individuals attracted to those who fulfill their preferences but cannot or do not form relationships with them, or are stated preferences generated through a process that does not reflect normative preferences at all? This pattern draws into question how stated preferences are incorporated into choice behavior.

To study how stated preferences are used in decision-making, researchers must overcome several methodological concerns. First, stated preferences need to be measured prior to decision-making, to ensure that preferences do not shift over time or through exposure to the stimulus; for example, individuals in a satisfying relationship may shift their preferences towards the level of attributes of their current partner, although those are not the criteria held when the partner was chosen. The second issue deals with the stimulus itself—that is, the potential romantic partners. Human interaction is rich in information, meaning photos, trait ratings on paper, or even videos are impoverished stimuli for social choice compared to a face-to-face context. Even in naturalistic dating contexts, given the variability of information availability between say, face-to-face dating and online dating, the presence of the stated-revealed preference gap preference can vary (Eastwick, Finkel, & Eagly, 2011). Finally, there is the difficulty of constructing a choice set. There are few naturalistic contexts in which individuals are encountering multiple romantic partners at once who can be compared on their characteristics (recent advances in online dating notwithstanding). Even if one is in a position to consider multiple partners, the long length of relationship formation makes it difficult for scientists to examine the entire mate choice process in the lab. One notable exception is Campbell and colleagues (2016), who in a well-controlled

study found that the traits of an obtained partner match preferences stated prior to relationship formation. However, Campbell et al.'s result does not indicate what mate options were available or pursued; participants may not have intentionally sought out partners consistent with their preferences, but simply ended up with one. Overall, it is difficult to capture all factors relevant to the stated-revealed preference gap in typical lab settings.

The solution to this problem has been speed-dating, where participants are introduced to many partners in brief interactions. If a participant meets a partner they would like to pursue further contact with, they make an offer; if both individuals mutually make offers, their contact information is exchanged. A follow-up can see which partners were actively pursued. Speed-dating events contain real in-person daters with real potential to form relationships, overcoming issues of task artificiality and the poverty of the stimulus. A natural choice set is created with individuals varying in numerous qualities, and the entire initial interaction for numerous couples can be captured in a short time period. By asking participants to state what they desire in a mate (stated preferences) and by measuring the characteristics of the individuals to whom offers are made (revealed preferences), scientists can examine whether individuals' decision-making strategies are consistent with maximizing the match of a partner to one's stated preferences.

The discrepancies between stated and revealed preferences varies across speed-dating events. Some have found correspondence (Li et al., 2013), but others have not (Fletcher, Kerr, Li, & Valentine, 2014; Eastwick & Finkel, 2008; Todd et al., 2007). Several explanations have been provided for the inconsistency of this pattern. Perhaps the discrepancy is unique to the face-to-face speed-dating choice environment: Li et al. (2013) found a consistent relationship between preferences and romantic interest in both online chat and speed-dating partners, but Eastwick et al. (2011) found the gap in individuals meeting face-to-face but not when viewing

dating profiles. Another potential cause is sample variability: if participants are relatively homogenous (both due to sampling errors but also due to induced homophily in geographic areas), the minimal variance will limit the influence of that predictor on choice, since most of one's options are very similar. Li et al. (2013) found that when college samples are augmented to include individuals low on valued traits (status and attractiveness), the sexes choose mates according to their general stated preferences (which varied between the sexes). However, Todd et al.'s (2007) real-world sample did exhibit a stated-revealed preference gap.

Beyond experimental processes, the stated-revealed preference gap has been proposed to be a result of both individual cognitive processes as well as the competitive nature of mate choice. Individuals may have difficulty articulating their decision-making criteria or do not understand how certain stimuli, mental states (e.g. arousal), or environments may impact their responses (Ariely & Loewenstein, 2006; Nisbett & Wilson, 1977; see Todd et al., 2007). As individuals assumedly have far fewer romantic relationships than, for example, friendships in a lifetime, individuals may still be learning which traits in a mate produce satisfaction. The preferences of these individuals could change based on additional experience gained over the course of, say, a speed-dating experiment. Alternatively, daters may be purposely misrepresenting their preferences if it could result in negative social evaluation (i.e. social desirability effects, e.g. valuing attractiveness over a good personality).

Perhaps individuals do know, truthfully state, and use their normative preferences but are considering how to allocate their mating efforts for maximum success. Exclusive mate choice is typically bi-directional, meaning a relationship forms only if both partners express interest. If a partner has traits which are universally desirable, there will be more intense competition for that mate (on traits where similarity is desired, this competition is partially relaxed, as the preferred-

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trait level is idiosyncratic). If a highly suitable mate is unlikely to respond positively to one's advances, the effort (in terms of time, money, or emotional pain of rejection) may be better spent on a less ideal, but more receptive, partner. When competition is absent and rejection risks are reduced, individuals express greater interest in the most attractive partners (Shanteau & Nagy, 1979; Greitemeyer, 2010).

Overall, these inconsistent findings suggest that the relationship between stated preferences and revealed preferences is far from direct. Its presence may be dependent on setting and population, or the result of differences in how individuals state their preferences, what their normative preferences are, and how those normative preferences interact with a dynamic choice environment. Given these discrepancies, rather than relying solely on evidence from romantic choice, further study in other social domains may provide additional evidence towards unravelling how, more broadly, stated preferences relate to revealed preferences. If such patterns do manifest across several social domains with varying choice constraints (e.g. competition, exclusivity, sexual compatibility), researchers can eliminate potential causes of the stated-revealed preference gap. Since the existing literature tends to focus on stated preferences and stated interest in romantic relationships, it could be important to look for similar findings in other social domains—for example, interest in collaborating with a speed-networking partner (Muurlink & Matas, 2011) or perceived adoptability of a dog (Wright, Smith, Daniel, & Adkins, 2007). If the stated-revealed preference gap fails to manifest elsewhere, this would not only undermine the central hypothesis of this dissertation, but also warrant caution in general for using the existing rich literature of mate choice to generate hypotheses for other, less studied social domains.

1.2   Should We Expect These Patterns to Generalize to Other Social Domains?

It is unclear whether positive assortment and the stated-revealed preference gap will manifest in other social domains. There are many patterns of preference that appear in several social contexts, including proximity, reciprocity, likeness-begets-liking, and mere-exposure effects, as well as a preference for interacting with physically attractive individuals. Because romantic partner choice has both evolutionary relevance as well as important individual impacts over the life course, specific strategies may have arisen through selection, learning, or other means (although the evidence that these strategies are ideal for mate choice is far from conclusive—Frey & Eichenberger, 1996). In contrast, some types of social partner are relatively new within human history (meaning they cannot have extensive selection upon them) or lack important consequences (e.g. reproduction); in others, individuals simply lack experience with them (e.g. graduate students choosing collaborators). In these cases, individuals could generalize strategies from other social domains where they have greater experience (e.g. friends, romantic partners) and apply them. However, because the role and choice constraints of different social domains differ, the efficacy of these strategies may vary between social domains.

In the next sections, I describe some key differences between romantic and non-romantic social domains, as well as a sample of the evidence for the stated-revealed preference gap and assortment in areas beyond mate choice.

1.2.1   What Differentiates Romantic and Non-Romantic Social Domains from Each Other?

As noted above, social choice varies from non-social choice problems, but there are also several key differences between romantic relationships and other social ties which could influence whether particular patterns of choice appear. There is no agreed-upon system or

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dimensions for differentiating relationships (Määttä & Uusiautti, 2013), although clearly there are a number of dimensions that vary, such as the balance of power (e.g. employer-employee), expected norms for behavior, the intended longevity of the relationship, and the level of intimacy and inclusion of the other in one's self-concept.

Interdependence theory provides a useful architecture for these disparate dimensions, focusing on what one gives and receives from a relationship partner (Thibaut & Kelley, 1959). Social ties differ in the number and strength of interdependencies between its members, including intrinsic (e.g. personal support), sexual, extrinsic (e.g. monetary support), and formal (e.g. legal marriage) bonds (Marsiglio & Scanzoni, 1995; see also Sprecher & Regan, 2002). Interdependencies are not exclusive; in fact, romantic relationships typically involve all of the aforementioned bonds. Each interdependency comes with particular benefits and consequences (for example, boss and employee ties subject individuals to explicit rules, regulations, and protections) and vary in the difficultly and consequences to resolve them (e.g. a divorce vs. not renewing a lease). Stronger interdependencies are time- and/or resource-intensive and can limit the number of relationships one can maintain of this magnitude (e.g. a best friend, a single spouse). Individuals are likely to be more choosy in selecting a partner that must fulfill multiple and/or higher-intensity roles.

Social partners also vary in genetic relatedness. Romantic and sexual partners can produce offspring; kin also share our genetics, but are not chosen by us, but rather by other kin. Because of the fitness benefits incurred by choosing a good mate for producing offspring or recognizing and assisting kin, patterns of choice in these domains may vary from other social partners which may benefit our own fitness (e.g. dogs for hunting partners) but are not closely genetically related.

Another critical difference between social ties is exclusivity: how many partners of a particular type someone can (or is expected to) maintain. Romantic partners are relatively singular in their (general) monogamy, such that individuals can befriend numerous co-workers, roommates, or dodgeball teammates, but typically only have one spouse. In order to form new monogamous relationships, there are usually clear demarcations when a relationship begins and ends (formally or otherwise). These social announcements are essential for others searching for their own monogamous bonds to know who is and is not available as a partner. In contrast, the start of a friendship, a non-exclusive role, is more subtle, with many relationships ending as a result of a lack of propinquity rather than active deselection: leaving a workplace or promotions for co-workers, the end of a dodgeball season for teammates, the move to a new university for academics. Clear markers make it easier to study the formation and dissolution of romantic partnerships than other relationships—at least for traditional methods. However, the digital age has found new methods for studying the selection, maintenance, and deselection of other relationships (e.g. longitudinal email correspondence between students at universities, Kossinets & Watts, 2009; academic publication data and collaboration relationships, Cabanac, Hubert, & Milard, 2015; Wang, Yu, Bekele, Kong, & Xia, 2017).

Overall, the large number of interdependencies between members, the exclusivity of the relationship, the evolutionary significance, and the ease of demarcation between partners have made romantic relationships ideal for the study of relationship formation and dissolution. However, it is now not only easier to examine other relationship types, but essential in order to see which qualities of a relationship influence social choice strategies.

1.2.2 Should the Stated-Revealed Preference Gap Appear Outside Romantic Domains?

Whether the stated-revealed preference gap manifests across domains depends on its initial cause in romantic partners, which remains unresolved. If individuals are unaware of or unable to articulate their true normative preferences or real world constraints prevent those preferences from being fulfilled, it seems likely gaps would appear broadly across choices as a whole. Alternatively, if the gap is due to a shift in preferences due to sexual arousal, the stated-revealed preference gap would appear only in the search for sexual/potentially sexual relationships or towards relationship partners that otherwise elicit arousal. If the gap is instead due to demand effects, it should manifest in domains where stigmas exist for holding certain preference levels; for example, when acquiring a companion animal, stigma might be placed on buying a dog versus adopting it, so an individual may state a preference for adopting but reveal their preference by purchasing a dog in a store. Finally, if the cause of the gap is due to the unique nature or constraints of romantic relationships, the gap may appear in domains with shared qualities (e.g. high levels of intrinsic support in both romantic partners and platonic friendships).

Within a social context, an alternative way to study the stated-revealed preference gap is to measure the *real-ideal* gap, the difference between the qualities of one's *existing* partners and ideal preferences (in contrast to whether individuals *choose new partners* consistent with their stated preferences). The ideal-real approach is used within romantic domains as well (e.g. Ruvolo & Veroff, 1997; Eastwick, Luchies, Finkel, & Hunt, 2014). Work on the real-ideal gap is similar, but not identical, to research on the stated-revealed preference gap. Ideal preferences are made under the assumption of unidirectionality: the traits of a perfect partner if you could freely choose anyone. This removes one potential cause of the stated-revealed preference gap, but does

not allow direct comparison to stated preferences, as the directions for stating preferences vary by experiment, in terms of describing an acceptable partner or an ideal partner. Ideal preferences are also usually measured at the same time as the assessment of one's partner, meaning unlike speed-dating studies, it is unclear whether individuals are exhibiting a discrepancy by circumstance (i.e. lack of suitable partners), choice (i.e. actively choosing partners inconsistent with stated preferences), or convergence.

Compared to romantic partners, individuals have lower ideal standards for friends on identical constructs (e.g. social status, interpersonal and personality factors; Sprecher & Regan, 2002). Most friendship studies focus on traits that are universally preferred (e.g. Mendelson & Aboud, 1999) rather than idiosyncratic, which could artificially deflate the predictive power of these variables on revealed preferences in comparison to mate choice. There are some discrepancies between males and females' ideal preferences for friends, as in romantic partner choices, although effect sizes are relatively small (Hall, 2011; Demir & Orthel, 2011; Vigil, 2007). In general, larger discrepancies between ideal and real characteristics leads to lower satisfaction in non-romantic relationships (Demir & Orthel, 2011), as in romantic relationships (e.g. Ruvolo & Veroff, 1997).

Work on the ideal-real gap in non-mating social domains provides a theoretical foundation that in these areas, individuals also have preferences for social partners which vary between individuals and influence relationship outcomes -- but these studies do not eliminate the need for direct study of the stated-revealed preference gap in these domains. In particular, to examine the cause of the stated-revealed preference gap beyond romantic domains, a similar paradigm must be applied, where preferences are measured prior to choice, and the qualities of the chosen partner are compared to other potential choices.

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1.2.3 Should Assortment Appear Outside Romantic Domains?

As noted above, positive assortment is assumed to be beneficial in the mating arena, but it is unclear whether these benefits are conferred across all social domains and situations. If individuals can change their search strategies and receive feedback on their success, assortative and homophilic strategies should be avoided in domains where individuals have experience and do not incur benefits from positive assortment. For example, when building a team, differently specialized labor can benefit team performance: e.g. homogenous research teams may not benefit from bringing in an additional specialist in the same content area, in contrast to a colleague with a new perspective or skillset (Luo & Deng, 2009).

If positive assortment is not driven by a homophilic strategy, but rather the result of aspirational competition for limited partners of varying quality (Kalick & Hamilton, 1982), positive assortment should also occur when some partner qualities are universally desired. Most individuals have limited time and resources to invest in a particular close relationship type and can only maintain a limited number of such relationships. In addition, while preferred traits may vary by domain (e.g. wealth in a business partner, kindness in a friend, athletic skill in a teammate), some traits are likely to be desirable to many people, which will intensify competition. Therefore, positive assortment seems likely to appear across social domains if competition is the cause.

Of course, homophily may be a mediator for kin selection or promoting cooperation. The mediation may manifest as an unconscious draw to the similar (as proposed by Payne & Jaffe, 2005), in which case, it would apply to all social partners, including those indirectly linked to fitness. For example, inclusive fitness may be a plausible explanation of cooperation between two similar-looking individuals, but it is unclear whether these fitness benefits are also conferred

by choosing similar-looking dogs (Payne & Jaffe, 2005). Thus, assortative patterns may not be generated by a conscious cognitive process driven by feedback.

Examining whether assortment occurs in social choice problems with different constraints provides additional evidence as to whether homophily is a domain-general strategy applied to all social situations (regardless of whether it will produce the best results) or a strategy selected specifically based on problem constraints.

1.2.3.1 Patterns of assortment in other domains

In contrast to the stated-revealed preference gap, assortative mating is well-documented across numerous species (e.g. Crespi, 1989) and positive assortment is seen in numerous human relationships, ranging from short-term interaction partners to our closest confidents (see McPherson et al., 2001 for a thorough review). The largest amount of work outside of mate choice has examined friends and co-workers, and recent work has also focused on partner facial resemblance.

Positive assortment has been observed in friendships across the lifespan (McPherson et al., 2001). In children, the more traits they share with a social partner, the higher the likelihood of a friendship forming (Kupersmidt, DeRosier, & Patterson, 1995). In rare longitudinal studies of social interaction, children's similarity to friends grows with time as a result of all assortment mechanisms, including socialization, deselection of less similar friends, and increased levels of initial overlap with newly selected friends over time (Brechwald & Prinstein, 2011; Kandel, 1978). In adults, friends typically are highly similar in racial attitudes, identity statements, and some personality assessments (Lee et al., 2009; Syed & Juan, 2012).

In the workplace, trait segregation is found on a wide range of traits including sex, education, race, experience level, and religion (Hellerstein & Neumark, 2008; MchPherson et al., 2001). Academia is no exception, where collaborations and other ties tend to share duration in the academy, research accomplishments, and specialty (Blau, 1974; Cabanac et al., 2015; Wang et al., 2017).The strength of homophily is enhanced by induced homophily driven by employee nomination of new employees from their existing social networks (Marsden & Gorman, 2001). Similar individuals in the workplace also tend to incur benefits in terms of access to resources, mentorship and promotion (e.g. Ibarra, 1995, 1997; Opper, Nee, & Brehm, 2015; McPherson & Smith-Lovin, 1982).

A relatively newly studied area of positive assortment is facial resemblance. Hehman and colleagues (2018) found that individuals' group membership could be predicted based on photos using friends' photos on Facebook®, fraternity composites, and baseball rosters. Resemblance is based not just on objective facial qualities but also impressions of faces. The attractiveness of faces is correlated for pairs of friends but not as a highly as romantic partners (Feingold, 1988), and romantic partners' personalities are rated similarly based solely on photos (Little, Burt, & Perret, 2006). Facial similarity extends beyond one's fellow man: humans can be paired with their owned dogs based on photos alone (Nakajima, Yamamoto, & Yoshimoto, 2009; Roy & Christenfeld, 2004, 2005), although questions remain about whether this effect is driven by similarity or another relationship and whether this effect results from selection or convergence.

As a whole, positive assortment between romantic and non-romantic partners covers similar dimensions. Co-workers, friends, and spouses share physical characteristics, values, and personality traits, in addition to demographics such as race, education, age, and religion. Given

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the differences between these choice problems, homophily may therefore be exhibited in many social domains.

1.2.4   How Does Romantic Search Relate to Other Types of Resource Search?

The aim of this thesis is to show commonalities between romantic choice and other non-romantic social choices. However, if romantic choice generalizes to other social domains, we can also ask whether romantic choice shares qualities with other <u>non-social</u> choice domains. Consider the search for another evolutionary relevant resource, food search. Given that nutrients are essential for survival (and therefore fitness), foraging is assumed to be under natural selective pressure. Since mate search is also under selection pressure (including through *sexual* selection), the features of efficient strategies evolved for food foraging could provide unique insight to the study of how humans search for romantic partners.

The structure of romantic search problems has both similarities and differences to those in classic food foraging. Like romantic partners, food resources are not distributed randomly and evenly in the environment; clusters of similar value (e.g. berry bushes) are instead found in proximity (in terms of geography for berries and network distance for mates). The exclusivity of a romantic relationship, which is relatively unique among, is also a factor for some physical resources (for example, a calorie of energy, although a source providing numerous calories, such as a berry patch, may be shared). But in contrast, resource search is unidirectional: the berry does not get to choose who picks it. Further comparisons of these two areas could open up new hypotheses about how cognitive mechanisms for search exapt to new types of problems.

1.3   Implications and the Current Work

Overall, the search for romantic partners is distinct in many ways from the search for other social partners and non-social resources. As choice constraints vary between relationship

types—including bidirectional choice, number of allowable partners of a given type, the nature of the relationship, and the amount of competition—search strategies may vary in efficacy and manifestation. However, there is emerging evidence and theoretical support that similar decision-making patterns, especially assortment, manifest when individuals seek out friends, co-workers, and companion animals. Studying problems with varying constraints provides insight into why patterns appear, which can guide future studies of the potential cognitive mechanisms producing the effects. Overall, comparisons between romantic choice and patterns of choice in other social and non-social domains is essential for creating a holistic picture of social search.

If these patterns appear in other domains, they may have unexpected consequences absent in romantic choice. For example, if new co-workers are chosen according to homophily of race, age, or sex, workplaces become homogenous, which not only is discriminatory, but also decreases the likelihood of innovation within the workplace (Armstrong et al., 2010; Lambert, 2016). Alternatively, if the stated-revealed preference gap manifests itself in romantic partners, the result is a missed connection; if the same pattern appeared in the choice of companion animals, animal shelters choosing which animals to send to adoption could risk low success rates.

In this dissertation, I examine decision-making patterns in three search domains related to romantic partners. I test the hypothesis that similar patterns of choice are exhibited in multiple understudied social domains and investigate what traits impact their manifestation. Social choice is difficult to translate into typical controlled lab tasks where, for instance, individuals are given a description of a partner using numeric values on various traits (despite dozens of studies finding new relevant trait factors each year) and asked to choose between n such options—a far cry from naturalistic choice. To this end, the core approach in this work will be to move beyond

the lab to work with data collected in non-laboratory settings, particularly data considered 'messy'. As a result, I do not intend to identify exact decision-making mechanisms as modelled through lab tasks, but rather to look at whether the underlying results of choice are consistent across domains.

First, I consider the similarities between romantic and non-social search (Chapter 2). In resource search, optimal foraging theory (OFT; Stephens & Krebs, 1986) has been foundational for understanding how individuals maximize their gains in spatial environments. Because both mate choice and resource gain relate strongly to fitness and selection pressures, romantic partners also may exhibit OFT-like search patterns. If so, OFT could provide a rich theoretical background for understanding what influences social choice.

Next, I consider two social domains contrasting with romantic choice which have received relatively little attention in the social choice literature. These include academics forming research collaborations and humans choosing canine companion animals.

1.3.1   What's in a Collaborator?

Academics collaborate to study new research problems, acquire new expertise, and gain access to funding, among other reasons. Collaboration increases research productivity through skill specialization, providing a strong incentive to form relationships with others. Ties between authors are typically explicit (in terms of co-authorship), and many such ties can be held simultaneously.

Forming successful collaborations and relationships with one's colleagues is critical to the success of academic scientists (Forret & Dougherty, 2004; Wollf & Moser, 2009). However, finding appropriate collaborators can be difficult, as the academic expertise desired may be rare

and time-costly to find. It is unsurprising that, rather than engaging in a targeted search for the "best" collaborators, individuals may instead settle for partners of convenience from pre-existing contacts.

Studies have primarily focused on how collaborations form using existing online collaboration data (e.g. Wang et al., 2017), which provides insight into co-publishing patterns and which factors influence relationship formation (e.g. years in the field, shared institutions, academic specialty), but does not examine known influencers of social choice, such as homophily of values or personality. In Chapter 3, I examine how objective traits (e.g. area of expertise) and perceived traits (e.g. similarity) influence how collaborations form. To strengthen comparisons to mate choice, I adapt speed-dating, the most common method for testing the stated-revealed preference gap, into speed-networking. I test whether the academic collaborators chosen are those most in line with complementarity of stated needs or shared qualities between partners.

1.3.2   What's in a Dog?

I next consider another social partner assumed to be chosen for a lifetime, who becomes a member of the family and often shares the same bed: the domestic dog. Dogs have co-evolved alongside us for the last 10,000 years, and occupy a similar ecological niche (Topál et al., 2009), despite large differences in evolutionary ancestry. Three of humans' most unique behaviors—sociability, synchronization, and constructive activity—are shared by dogs both broadly and in terms of individual subfacets (Topál et al., 2009; see also Hart, 1995). Dogs elicit social behavior and promote relationships with humans, based on common social structures such as dominance structure and attachment (Hart, 1995).

How does the human-dog relationship compare to various human-human types of social partners? In some ways, today's dogs resemble children, in that owners have a legal responsibility for their care and needs, as well as (generally) co-residing within the same home (these responsibilities also integrate dogs in our daily activities and ease relationship maintenance). When individuals lack children or live-in romantic partners, the attachment role of dogs escalates in importance (Albert & Bulcroft, 1988), and one in three individuals consider the dog the closest or most significant family relationship (Barker Barker, 1988). In other ways, dogs act as friends, serving as activity partners and non-judgmental listeners and facilitating social interaction with others (e.g. Guéguen & Ciccotti,), as well as opportunities for social play and touch which may be difficult to establish in adult human friendships (see Hart, 1995 for a review). Finally, dogs historically have worked with humans to achieve common goals (e.g. sheepherding, protection), alike to today's co-workers. But unlike humans, dogs cannot communicate complex ideas or exchange dialogue with us, and the amount of genetic similarity is far less than that of fellow humans.

In short, dogs' social roles overlap with humans in numerous ways, including occupying a similar ecological niche, the promotion of social behavior, and shared roles with other social partners in society. Therefore, dogs have the capacity to both elicit and respond to human social behaviors and give us the opportunity to examine which social choice features generalize to other species. In particular, if patterns of human social choice extend to choice of dogs, it implies that these patterns are not the byproduct of enhanced genetic overlap or complex language.

In order to study dog choice, instead of working with existing dog owners, I assess humans' evaluations of their dogs at the time of relationship initiation through a field study in an animal shelter. In Chapter 4, I examine whether the stated-revealed preference gap manifests in

humans choosing companion dogs. In Chapter 5, I look at perceived homophily of personality in dogs and their human adopters. To do so, I collected the preferences of individuals visiting dogs at the shelter. I then further surveyed individuals who did adopt a dog, asking them to describe their own personality, the perceived personality traits of their dog, as well as how well their dog fulfilled their stated preferences.

Overall, this dissertation is a three-fold comparison of romantic partner search to other types of search, in order to examine how search constraints may influence the cognitive mechanisms used in decision-making.

1.4 References

Albert, A., & Bulcroft, K. (1988). Pets, families, and the life course. *Journal of Marriage and the Family*, 543-552.

Ariely, D., & Loewenstein, G. (2006). The heat of the moment: The effect of sexual arousal on sexual decision making. *Journal of Behavioral Decision Making*, *19*(2), 87-98.

Armstrong, C., Flood, P. C., Guthrie, J. P., Liu, W., MacCurtain, S., & Mkamwa, T. (2010). The impact of diversity and equality management on firm performance: Beyond high performance work systems. *Human Resource Management*, *49*(6), 977-998.

Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *science*, *211*(4489), 1390-1396.

Barker, S. B., & Barker, R. T. (1988). The human-canine bond: Closer than family ties? *Journal of Mental Health Counseling, 10*(1), 46-56.

Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2008). How are preferences revealed?. *Journal of Public Economics*, *92*(8-9), 1787-1794.

Blau, J. R. (1974). Patterns of communication among theoretical high energy physicists. *Sociometry*, 391-406.

Bowles, S., & Gintis, H. (2011). *A cooperative species: Human reciprocity and its evolution*. Princeton University Press.

Brechwald, W. A., & Prinstein, M. J. (2011). Beyond homophily: A decade of advances in understanding peer influence processes. *Journal of Research on Adolescence, 21*(1), 166-179.

Brewer, M. B. (1991). The social self: On being the same and different at the same time. *Personality and Social Psychology Bulletin*, *17*(5), 475-482.

Burley, N. (1983). The meaning of assortative mating. *Ethology and Sociobiology*, *4*(4), 191-203.

Buss, D. M., & Barnes, M. (1986). Preferences in human mate selection. *Journal of Personality and Social Psychology*, *50*(3), 559.

Buston, P. M., & Emlen, S. T. (2003). Cognitive processes underlying human mate choice: The relationship between self-perception and mate preference in Western society. *Proceedings of the National Academy of Sciences*, *100*(15), 8805-8810.

Cabanac, G., Hubert, G., & Milard, B. (2015). Academic careers in Computer Science: Continuance and transience of lifetime co-authorships. *Scientometrics*, *102*(1), 135-150.

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

Crespi, B. J. (1989). Causes of assortative mating in arthropods. *Animal Behaviour*, *38*(6), 980-1000.

Cohen, S. P. (2002). Can pets function as family members?. *Western Journal of Nursing Research*, *24*(6), 621-638.

Dainton, M., & Stafford, L. (1993). Routine maintenance behaviors: A comparison of relationship type, partner similarity and sex differences. *Journal of Social and Personal Relationships*, *10*(2), 255-271.

Davis, J. L., & Rusbult, C. E. (2001). Attitude alignment in close relationships. *Journal of personality and social psychology*, *81*(1), 65.

Demir, M., & Orthel, H. (2011). Friendship, real–ideal discrepancies, and well-being: Gender differences in college students. *Journal of Psychology*, *145*(3), 173-193.

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. http://doi.org/10.1037/0022-3514.94.2.245

Eastwick, P. W., Finkel, E. J., & Eagly, A. H. (2011). When and why do ideal partner preferences affect the process of initiating and maintaining romantic relationships?. *Journal of Personality and Social psychology*, *101*(5), 1012.

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.

Eysenck, H. J., & Wakefield Jr, J. A. (1981). Psychological factors as predictors of marital satisfaction. *Advances in Behaviour Research and Therapy*, *3*(4), 151-192.

Feingold, A. (1988). Matching for attractiveness in romantic partners and same-sex friends: A meta-analysis and theoretical critique. *Psychological Bulletin*, *104*(2), 226.

Fiore, A. T., & Donath, J. S. (2005). Homophily in online dating: when do you like someone like yourself?. In *CHI'05 Extended Abstracts on Human Factors in Computing Systems*(pp. 1371-1374). ACM.

Fletcher, G. J., Kerr, P. S., Li, N. P., & Valentine, K. A. (2014). Predicting Romantic Interest and

Decisions in the Very Early Stages of Mate Selection Standards, Accuracy, and Sex

Differences. *Personality and Social Psychology Bulletin*, *40*(4), 540-550.

Forret, M. L., & Dougherty, T. W. (2004). Networking behaviors and career outcomes:

differences for men and women?. *Journal of Organizational Behavior*, *25*(3), 419-437.

Frey, B. S., & Eichenberger, R. (1996). Marriage paradoxes. *Rationality and Society*, *8*(2), 187-

206.

Granovetter, M. (1983). The strength of weak ties: A network theory revisited.

Greitemeyer, T. (2010). Effects of reciprocity on attraction: The role of a partner's physical

attractiveness. *Personal Relationships*, *17*(2), 317-330.

Guéguen, N., & Ciccotti, S. (2008). Domestic dogs as facilitators in social interaction: An

evaluation of helping and courtship behaviors. *Anthrozoös*, *21*(4), 339-349.

Hall, J. A. (2011). Sex differences in friendship expectations: A meta-analysis. *Journal of Social

and Personal Relationships*, *28*(6), 723-747.

Hart, L. A. (1995). Dogs as human companions: a review of the relationship. *The domestic dog:

Its evolution, behaviour and interactions with people*, 161-178.

Hehman, E., Flake, J. K., & Freeman, J. B. (2018). The Faces of Group Members Share Physical

Resemblance. *Personality and Social Psychology Bulletin*, *44*(1), 3-15.

Hellerstein, J. K., & Neumark, D. (2008). Workplace segregation in the United States: Race,

ethnicity, and skill. *The Review of Economics and Statistics*, *90*(3), 459-477.

Hitsch, G. J., Hortaçsu, A., & Ariely, D. (2010). What makes you click?—Mate preferences in online dating. *Quantitative Marketing and Economics*, *8*(4), 393-427.

Hong, L., & Page, S. E. (2001). Problem solving by heterogeneous agents. *Journal of Economic Theory*, *97*(1), 123-163.

Huston, T. L., & Levinger, G. (1978). Interpersonal attraction and relationships. *Annual Review of Psychology*, *29*(1), 115-156.

Ibarra, H. (1995). Race, opportunity, and diversity of social circles in managerial networks. *Academy of Management Journal*, *38*(3), 673-703.

Ibarra, H. (1997). Paving an alternative route: Gender differences in managerial networks. *Social Psychology Quarterly*, 91-102.

Jaffe, K. (2016). Extended inclusive fitness theory: synergy and assortment drives the evolutionary dynamics in biology and economics. *SpringerPlus*, *5*(1), 1092.

Kalick, S. M., & Hamilton, T. E. (1986). The matching hypothesis reexamined. *Journal of Personality and Social Psychology*, *51*(4), 673.

Kandel, D. B. (1978). Homophily, selection, and socialization in adolescent friendships. *American journal of Sociology*, *84*(2), 427-436.

Kossinets, G., & Watts, D. J. (2009). Origins of homophily in an evolving social network. *American Journal of Sociology*, *115*(2), 405-450.

Kreager, D. A., Cavanagh, S. E., Yen, J., & Yu, M. (2014). "Where have all the good men gone?" Gendered interactions in online dating. *Journal of Marriage and Family*, *76*(2), 387-410.

Kupersmidt, J. B., DeRosier, M. E., & Patterson, C. P. (1995). Similarity as the basis for

children's friendships: The roles of sociometric status, aggressive and withdrawn behavior,

academic achievement and demographic characteristics. *Journal of Social and Personal*

Relationships, *12*(3), 439-452.

Lambert, J. (2016). Cultural diversity as a mechanism for innovation: Workplace diversity and

the absorptive capacity framework. *Journal of Organizational Culture, Communications and*

Conflict, *20*(1), 68.

Le, B., Dove, N. L., Agnew, C. R., Korn, M. S., & Mutso, A. A. (2010). Predicting nonmarital

romantic relationship dissolution: A meta-analytic synthesis. *Personal Relationships*, *17*(3),

377-390.

Lee, K., Ashton, M. C., Pozzebon, J. A., Visser, B. A., Bourdage, J. S., & Ogunfowora, B.

(2009). Similarity and assumed similarity in personality reports of well-acquainted

persons. *Journal of Personality and Social Psychology*, *96*(2), 460.

Levitt, S. D., & List, J. A. (2007). What do laboratory experiments measuring social preferences

reveal about the real world?. *Journal of Economic Perspectives*, *21*(2), 153-174.

Li, N. P., Yong, J. C., Tov, W., Sng, O., Fletcher, G. J., Valentine, K. A., ... & 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.

Little, A. C., Burt, D. M., & Perrett, D. I. (2006). Assortative mating for perceived facial

personality traits. *Personality and Individual Differences*, *40*(5), 973-984.

Luo, X., & Deng, L. (2009). Do birds of a feather flock higher? The effects of partner similarity on innovation in strategic alliances in knowledge-intensive industries. *Journal of Management Studies*, *46*(6), 1005-1030.

Määttä, K., & Uusiautti, S. (2013). Mission impossible? A scientific comparison between the overlapping and diverging phenomena of friendship and love. In *Many Faces of Love* (pp. 121-128). SensePublishers, Rotterdam.

Marsden, P. V., & Gorman, E. H. (2001). Social networks, job changes, and recruitment. In *Sourcebook of Labor Markets* (pp. 467-502). Springer, Boston, MA.

Marsiglio, W., & Scanzoni, J. H. (1995). *Families and friendships: Applying the sociological imagination*. HarperCollins College Publishers.

McPherson, J. M., & Ranger-Moore, J. R. (1991). Evolution on a dancing landscape: organizations and networks in dynamic Blau space. *Social Forces*, *70*(1), 19-42.

McPherson, J. M., & Smith-Lovin, L. (1982). Women and weak ties: Differences by sex in the size of voluntary organizations. *American Journal of Sociology*, *87*(4), 883-904.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, *27*(1), 415-444.

Mendelson, M. J., & Aboud, F. E. (1999). Measuring friendship quality in late adolescents and young adults: McGill Friendship Questionnaires. *Canadian Journal of Behavioural Science*, *31*(2), 130.

Murphy, J. J., Allen, P. G., Stevens, T. H., & Weatherhead, D. (2005). A meta-analysis of hypothetical bias in stated preference valuation. *Environmental and Resource Economics*, *30*(3), 313-325

Muurlink, O., & Poyatos Matas, C. (2011). From romance to rocket science: Speed dating in higher education. *Higher Education Research & Development*, *30*(6), 751-764.

Nakajima, S., Yamamoto, M., & Yoshimoto, N. (2009). Dogs look like their owners: replications with racially homogenous owner portraits. *Anthrozoös*, *22*(2), 173-181.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, *84*(3), 231.

Opper, S., Nee, V., & Brehm, S. (2015). Homophily in the career mobility of China's political elite. *Social Science Research*, *54*, 332-352.

Payne, C., & Jaffe, K. (2005). Self seeks like: Many humans choose their dog pets following rules used for assortative mating. *Journal of Ethology*, *23*(1), 15-18.

Richard, L. S., Wakefield Jr, J. A., & Lewak, R. (1990). Similarity of personality variables as predictors of marital satisfaction: A Minnesota Multiphasic Personality Inventory (MMPI) item analysis. *Personality and Individual Differences*, *11*(1), 39-43.

Robinson, M. R., Kleinman, A., Graff, M., Vinkhuyzen, A. A., Couper, D., Miller, M. B., ... & van Vliet-Ostaptchouk, J. V. (2017). Genetic evidence of assortative mating in humans. *Nature Human Behaviour*, *1*(1), 0016.

Roy, M. M., & Christenfeld, N. J. (2004). Do Dogs Resemble Their Owners?. *Psychological Science*, *15*(5), 361-363.

Roy, M. M., & Christenfeld, N. J. (2005). Dogs still do resemble their owners. *Psychological Science*, 16(9), 743-744.

Rushton, J. P., & Bons, T. A. (2005). Mate choice and friendship in twins: evidence for genetic similarity. *Psychological Science*, *16*(7), 555-559.

Rushton, J. P., Russell, R. J., & Wells, P. A. (1984). Genetic similarity theory: Beyond kin selection. *Behavior genetics*, *14*(3), 179-193.

Ruvolo, A. P., & Veroff, J. (1997). For better or for worse: Real-ideal discrepancies and the marital well-being of newlyweds. *Journal of Social and Personal Relationships*, *14*(2), 223-242.

Schelling, T. C. (1971). Dynamic models of segregation. *Journal of Mathematical Sociology*, *1*(2), 143-186.

Schimel, J., Pyszczynski, T., Greenberg, J., O'Mahen, H., & Arndt, J. (2000). Running from the shadow: Psychological distancing from others to deny characteristics people fear in themselves. *Journal of Personality and Social Psychology, 78*(3), 446-462. doi:10.1037/0022-3514.78.3.446

Segal, M.W. (1974). Alphabet and attraction: An unobtrusive measure of the effect of propinquity in a field setting. *Journal of Personality and Social Psychology, 30,* 654-657.

Shanteau, J., & Nagy, G. F. (1979). Probability of acceptance in dating choice. *Journal of Personality and Social Psychology*, *37*(4), 522.

Shaw Taylor, L., Fiore, A. T., Mendelsohn, G. A., & Cheshire, C. (2011). "Out of my league": A
real-world test of the matching hypothesis. *Personality and Social Psychology
Bulletin*, *37*(7), 942-954.

Singh, R., & Teoh, P., Boon, J. (1999). Attitudes and attraction: A test of two hypotheses for the
similarity-dissimilarity asymmetry. *British Journal of Social Psychology*, *38*(4), 427-443.

Sprecher, S., & Regan, P. C. (2002). Liking some things (in some people) more than others:
Partner preferences in romantic relationships and friendships. *Journal of Social and Personal
Relationships*, *19*(4), 463-481.

Spuhler, J. N., & Clark, P. J. (1961). Migration into the human breeding population of Ann
Arbor, Michigan, 1900-1950. *Human Biology*, *33*(3), 223-236.

Stephens, D. W., & Krebs, J. R. (1986). *Foraging theory*. Princeton, NJ: Princeton University
Press.

Syed, M., & Juan, M. J. D. (2012). Birds of an ethnic feather? Ethnic identity homophily among
college-age friends. *Journal of Adolescence*, *35*(6), 1505-1514.

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.

Thibaut, J.W., & Kelley, H.H., (1959). The social psychology of groups. New York: Wiley.

Thiessen, D., & Gregg, B. (1980). Human assortative mating and genetic equilibrium: An
evolutionary perspective. *Ethology and Sociobiology*, *1*(2), 111-140.

Topál, J., Miklósi, Á., Gácsi, M., Dóka, A., Pongrácz, P., Kubinyi, E., ... & Csanyi, V. (2009). The dog as a model for understanding human social behavior. *Advances in the Study of Behavior*, *39*, 71-116.

Tregenza, T., & Wedell, N. (2000). Genetic compatibility, mate choice and patterns of parentage: invited review. *Molecular Ecology*, *9*(8), 1013-1027.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *The Quarterly review of biology*, *46*(1), 35-57.

Vandenberg, S. G. (1972). Assortative mating, or who marries whom?. *Behavior Genetics*, *2*(2-3), 127-157.

Vigil, J. M. (2007). Asymmetries in the friendship preferences and social styles of men and women. *Human Nature*, *18*(2), 143-161.

Wang, W., Yu, S., Bekele, T. M., Kong, X., & Xia, F. (2017). Scientific collaboration patterns vary with scholars' academic ages. *Scientometrics*, *112*(1), 329-343.

Watson, D., Klohnen, E. C., Casillas, A., Nus Simms, E., Haig, J., & Berry, D. S. (2004). Match makers and deal breakers: Analyses of assortative mating in newlywed couples. *Journal of Personality*, *72*(5), 1029-1068.

Wolff, H. G., & Moser, K. (2009). Effects of networking on career success: a longitudinal study. *Journal of Applied Psychology*, *94*(1), 196.

Wright, J. C., Smith, A., Daniel, K., & Adkins, K. (2007). Dog breed stereotype and exposure to negative behavior: Effects on perceptions of adoptability. *Journal of Applied Animal Welfare Science*, *10*(3), 255-265.

2   Romantic Search as a Foraging Problem

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Prior to considering how individuals choose *other social partners* as they choose mates, I
first consider how individuals search for romantic partners as they do for other *non-social*
resources. The search for resources (food, in particular) is a universal necessity for mobile
organisms, and strategies used in those situations could be applied to new domains (such as the
search for a romantic partner) rather than developing new strategies for each type of search.
However, if that approach is not successful, perhaps as a result of changed constraints of the
choice problem, new strategies may result.

In this chapter I consider whether mate search can be usefully informed by studies of
foraging. Understanding what components of social search are unique can reveal why different
search strategies are used across domains.

2.1.1   Modeling Mate Search as Patchy Foraging

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 wellbeing, 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 tradeoffs between seeking resources ("exploring") and making use of them ("exploiting"). If individuals flexibly search similarly across social and non-social problems, romantic partners could exhibit patterns predicted by OFT, which could advance the study of mate choice and the central hypothesis of this dissertation.

OFT examines 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 non-overlapping 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 (though 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).

2.1.2   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 is time and effort allocated between exploring for new relationships and exploiting (benefitting from) the current relationship? I touch on each of these topics in turn.

2.1.2.1 Exploring for and Starting Relationships

Opportunities to enter 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 their 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 two-sided search in the particular mating context (where both parties must agree for a relationship to start), which differs from 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 is 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, though 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.

2.1.2.2 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 benefitted 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, etc.) 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 datasets that are freely available to researchers: The Married and Cohabitating 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, though 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.

2.1.2.3   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 and 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 an individual 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 an individual experiences 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 (though 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 post-breakup 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.

I 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, I investigate how people may balance the explore/exploit tradeoff 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

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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), the 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.

2.2 Method: Testing Search and Relationship Duration

I analyze a dataset of 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. I therefore also analyze cohabitations, which are typically less stable and shorter than marriages, often either ending or transitioning to marriage within five years (Bramlett & Mosher, 2002).

2.2.1 Dataset: CDC National Survey for Family Growth

For marriages and cohabitations, I 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 dataset, 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

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amount of sexual education. Most importantly for the present purposes, it also includes the dates
of the beginning and end of marriages and cohabitations.

2.2.2 Participants

10,205 individuals (female = 55.8%) were included in the sample I 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.
I 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 ($n =
2002$) were not included in the analysis. I also excluded the 15.5% of the sample who never had
sexual intercourse.

2.2.3 Measures

My 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.

I define the search (or travel) time before a given relationship as follows: For the first
search period leading up to the first marriage, I use the number of months between the
individual's first sexual intercourse and the date of their 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 one month into the first marriage

($n = 59$) were excluded. I 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 duration 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.

I 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].

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[1] Individuals' search for cohabitation partners and marriage partners may overlap. Given this, I

also excluded from the first cohabitation gap analysis those individuals (436) who had married

before entering their first non-marital 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). I did not

exclude from the marriage gap analysis those individuals who cohabitated prior to marriage,

2.3   Results: Survival Analysis of Relationship Duration Patterns

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). I incorporate this 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 states I am interested in are being in a relationship (or being single). Specifically within the CDC data, I analyze the survival likelihoods of marriages and cohabitations over time, based on observation of those relationships that ended either through divorce, annulment, or separation in the case of marriages, or through a partner exiting a shared non-marital cohabitation. The duration for ended relationships is calculated as described earlier, while the duration of relationships which have not yet ended are 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 dataset uses imputed values for some missing values). By analyzing the proportion of

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because cohabitation frequently precedes marriage as a part of the evaluation period, while the opposite is not true.

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relationships that reach a certain duration without the relationship end-event occurring, I 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, I 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:

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

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).

I 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-

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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, non-continuous covariate analysis and assumption checks (e.g. proportional hazard assumption). All covariates passed this test unless otherwise noted.

research-based prediction). I focus on two factors: the length of search periods (as dictated by the foraging hypothesis), and the age of one's first sexual intercourse. I 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, Ellison, Evans, Lee & Sue, 1993). Individuals with earlier sexual encounters may also be more likely to have unstable pair bonds (Belsky, Steinberg, and 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 the 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 Supplemental Materials, Appendix 7.1, where intact family during childhood, attitudes towards 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, I 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

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(*SD* = 66.2); the mean first marriage length was 83.7 months (*SD* = 66.4). For the cohabitation 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 2.1. Censorship within the data indicates the marriage or cohabitation continuing rather than dissolving. Because I 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.

Predicted event: End of…	Events/ Observations	Concordance	Variable	β Coefficient	e^{β}	95% CI on β Coefficient
First Marriage	1434/3916	0.650	Prior Search Period (First Marriage Gap)	-0.289	0.749***	−0.3558 to −0.2212
			Age at First Sexual Intercourse	-0.696	0.499***	−0.7699 to −0.6212
First Cohabitation	1990/2669	0.529	Prior Search Period (First Cohabitation Gap)	-0.048	0.953[i]	−0.0967 to 0.0006
			Age at First Sexual Intercourse	-0.132	0.877***	−0.1777 to −0.0860

[i]: $p < 0.07$ *: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Table 2.1: 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.

In line with the 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 dataset for which the individual with the predicted higher hazard rate for relationship dissolution actually had their 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 ($\chi^2(2) = 366.3$, $p < 0.001$), but for cohabitation the improvement was more modest ($\chi^2(2) = 32.8$, $p < 0.001$).

To test the second, non-foraging based prediction, that one would search longer after a longer relationship, I 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 2.2). 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.

Predicted event: End of...	Events/ Observations	Concordance	Variable	β Coefficient	e^β	95% CI on β Coefficient
Second Marriage Gap	544/1434	0.550	Prior Search Period (First Marriage Gap)	-0.160	0.852**	-0.2682 to -0.0514
			Age at First Sexual Intercourse	-0.117	0.890*	-0.2212 to -0.0128
Second Cohabitation Gap	359/988	0.612	Prior Search Period (First Cohabitation Gap)	-0.370	0.691***	-0.5069 to -0.2322
			First Cohabitation Duration	-0.126	0.881*	-0.2493 to -0.0031
			Age at First Sexual Intercourse	-0.325	0.722***	-0.4431 to -0.2075

$^\cdot: p < 0.07$ $*: p < 0.05$ $**: p < 0.01$ $***: p < 0.001$

Table 2.2: 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). (Note that the second cohabitation gap analysis only includes women who began at least two cohabitations uninterrupted by marriage; see footnote 1.)

The resulting model produced a concordance of 0.550, not much above chance, but fitting significantly better than the null model (Likelihood Ratio test, $\chi^2(2) = 10.0$, $p = 0.00673$). Both prior search period and age at first 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 was 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 non-foraging 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, $\chi^2(3) = 50.9$, $p < 0.001$).

2.4   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, I analyzed a large dataset 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. I tested a prediction of optimal foraging theory that longer search for a relationship-patch should result in longer time spent in each relationship, and 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, I 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, I 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—though 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 Supplemental Materials, Appendix 7.1). These results support the central hypothesis of this dissertation that search strategies generalize across domains, including the boundary of social and non-social search. 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 optimal foraging theory 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 non-depleting 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

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possibility, further research should consider datasets 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 an individual 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 (Stephen & 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. Relatedly, 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 behTaavior.

For now, the applicability of ideas from optimal foraging theory 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, or only for less serious (e.g. premarital) relationships, or for none. More generally, the approach I have used here, analysis of large readily available relationship datasets via statistical packages for finding patterns over time, should be increasingly useful in testing predictions that arise from the evolutionary behavioral sciences.

2.5 References

Baker, L. A., & Emery, R. E. (1993). When every relationship is above average: Perceptions and expectations of divorce at the time of marriage. *Law and Human Behavior, 17*(4), 439-450.

Beachly, W.M., Stephens, D.W., & Toyer, K.B. (1995). On the economics of sit-and-wait foraging: Site selection and assessment. *Behavioral Ecology, 6*(3), 258-268.

Beckage, N., Todd, P.M., Penke, L., & Asendorpf, J.B. (2009). Testing sequential patterns in human mate choice using speed dating. In N. Taatgen and H. van Rijn (Eds.), *Proceedings of the 2009 Cognitive Science Conference* (pp. 2365-2370). Cognitive Science Society. Online at http://csjarchive.cogsci.rpi.edu/proceedings/2009/index.html

Belsky, J., Steinberg, L., & Draper, P. (1991). Childhood experience, interpersonal development, and reproductive strategy: An evolutionary theory of socialization. *Child Development*, *62*(4), 647-670.

Bingham, C. R., Miller, B. C., & Adams, G. R. (1990). Correlates of age at first sexual intercourse in a national sample of young women. *Journal of Adolescent Research*, *5*(1), 18-33.

Bramlett, M. D., & Mosher, W. D. (2002). Cohabitation, marriage, divorce, and remarriage in the United States. National Center for Health Statistics: *Vital and Health Statistics*, *23*(22), 1-32.

Byers, E. S. (2005). Relationship satisfaction and sexual satisfaction: A longitudinal study of individuals in long-term relationships. *Journal of Sex Research, 42*(2), 113-118.

Charnov, E. L. (1976). Optimal foraging, the marginal value theorem. *Theoretical Population Biology, 9*(2), 129-136.

Chisholm, J. S., Ellison, P. T., Evans, J., Lee, P. C., Lieberman, L. S., Pavlik, Z., ... &

    Worthman, C. M. (1993). Death, hope, and sex: life-history theory and the development

    of reproductive strategies [and comments and reply]. *Current Anthropology*, *34*(1), 1-24.

Christensen, H. T. (1963). Child spacing analysis via record linkage: new data plus a summing

    up from earlier reports. *Marriage and Family Living, 25*(3), 272-280.

Cohen, S. E. & Todd, P. M. (2017). Expected Utility in Romantic Relationships: Satisfaction as a

    Cue for Romantic Partnership Dissolution. In G. Gunzelmann, A. Howes, T. Tenbrink, &

    E. J. Davelaar (Eds.), *Proceedings of the 39th Annual Conference of the Cognitive*

    Science Society (pp. 234-239). Austin, TX: Cognitive Science Society.

Cox, D. R. (1992). Regression models and life-tables. In *Breakthroughs in Statistics* (pp. 527-

    541). Springer New York.

Davidson-Pilon, C. (2016). Lifelines [Computer software]. Github repository,

    https://github.com/CamDavidsonPilon/lifelines.

De Jong Gierveld, J. (2004). Remarriage, unmarried cohabitation, living apart together: Partner

    relationships following bereavement or divorce. *Journal of Marriage and Family*, *66*(1),

    236-243.

Dibble, J. L., & Drouin, M. (2014). Using modern technology to keep in touch with back

    burners: An investment model analysis. *Computers in Human Behavior, 34*, 96-100.

Giraldeau, L. A., & Caraco, T. (2000). *Social Foraging Theory*. Princeton University Press.

Hogan, D. P., & Kitagawa, E. M. (1985). The impact of social status, family structure, and

    neighborhood on the fertility of black adolescents. *American Journal of Sociology*, *90*(4),

    825-855.

Huston, T. L., & Vangelisti, A. L. (1991). Socioemotional behavior and satisfaction in marital

relationships: a longitudinal study. *Journal of Personality and Social Psychology, 61*(5),

721-733.

Hutchinson, J. M. C., & Halupka, K. (2004). Mate choice when males are in patches: Optimal

strategies and good rules of thumb. *Journal of Theoretical Biology, 231*(1), 129-151.

Kaplan, E. L., & Meier, P. (1958). Nonparametric estimation from incomplete

observations. *Journal of the American Statistical Association*, *53*(282), 457-481.

Kelley, H. H., & Thibaut, J.W. (1978). *Interpersonal Relations: A Theory of Interdependence.*

New York: John Wiley & Sons.

Krebs, J. R., Stephens, D. W., & Sutherland, W. J. (1983). Perspectives in optimal foraging. In

A. H. Bush & G. A. Clark (eds.), *Perspectives in Ornithology: Essays Presented for the*

Centennial of the American Ornithologists' Union(165-221). Cambridge: Cambridge

University Press.

Martel, V., Wajnberg, E., & Boivin, G. (2008). Patch time allocation in male parasitoids.

Ecological Entomology, 33(5), 608-613.

McNamara, J.M. & Forslund, P. (1996). Divorce rates in birds: Predictions from an optimization

model. *American Naturalist, 147*, 609-640.

Milinski, M., & Bakker, T. C. (1992). Costs influence sequential mate choice in sticklebacks,

Gasterosteus aculeatus. Proceedings of the Royal Society of London B: Biological

Sciences, 250(1329), 229-233.

Miller, B. C., & Olson, T. D. (1988). Sexual attitudes and behavior of high school students in

relation to background and contextual factors. *Journal of Sex Research*, *24*(1), 194-200.

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

National Center for Family and Marriage Research (2010). *Married and Cohabiting Couples* (ICPSR31322-v1). Retrieved from

https://www.icpsr.umich.edu/icpsrweb/DSDR/studies/31322

National Center for Health Statistics. (2016). *2013-2015 National Survey of Family Growth Public* [Data files and documentation]. Retrieved from

http://www.cdc.gov/nchs/nsfg/nsfg_2013_2015_puf.htm

Parker, G. A. (1978). Searching for mates. In J.R. Krebs & N.B. Davies (Eds.), *Behavioural Ecology: an Evolutionary Approach* (pp. 214-444). Oxford, Blackwell Scientific Publications.

Rhodes, G., Simmons, L. W., & Peters, M. (2005). Attractiveness and sexual behavior: Does attractiveness enhance mating success? *Evolution and Human Behavior*, *26*(2), 186-201.

Rusbult, C. E. (1983). A longitudinal test of the investment model: The development (and deterioration) of satisfaction and commitment in heterosexual involvements. *Journal of Personality and Social Psychology, 45*(1), 101-117.

Schvaneveldt, P. L., Miller, B. C., Berry, E. H., & Lee, T. R. (2001). Academic goals, achievement, and age at first sexual intercourse: Longitudinal, bidirectional influences. *Adolescence*, *36*(144), 767.

Simão, J., & Todd, P.M. (2003). Emergent patterns of mate choice in human populations. *Artificial Life, 9*, 403-417.

Simpson, J. A. (1987). The dissolution of romantic relationships: Factors involved in relationship stability and emotional distress. *Journal of Personality and Social Psychology*, *53*(4), 683-692.

Sprecher, S. (1999). "I love you more today than yesterday": Romantic partners' perceptions of changes in love and related affect over time. *Journal of Personality and Social Psychology*, *76*(1), 46-53.

Sprecher, S., Felmlee, D., Metts, S., Fehr, B., & Vanni, D. (1998). Factors associated with distress following the breakup of a close relationship. *Journal of Social and Personal Relationships*, *15*(6), 791-809.

Stephens, D. W., & Krebs, J. R. (1986). *Foraging Theory*. Princeton, NJ: Princeton University Press.

Therneau, T. M., & Grambsch, P. M. (2000). *Modeling Survival Data: Extending the Cox Model*. Springer, New York, NY.

Todd, P. M., & Miller, G. F. (1999). From pride and prejudice to persuasion: Satisficing in mate search. In G. Gigerenzer, P.M. Todd, & the ABC Research Group, *Simple Heuristics that Make Us Smart* (pp. 287-308). New York: Oxford University Press.

Twenge, J. M., Campbell, W. K., & Foster, C. A. (2003). Parenthood and marital satisfaction: a meta-analytic review. *Journal of Marriage and Family, 65*(3), 574-583.

3 Homophily and Complementarity of Needs in Collaborators

Academics often network to find collaborators for new projects, as searching for others with a needed skill set can be much faster than developing the skill set personally. It can be much easier, after all, to find an existing resource than to build a new one. However, compared to other professional domains, finding appropriate collaborative partners can be time-costly: the sought-after academic expertise may be rare, and there may be many potential partners to search through in a limited amount of time (e.g., before a grant deadline). Like romantic partners, these search constraints can lead to unique patterns of choice. In this chapter, I develop a new method for pairing potential collaborators based on speed-dating, examining whether complementarity of needs or assortmemt are exhibited in the collaborating pairs, and whether manipulations of these measures influence collaboration rates.

3.1.1 The Search for a Collaborator

When academics seek out collaborators, they are searching for someone to assist in the development or completion of a research project. The criteria for a collaborator may vary by individual or even by project, including access to a piece of equipment, funding, manhours, expertise in a technique, or intellectual assistance in forming the project's basis. These collaborative preferences are presumed to be idiosyncratic.

As a search problem, finding a collaborator in a new area is additionally hampered by the lack of shared tacit (or implicit) understanding on a common subject area (as opposed to explicit information one might find in a textbook), which can produce a language barrier that limits meaningful discussion on a topic (Levin & Cross, 2004; Popper, 1972). Existing workplace ties within academics tend to share specialty and research accomplishments (Blau, 1974; Cabanac,

Hubert, & Milard, 2015; Wang, Yu, Bekele, Kong, & Xia, 2017). Therefore, homophily of knowledge is also a useful (and idiosyncratic) trait for pairing potential collaborators.

Collaborative behavior is also socially facilitated by developing camaraderie, inclusive communication and strong working relationships through trust and time (Ellinger, Keller, & Hansen, 2006). In particular, trust is a critical collaborative "lubricant" or moderator (Das & Teng, 1998; Dasgupta, 1988); without it, criticisms can be seen as insults rather than as valuable advice, leading people to be uncomfortable with the offering and critiquing of ideas that are vital in successful collaboration (Lane & Bachmann, 1997). One important predictor of successful relationship formation is shared qualities, not just in terms of research, but also personal experience and personality (see Chapter 1). Other workplace ties are not based solely on professional overlap, but also assortment on demographics like race, gender, and length of time at an institution (Hellerstein & Neumark, 2008; Blau, 1974), suggesting such search patterns could prevail in collaborator search. Unfortunately, these dyadic and demographic factors are difficult to predict and are not available in the datasets of publishing data typically used to predict collaboration formation (e.g. Wang et al., 2017).

In sum, academics face a difficult search task, where they are typically in time-poor conditions and seeking out a rare set of qualities based on both professional and social compatibility. Therefore, rather than engaging in a targeted search for the "best" collaborators, individuals may instead settle for partners of convenience from pre-existing contacts or those in close proximity (meaning ties could be based on propinquity or homophily, rather than the unique expertise desired), which may impact collaborative quality. Like romantic partners, search frictions could lead to individual's desire for a particular collaborator to be unmet, as well as a tendency towards homophily.

3.1.2 Prior Research Pairing Collaborators

In order to facilitate the search for a collaborator, several past works have attempted to ease the collaborative partner search process by pairing researchers using algorithmic examination of research similarity and social tie strength between potential collaborators in the publicly available publication record (i.e. homophily). These approaches are generally tested by using one's findings to predict collaborations that already exist in the record— a revealed preference approach. Specific approaches may consider the number of shared co-authors between two individuals (Newman, 2001) and the overall features of connectedness in the social network topology (Liben-Nowell & Kleinberg, 2007; Newman, 2001).

While a revealed preference approach does expedite the pairing up of potential collaborators, it is not without flaws. Revealed preferences are often assumed to be normative preferences, which may not necessarily be true, especially under search frictions or in time-poor conditions (Beshears, Choi, Laibson, & Madrian., 2008). As mentioned, the specific expertise that researchers seek out in collaborators may be rare, so using *existing* collaborations may only reveal what traits individuals *end up with* in a collaborator, rather than what their *ideal* collaborator would be. In difficult conditions, individuals may use social search strategies from other domains, including homophily. The assumption that individuals who are *objectively similar* are the "best", or even *preferred*, collaborative partners may not be correct, but rather a consequence of the search process. However, this assumption is rarely tested in this domain (c.f. Vaggi et al., 2014). Studies relying on existing publication data are also hampered because the only cues available for predicting hypotheses are those in the record, which may exclude important predictors beyond professional similarity. In particular, analysis is generally limited to the explicit knowledge captured in individuals' publication records rather than shared

professional background, meaning suggested partners, while being similar explicitly, may lack the tacit knowledge requisite to produce meaningful quality (see Chaiwanarom, Ichise, & Lursinsap, 2010 for an exception using complementary skills).

In sum, pairing approaches based solely on revealed preferences could be improved upon by both observing the process of search and additional characteristics. First, researchers can examine individuals' specific needs in a collaborator (i.e. stated preferences), in addition to their revealed preferences, to more accurately model the choice task (Kroes & Sheldon, 1988) and allow comparison to other social choice domains. By examining the partners available to an academic, in addition to whom they choose, it is possible to examine whether individuals specifically seek out similarity in a partner. Second, a face-to-face approach can examine additional cues which could influence collaboration formation, such as perceptions of one's partner.

Vaggi et al. (2014) is one of the few studies to study algorithmic matching and include stated preferences to pair potential collaborators. He found that when introducing academics in-person to a set of partners, half of whom were dissimilar (in terms of overlapping knowledge and social contacts) and half similar (in terms of pairs having high overlap in one partner's desired knowledge and the other's actual knowledge in this area), individuals considered meeting the more similar partners beneficial and stated that it led to new collaborations. This suggests that, beyond similarity, partners that fulfill one's stated preferences for expertise are also preferred. However, Vaggi and colleagues' outcome of interest was satisfaction, rather than collaborative formation, meaning the entire search process was not observed, leaving open questions about which partners were actually *chosen* for collaboration.

3.1.3 New Methods for Studying Collaboration Formation

Collaborator choice, with its intricacies of several criteria influencing decisions and search frictions, resembles the issues faced by romantic partner search. In romantic partner choice, there are often differences between what individuals say they are interested in and the qualities of the partners they choose (Todd, Penke, Fasolo, & Lenton, 2007), and similarity is a good predictor of choice (McPherson, Smith-Lovin, & Cook, 2001). If the same phenomena arise in these two domains, an appropriate method for studying professional choice would be to derive an experimental structure using the same methodology.

Speed-dating has been an essential tool for examining which factors influence romantic relationship formation. Recall that during a speed-dating event, individuals meet rapidly in pairs and interact for a fixed amount of time (e.g. 2-8 minutes, depending on the event), before a bell rings to signal the end of that "speed-date". Half of the individuals then shift to meet the next potential partner, until many pairs have met. After each such speed-date, both individuals privately indicate whether they would like to meet the other person again on a "real" date, and if both are interested, they are sent each other's contact information. This simple structure for introductions makes speed-dating events relatively easy to organize and readily scalable to large groups.

"Speed-networking" is a new application of this partnering paradigm where participants meet briefly with many other professionals, one at a time, to rapidly expand their professional or social networks. Within academia, speed-networking has been used to introduce large swaths of a particular community in a short period of time, for goals including forming interdisciplinary collaborative pairs, creating commercial ties to academic research, and matching junior faculty to senior mentors (Cook, Bahn & Menaker, 2010; see Muurlink & Matas, 2011 for a review).

Speed-networking addresses some of the social issues that can impair computational approaches to creating collaborations. These events provide social context by having individuals personally interact in face-to-face pairs, which allows both assessment of non-research traits essential to collaboration as well as in-person social experience which can generate trust and enhance knowledge exchange (Tsai & Ghosal, 1998). Speed-networking is still an improvement over unpartnered networking (e.g. cocktail hours), because in these situations, individuals may be influenced by homophily (as they are in most social situations), gravitating towards similar-looking others or pre-existing ties (McPherson et al., 2001). However, while the random rotation scheme of speed-networking may be sufficient for an event just aimed at "networking"—that is, increasing the number of contacts for each participant—this approach yields a low chance of finding a specific type of partner for collaborating.

3.1.4   Approach and Aims of This Research

Algorithmic matching and speed-networking address the common goal of creating new working relationships, but both have drawbacks limiting their usefulness. Combining the two approaches of computational algorithms for personalized choice and an environment for rapidly assessing social compatibility through speed-networking could improve success rates. In addition, it is possible to study whether homophily or stated preferences for a particular expertise in a partner are predictive of collaboration.

In this work, I expand upon previous efforts (such as Vaggi et al., 2014) to unite these two methods as "paired speed-networking". Individuals meet a carefully selected subset of the population who are most likely to fulfill their research goals, with the aim of improving the rate of useful collaboration formation while demanding minimal time from those involved. I develop and test an algorithm to match participants to potential research partners based on their *objective*

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similarity, a combination of their current research areas and techniques used (homophily), and the overlap between the desired knowledge of one individual and the knowledge base of another.

After these pre-determined pairs have met at a speed-networking event, I assess the mutual perceptions of the individuals in each pair including their intention to collaborate and then track whether each pair does in fact collaborate in the near future. In particular, I test whether objective research similarity (as generated by the algorithmic matching method) corresponds with how similar an individual considers a partner (*perceived similarity*) and how both of these factors affect the likelihood of collaboration. This approach follows the assumption that increasing the rate of potentially productive introductions in speed-networking using matching should subsequently increase collaboration rates.

The goals of this chapter are to determine whether there are characteristics that predict who will form research collaborations together and if so to test whether they can be leveraged to increase collaboration through speed-networking events. This method does not specifically test the stated-revealed preference gap by examining all preferred aspects in a collaborator, but rather whether a collaborator providing some of the unique expertise academics state they desire is more likely to be chosen as a collaborator (complementarity of different needs, as opposed to complementary levels on the same trait).

This set of experiments addresses three main limitations of earlier collaboration studies. First, this paradigm tests the effectiveness of a matching algorithm in a naturalistic social setting where collaborations can form, rather than focusing on predicting previous collaborations. Second, those few previous studies that collected data generally assessed only broad measures of satisfaction and collaborative intent immediately after the event (e.g. "Do you think you will collaborate after the event with another participant?"), which could overestimate collaboration

rates and the impact of experimental manipulations. In contrast, this study assesses actual collaborative behavior through a short-term seed-funding opportunity and long-term follow-up surveys to track collaboration formation, duration and satisfaction. Third, I manipulate experimental groups to test different matching methods under identical conditions (cf. the partner matching study of Vaggi et al., 2014, which tested a matching mechanism, but without using experimental groups).

For the current chapter, the research questions and expectations are:

1. Is it possible to predict which pairs of individuals will collaborate, and can collaboration rates be manipulated?

H1a: Pairs of individuals with high objective similarity should be more likely to collaborate than low objective similarity pairs

H1b: Matching schemes that increase the mean objective similarity of pairs who meet in speed-networking should produce higher collaboration rates.

2. How do participants use and determine perceived similarity?

H2a: Participants will collaborate more with partners with higher perceived similarity than partners with lower perceived similarity.

H2b: Participants will judge perceived similarity of their partners based on overlap in objective information such as research experience and interests. That is, perceived and objective similarity should be highly correlated.

To answer these questions, I analyze data from three experimental speed-networking sessions run by internal organizations at Indiana University. All methods were approved by the

Indiana University Institutional Review Board. Each session had a unique interdisciplinary research theme chosen by the respective organizers to recruit faculty with a common interest, and each incorporated different manipulations designed by the authors.

3.2 Experiment 1

3.2.1 Method

For the first experimental speed-networking session, participants were recruited using an advertisement on a university-level faculty email list. Seed funding was announced for collaborations resulting from the session, up to $2,000 per team, as an incentive for collaborating with one or more other participants. In total, 37 faculty members completed the pre-experiment survey to qualify for attendance; 34 faculty members attended the experiment. Data analyses were completed using anonymized data from this experiment.

3.2.1.1 Matching the Participants

In order to match participants with partners, prior to the experiment, all participants completed a registration survey including questions on participant's goals for the experiment, professional demographics, and their research techniques and areas of interest, as well as other techniques and areas of interest they were interesting in learning more about. Each of these questions had multiple categorical answers (See Supplemental Materials, Appendix 7.2.1 for a list of the research techniques and areas). These questions provided an objective description of each individual's research which was used to measure the research overlap between all pairs of participants. This research overlap measure was then used to determine which pairs would be introduced at the speed-networking event. This measure is referred to as *objective similarity,* to distinguish it from the subjective participant perception of similarity that I also collected from

pairs who actually met (*perceived similarity*). The objective similarity of each pair was calculated by comparing two individuals' answers for the following questions:

- AREA HAVE: Which areas have you studied or done research in?

- TECHNIQUE HAVE: What techniques do you consider important to your research?

- AREA WANT: If you indicated you're interested in learning about research in a different area, what topics would you like to learn about?

- TECHNIQUE WANT: If you indicated you were interested in finding an expert in a technique, what techniques are you interested in?

Participants answered each question by selecting all answers that applied from a provided list of possible topic areas or techniques (developed to fit the particular research focus of the event). I calculated objective similarity between a pair of participants using the following equation:

$$\text{Objective Similarity} = .3(\text{AREA HAVE: AREA HAVE}) +$$

$$.3(\text{TECHNIQUE HAVE: TECHNIQUE HAVE}) +$$

$$.15(\text{AREA WANT: AREA HAVE}) + .15(\text{AREA HAVE: AREA WANT}) +$$

$$.15(\text{TECHNIQUE HAVE: TECHNIQUE WANT}) +$$

$$.15(\text{TECHNIQUE WANT: TECHNIQUE HAVE}) \quad\quad (1)$$

where (x:y) measures the number of matching selected answers between question x for the first participant and question y for the second participant. The weights applied to each set of matching answers were designed to give equal importance to overlap of research areas and techniques and mutual complementarity of needs. For every possible pair of the *n* participants, the overlap in

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research was calculated to generate an *n*-by-*n* symmetrical objective similarity matrix used to assign participants into meeting pairs. Objective similarity values from this matching equation ranged from 0.0 to 2.25.

To prevent existing contacts from meeting at the event, participants noted their pre-existing relationships with other participants from a choice of "Collaborated together", "Published together", "Overlapping research interests", "Taught together", "Acquaintance", or "Other", selecting all that applied (or selecting none). This allowed me to reconstruct the social network between participants (a subset of their overall local academic network) as an *n*-by-*n* directional binary matrix of pre-existing ties, where each entry in the matrix indicated whether a participant identified any type of previous relationship with another participant (meaning that person was an ineligible partner, 0) or not (an eligible partner, 1). Though some reported ties were unidirectional, only bidirectional ties where both individuals indicated some type of pre-existing relationship were considered ineligible to meet at the event.

By calculating the entry-wise product of the pre-existing tie matrix by the objective similarity matrix, I generated a matrix of the objective similarity of all eligible partnerships (those pairs of individuals who did not have an existing bidirectional relationship). Values ranged from 0 to 4.35. The experimental manipulation was designed to divide participants into two groups, one with members with large overlap in terms of research (high objective similarity) and the other group with little overlap (low objective similarity). I ran a Monte Carlo simulation in which participants were randomly divided into two groups of equal size 100,000 times and the division with the largest difference in mean objective similarity between groups was chosen for the actual event. Due to 3 invited participants who did not attend the event, the groups in the experiment differed slightly in size; the high objective similarity group (*n* = 16) was smaller than

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the low objective similarity group (n = 18). Participants were then assigned 10 random partners within their group.

3.2.1.2 At the Session

The experimental speed-networking session was run in a large meeting room over a 3-hour period during which participants received lunch and coffee. The experimental room was set up with two rows of ten small tables approximately four feet apart. Participants received a card upon arrival showing their assigned partners and meeting tables for each round. The experiment was divided into 10 rounds each nine minutes long, with a 10 minute break between rounds 5 and 6. Every round, participants met a new assigned partner at a two-person table to talk for 6 minutes (with a bell at 5 minutes indicating that one minute remained), followed by 3 minutes to complete a partner evaluation survey and move to the next partner.

For the partner evaluations, participants indicated how similar their partner's research was to their own (*perceived similarity)* on a Likert scale from 1 (very distant) to 5 (very close), and whether this particular partner furthered the participant's goals (*goal achievement),* a binary measure of yes or no. For each pair who met, there are thus two ratings of subjective perceived similarity (one from each of the two meeting partners) that can be compared to the single, pair-level algorithmic measure of objective similarity; for the specific purposes of this chapter, I focus only on perceived similarity. Participants could also suggest potential collaborators from their social network to their partners. Occasionally, one or both individuals in a pair did not complete the partner evaluation survey; these pairs are excluded from further pair-wise analysis but included in individual-level analyses.

3.2.1.3 Following the Session

At the end of the speed-networking session, participants completed an anonymous questionnaire measuring their satisfaction with the event and intent to collaborate with other attendees. Participants were also provided with information on how to apply for the seed-funding grant for new collaborations: Those who chose to collaborate together (in teams of two or more) could apply within two weeks of the session for an exclusive seed-funding grant from the organizing body, providing up to $2000 for multiple groups.

Following the experiment, participants were sent the contact information for the individuals they met who consented to sending their information to that participant, as well as the names of any other researchers that their partners had suggested. Participants were contacted after 3 and 12 months to see whether additional collaborations or interactions had occurred with people they met at the event, but completion rates were low and are not included in this chapter.

3.2.1.4 Measurements

Collaboration was measured in terms of the number of individuals and number of teams applying for seed-funding. When examining these teams at the dyad level (e.g. ratings of perceived similarity by the two team members when they met as partners at the event), they are referred to as 'collaborative pairs' or 'collaborative partners'. When examining differences between individuals who formed a team and applied for seed-funding and individuals who did not, the former are referred to as 'collaborators' and the latter as 'non-collaborators'.

Objective similarity was measured for each meeting pair using Equation (1) based on a research interest survey filled out prior to the experiment. One rating is available for each of the 150 pairs. The average objective similarity between pairs who met was 1.72 ($SD = 0.82$) for the high group and 0.77 ($SD = 0.48$) for the low group.

Perceived similarity was taken from the partner evaluation survey question about each partner's research interest overlap with the participant's own (5-point Likert-type item). Based on the number of attendees and assigned partners, a total of 310 partner evaluationsurveys and 155 pairs (to account for 60 partner evaluation surveys and 30 pairs between attendees and cancellations) were expected. However, there were occasions where neither member of a meeting pair recorded a meeting occurring (either by completing a seed-funding application or an partner evaluation survey) or where two individuals without partners in a round chose to meet. The total recorded interactions (where at least one partner completed an partner evaluation survey or submitted a seed-funding application) was 150 unique pairs and 297 partner evaluation surveys from those pairs (due to 3 occasions where a participant did not complete a survey about meeting a partner). There were 289 such perceived similarity ratings completed from the 297 partner evaluation surveys.

3.2.2 Results

3.2.2.1 H1: Objective Similarity

A total of 10 out of 34 attendees applied for one or more collaborative seed-funding grants, forming 6 teams of two individuals (with two attendees who were each in two teams). All 6 collaborating teams that applied were approved for the grant. Analyses were conducted at the pair-level unless otherwise noted. Contrary to H1a, objective similarity was not significantly higher for collaborative pairs ($n = 6$, $M = 1.35$, $SD = 1.06$) than for non-collaborative pairs meeting at the event ($n = 144$, $M = 1.23$, $SD = 0.81$) (Independent Samples t-test, $t(148) = 0.36$, p

= 0.72). This was also the case for the six[3] potential measures of overlap on objective similarity components (Independent Samples t-tests, α =0.008 for multiple comparisons). Comparing the experimental groups, two collaborative pairs came from the high objective similarity group, three pairs from the low group, and one pair contained a member from each experimental group (who met as a result of a participant cancellation), contrary to H1b.

3.2.2.2 H2: Perceived Similarity

However, perceived similarity *was* higher for collaborative pairs, indicating that correlates of perceived similarity may predict collaborative behavior. The pair-level score of perceived similarity, calculated by averaging the similarity ratings given by both partners toward each other, showed collaborative partners to be more similar ($n = 5$[4], $M = 4.60$, $SD = 0.22$) than non-collaborative partners ($n = 136$, $M = 2.68$, $SD = 0.98$). Due to variations in the number of collaborative and non-collaborative pairs and non-equal variances (Barlett's test, $p > 0.05$), I do not report t-test results, but the result shown in Figure 3.1 clearly supports H2a.

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[3] Including the average overlap in desired new techniques to current techniques, average overlap in desired new research areas to current research areas, shared current research areas, shared current techniques, as well as two components not included in objective similarity, overlap in desired new techniques and overlap in desired new research areas. Two of these components, overlap in new techniques known and average overlap in desired new techniques to current techniques, had non-equal variance (Bartlett's test, $p < 0.05$ and could not be compared with a t-test.

[4] The in-event survey for one collaborative pair was not completed by either partner (leaving us with one less datapoint of perceived similarity).
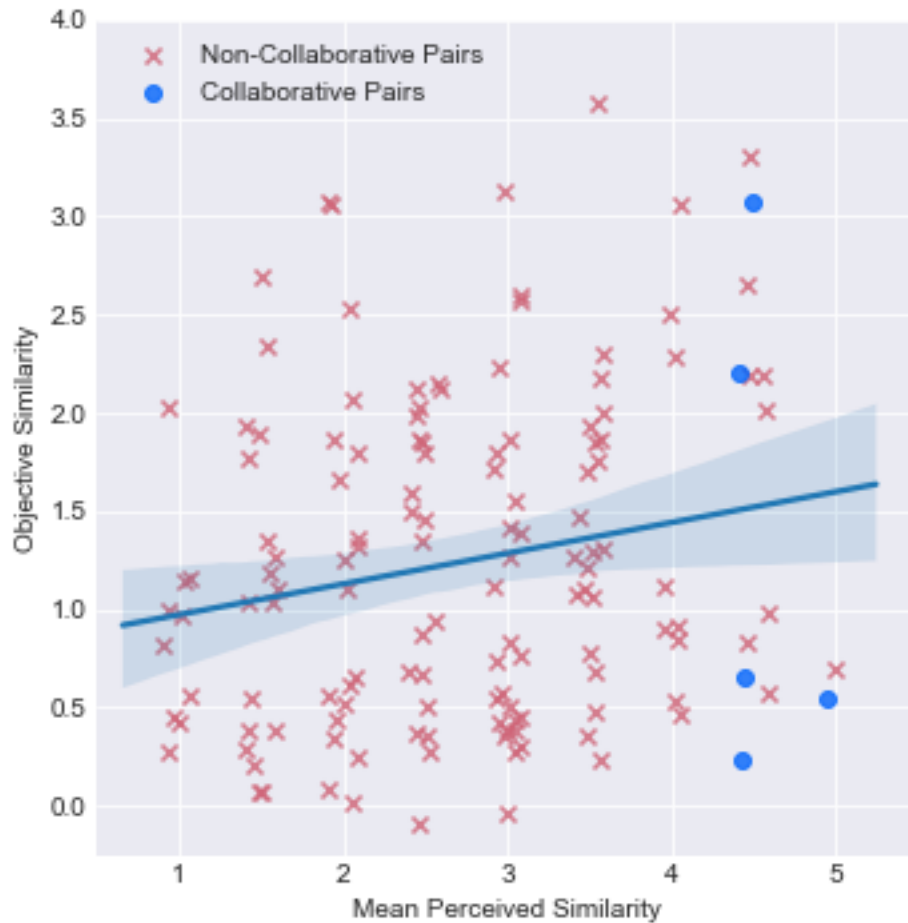
Figure 3.1: Scatterplot of the objective similarity of each pair who met during the event (y-axis) versus the mean of the perceived similarity scores of the two partners in that pair (x-axis). Pairs who formed a collaboration are in blue, and those who did not are in red. The plot has had jitter applied for ease of reading. Regression line in blue; shaded areas around line indicate 95% Confidence Interval.

There was a modest correlation between objective similarity and the mean of pairs' perceived similarity ratings (Spearman's R, $r(139) = 0.18$, $p = 0.03$). Based on this partial support for H2b, I further examined the individual components of objective similarity to see if they could predict successful collaborations to further Experiment 2.

3.3   Experiment 2

3.3.1   Method

While participants in Experiment 1 were matched according to an initial estimate of how to construct a useful measure of objective similarity (i.e. one that would approximate the participants' own judgment of similarity with their partner), for Experiment 2, I updated the measure of objective similarity based on what was learned from the first experiment using a regression model predicting perceived similarity using the objective similarity components (see calculations and limitations of this method in Supplemental Materials; Appendix 7.2.2). That is, I used the following equation for objective similarity, with the weights for each component coming from its regressed association with perceived similarity:

Objective Similarity = 0.204 (AREA HAVE: AREA HAVE) + 0.086 (TECHNIQUE

HAVE: TECHNIQUE HAVE)   (2)

where the component coefficients are as described in Supplemental Materials, Table 7.4.

I held a second speed-networking event with two distinct subgroups (based on slightly different scientific themes), forming pseudo-experimental and control conditions. The control group (2C, $n = 10$) met every member of their group (9 partners). For the experimental group (2E, $n = 16$), where each participant could not meet every member, each participant met 9 non-random within-group partners. These partners were non-randomly assigned to attempt to ensure

they met the three most objective similarity pairs at the individual level according to Equation 2 (see details and considerations on assignment in Appendix 7.2.2) but did not result in a difference in objective similarity (as defined by Equation 2) between the meeting pairs in the two groups (Independent Samples T-test, t (111) = 1.57, p = 0.12), and so I focus only on the impacts of perceived and objective (as defined by Equation 2) similarity on collaboration (not speaking to H1b). Individuals were not aware that they were in two distinct groups, as the route of table rotation was unique and unpredictable for each participant, masking the lack of interaction with the other group, and all other aspects of the experiment were the same for both groups (see Supplemental Materials, Appendix 7.2.3, for more details).

Experiment 2 followed the same procedure as Experiment 1, including the seed-funding incentive, with small changes to examine collaborative intent in greater detail. The pre-event survey questions on techniques and areas of research were updated to fit the new event theme (see Supplemental Materials, Appendix 7.2.4). Feedback from Experiment 1 indicated that excluding pairs with any previous relationships was too restrictive, as the relationship may not have touched on the speed-networking session's research theme. Instead, a new question was added to the registration survey to assess whether the participant had specifically discussed their interests related to the session's research theme with each of the other participants, which was used to limit allowable partners for matching. Finally, the partner evaluation survey included a new question asking whether the participant could collaborate with their current partner.

In total, 26 participants with 9 partners should produce 117 pairs and 234 partner evaluation surveys. However, ten partner evaluation surveys were not completed (n = 224). To be conservative, I considered a pair to have met if at least one member completed a partner evaluation survey or a pair completed a seed-funding grant application, for a total of 113 unique

pairs in 2C and 2E. The 4 missing pairs were all in 2E, and 2 partners did not complete the partner evaluation survey but their partner did. In two cases, one member of pair was missing a perceived closeness rating and were excluded from analysis of this measure.

3.3.2   Results

In total, 8 out of 26 participants from 6 pairs combined into 5 teams that applied for and received collaborative seed-funding grants. In the experimental condition (2E; $n = 68$ pairs), 5 pairs formed 4 collaboration teams and applied for seed funding (one team contained one person plus two partners of that person from two different pairs, each coded as a collaborative pair); and 1 pair formed a single collaboration team in the control condition (2C; $n = 45$). Several participants formed multiple collaborations with different partners.

3.3.2.1   H1: Objective Similarity

Unlike Experiment 1, collaborative pairs from all conditions ($n = 6$, $M = 0.58$, $SD = 0.36$) had significantly higher rating of objective similarity (as determined via Equation 2) than non-collaborative pairs ($n = 107$, $M = 0.29$, $SD = 0.28$) (Independent Samples t-test, $t (111) = 2.41$, $p = 0.02$), in support of H1a. Post-hoc analyses did not indicate that any particular component of objective similarity influenced this effect (Independent Sample's t-tests, all $p > 0.008$ or variance was non-equivalent and could not be compared). There was no mean objective similarity difference between 2C and 2E, so H1b could not be evaluated.

3.3.2.2   H2: Perceived Similarity

I failed to replicate the higher perceived similarity scores for collaborative than non-collaborative partners found in Experiment 1, contrary to H2a: Individuals in both groups did not

rate collaborative partners ($n = 5$[5], $M = 4.00$, $SD = 0.87$) as significantly more similar than non-collaborative partners ($n = 106$, $M = 3.49$, $SD = 1.02$) (Independent Samples t-test: $t\,(109) = 1.11$, $p = 0.27$). There was no significant correlation across groups between objective and perceived similarity (Spearman's R, $r(109) = 0.045$, $p = 0.64$), in contrast to H2b.

3.4 Experiment 3

3.4.1 Method

To assess the importance of direct incentives for collaborating on collaboration rates in a speed-networking event, I ran a third session in which no seed grant funding was offered. Participants were not required to sign up prior to the event, but rather were solicited at an internal workshop for women in technology fields. Consequently, no research interest data was collected for objective similarity and matching purposes, and pairs of partners were randomly assigned to meet. This setting allowed me to investigate the base rate of collaborations formed without experimental intervention in a naturalistic context.

At the event, 22 participants sat in two lines of chairs facing each other. Participants interacted with the partner in the chair seated across from them for 6 minutes, completed an partner evaluation survey, and then rotated to the next seat to talk with the next partner. This continued until most participants had met 7 partners, followed by the post-event survey. Collaborations were determined using an emailed follow-up survey sent two weeks after participants received partner contact information—at that point, participants were asked whether

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[5] One individual in an applicant pair, and another individual in a non-applicant pair did not complete a rating for closeness for their partner, lowering sample size.

they had contacted any attendees from the event, and if so, whether they formed a collaboration together. No other measures of collaboration were completed.

3.4.2   Results

Among the 22 participants and 75 pairs, a total of 3 collaborations (including one advising relationship) were reported to have formed between 6 individuals. The average rating of mean perceived similarity by all pairs who met was 2.75 ($SD = 1.02$, $n = 75$), corresponding to "Somewhat Similar." Of the possible 6 partner evaluation surveys that could be completed by the 3 collaborative pairs, only 2 were completed; comparing traits among collaborators and non-collaborators would be unreliable and the results are not reported.

3.5   Across All Experiments

After completing three experiments, I now compare whether the manipulations of each event (including the similarity of partners, matching method, and presence of external funding) influenced collaborative partner choice or collaboration rates. First, I list the current support for the hypotheses given the analysis of individual experiments, as shown in Table 3.2. H1b, predicting groups with a higher average objective similarity between pairs would collaborate more than lower objective similarity pairs, was not supported in Experiment 1, the only individual event where comparisons were made. For the remaining hypotheses, the results are mixed at best, perhaps due to the low number of collaborators. I next go through the hypotheses individually, pooling data across experiments where possible. Because Experiment 3 included no measures of objective similarity, for similarity of comparisons between hypothesis tests, the data are only used in the test of H1b; all other comparisons are pooled across Experiments 1 and 2.

Event	H1a	H1b	H2a	H2b
Experiment 1	No	No	Yes	Yes
Experiment 2	Yes	N/A	No	No
Experiment 3	N/A	N/A	N/A	N/A

Table 3.1: Support for original hypotheses following analysis of individual experiments.

3.5.1   Objective Similarity

3.5.1.1   H1a: Pairs of Individuals with High Objective Similarity Should Be More Likely to Collaborate Than Low Objective Similarity Pairs.

Prior analyses comparing collaborating and non-collaborating pairs were hampered by the infrequency of the former. Pooling the data across Experiments 1 and 2, I assessed the effect of the six individual components of within-pair objective similarity and mean perceived similarity on whether collaborations formed (1 = Yes), using logistic regression at the pair level in SPSS. None of the objective similarity components contributed significantly to predicting collaboration ($p > 0.008$) except average perceived similarity (Table 3.2). There was a significant fit of the equation to predicting collaboration X^2 (7, $n = 252$) = 27.147, $p<0.001$. The equation correctly predicted 95.6% of cases, but 0% of positive cases, almost identical to the null model using only an intercept.

	β	SE	Wald	p	Exp(β)
Constant	-9.796	2.374	17.021	**<0.001**	<0.001
Mean Perceived Similarity	1.774	0.525	11.409	**0.001**	5.892
AREA HAVE: AREA HAVE	-0.432	0.443	0.951	0.329	0.649
AREA WANT: AREA WANT	-16.906	3152.053	<0.001	0.996	<0.001
AREA WANT: AREA HAVE	-0.317	0.426	0.555	0.456	0.728
TECHNIQUE HAVE: TECHNIQUE HAVE	0.254	0.194	1.712	0.191	1.289
TECHNIQUE WANT: TECHNIQUE WANT	0.449	0.725	0.384	0.536	1.567
TECHNIQUE WANT: TECHNIQUE HAVE	0.142	0.359	0.156	0.692	1.153

Table 3.2: Results of logistic regression at pair level predicting collaboration on pooled data from Experiments 1 and 2 showing relation between specific components of the objective similarity function and the individual perceived similarity assessed for both. x:y measures the number of matching selected answers between question x for the first participant and question y for the second participant, and AREA HAVE = current areas of study, TECHIQUE HAVE = current techniques, AREA WANT = desired new areas of study, and TECHNIQUE WANT = desired new techniques. α=0.007.

Comparing collaborators and non-collaborators on both measures of objective similarity (Equations 1 and 2), there was no significant difference on either the original (Independent Sample's T-test, $t(261) = 0.09$, $p = 0.93$) or the reweighted objective similarity measures ($t(261) = 0.41, p = 0.68$).

Overall, these results show little relationship between objective similarity and collaboration rates, suggesting individuals choose collaborative partners using other criteria, and I fail to reject the null hypothesis that objective similarity does not impact collaborative behavior.

3.5.1.2   H1b: Matching Schemes That Increase the Mean Objective Similarity of Pairs Who Meet in Speed-Networking Should Produce Higher Collaboration Rates.

As stated above, there was been no support for H1b in Experiment 1. However, I designed the experimental speed-networking setups to have different levels and varieties of objective similarity between groups and partners, which was expected to have a corresponding effect on the rates of collaborations formed (H1b) and perceived similarity of partners (H2b). There were significant differences in objective similarity between events (Table 3.3), so I compare collaboration activity between them.

Event	Objective Similarity (Equation 1) Mean (*SD*)	Objective Similarity (Equation 2) Mean (*SD*)	*n*
1	1.23 (.81)^{A***}	0.26 (0.27)$^{A***,\,C**}$	150
2C	1.94 (1.20)$^{A***,\,B**}$	0.43 (0.39)^{A***}	45
2E	1.36 (0.74)^{B**}	0.35 (0.21)^{C**}	68

**: $p < 0.01$ ***: $p < 0.001$

Table 3.3 Comparisons of Objective Similarity (based on Equations 1 and 2) between different speed-networking events. Alphabetical superscripts indicate events compared: A (1 and 2C), B (2C and 2E), and C (1 and 2E).

I compared between experiments to see whether any particular method of matching leads to noticeably greater collaboration rates. In total, 15 unique pairs collaborated (in teams of 2 or 3), out of a total of 338 pairs that met across events. Across all events (1, 2E, 2C, and 3), 24 individuals collaborated out of 82 total attendees. Between experiments, there was no significant difference in the proportion of attendees who did and did not form collaborations (Chi Square Test of Independence with Yate's Correction, $X^2(3, n = 82) = 1.01$, $p = 0.80$). In regard to H1b, I fail to reject the null hypothesis that collaboration activity would not vary between events, which included manipulation of partner objective similarity.

3.5.2 Perceived Similarity

3.5.2.1 H2a: Participants Will Collaborate More with Partners with Higher Perceived Similarity Than Partners Lower Perceived Similarity.

As reported earlier, in Experiment 1 individuals rated individual collaborative partners as higher on perceived similarity than non-collaborative partners, but this finding was not replicated in Experiment 2. When the data is pooled across events, individuals overall rated non-collaborative partners as significantly less similar in research interests ($M = 3.0$, $SD = 1.07$, $n = 242$) than those in collaborative pairs ($M = 4.3$, $SD = 0.67$, $n = 10$[6]) (Independent Samples t-test, $t(250) = 3.71$, $p < 0.001$), in line with H2a. I reject the null hypothesis that perceived similarity does not vary between collaborative and non-collaborative pairs.

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[6] Recall that two collaborating pairs, one from each of Experiment 1 and 2, did not have a mean rating of perceived similarity by the partners due to incompleteness of data.

3.5.2.2 H2b: Participants Will Judge Perceived Similarity to Their Partners Based on Overlap in Objective Information Such as Research Experience and Interests. That Is, Perceived and Objective Similarity Should Be Highly Correlated.

To directly examine the relationship between objective and perceived similarity per H2b, a correlation was run comparing the mean perceived similarity of all pairs meeting at every event with the two measures of objective similarity. Both the original and revised objective similarity measures positively and significantly correlated with the mean perceived similarity of pairs (Spearman's R, $r(250) = 0.20$ and 0.34, respectively, $p < 0.005$). This finding provides support for H2b.

I also analyzed what components of objective similarity matter for judgments of perceived research similarity, pooling across the data from Experiments 1 and 2 (see Table 3.3) using data at an individual level (rather than the pair level). In a linear regression analysis conducted in SPSS, there were significant relationships between perceived research similarity and the components of overlapping objective similarity ($F(6, 504) = 8.974$, $p<0.001$). Specifically, higher ratings of overlap between currently used techniques for both partners significantly increased ratings of perceived similarity, but no other components had significant effects (see Table 3.4 below).

	Coefficients	SE	t	p(t)
Intercept	2.77	0.087	31.71	<0.001
AREA HAVE: **AREA HAVE**	0.153	0.064	2.38	0.018
AREA WANT: **AREA WANT**	0.118	0.068	1.735	0.083
AREA HAVE: **AREA WANT**	-0.030	0.031	0.953	0.341
TECHNIQUE HAVE: **TECHNIQUE HAVE**	0.127	0.029	4.349	**<0.001**
TECHNIQUE WANT: **TECHNIQUE WANT**	-0.06	0.102	-0.603	0.547
TECHNIQUE HAVE: **TECHNIQUE WANT**	-0.057	0.039	1.472	0.142

Table 3.4 Regression model on pooled data from Experiments 1 and 2 showing relation between specific components of the objective similarity function and the individual perceived similarity assessed for both individuals in a pair, where x:y measures the number of matching selected answers between question x for the first participant and question y for the second participant, and AREA HAVE = current areas of study, TECHIQUE HAVE = current techniques, AREA WANT = desired new areas of study, and TECHNIQUE WANT = desired new techniques. Significant values in bold, α=0.008

3.6   Discussion

I combined speed-networking and algorithmic matching to increase the likelihood of participants finding appropriate collaborators by having them rapidly meet many individuals in a social, face-to-face context to assess both the professional and social compatibility for a successful collaboration (Das & Teng, 1998; Dasgupta, 1988; Ellinger et al., 2006). This work assessed the efficacy of a matching algorithm in a naturalistic social setting and measured collaborations by seeing whether new collaborations actually formed, rather than success in predicting pre-existing collaborations or stated intentions to form new collaborations. Overall, this series of experiments suggests that speed-networking is an effective method for producing collaborations, but in a way that has little to do with the measures that are typically incorporated into algorithmic matching, such as matching by the overlap in stated preferences and a partners' expertise or the similarity of research areas.

I attempted several manipulations to influence collaboration rates. There was no significant difference in the number of collaborations that formed among individuals divided into groups with higher or lower similarity (Experiment 1), individuals ensured to meet their objective "best" partners at the event (Experiment 2E), and individuals paired randomly (Experiment 2C and Experiment 3). The only measures that somewhat predicted collaborations were the within-pair similarity as perceived by participants. The only features of objective similarity that correlated with perceived similarity were overlap in current techniques used and (marginally) current research areas, which is understandable since perceived similarity came from asking participants to rate the research similarity of their partner, but the low correlation coefficients suggest that other factors must influence participants' partner perceptions. It is thus

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unsurprising that the manipulations of objective overlap in Experiments 1 and 2 did not alter collaboration rates.

Humans are generally drawn by homophily to form social relationships with similar individuals. I examined whether this was also true for professional collaborative relationships, defining similarity as objectively measured overlap in research approach. The highest-similarity partners (in terms of overlap and complementarity of research areas and techniques) were not more likely to be collaborative partners, suggesting that any influence of homophily on collaborative preferences may not be based on features of research overlap. But the quest for an "objective" match ignores the fact that collaborations, as social relationships, also involve interpersonal compatibility and trust, which may be more important than any particular aspects of one's research. Collaborative aptitude may include social attributes (such as camaraderie). Just as a blind date set up by a dating app can often fail to connect two individuals who were seemingly well-matched on the basis of an array of survey questions, so can potential collaborations predicted solely from research descriptions falter. The success of speed-networking at producing collaborations may be the result of the same characteristics that have made speed-dating popular in a romantic context: the highly structured environment providing multiple encounters with one-on-one interaction that enables assessment of *personal compatibility*. Future studies could examine whether the social context where pairs of individuals meet affects their ability to judge their compatibility and collaborative potential (e.g., at a department mixer, over a cup of coffee, or over an online chat), as well as additional objective measures of research similarity or compatibility not included in this study (such as shared collaborative partners or publishing patterns).

3.6.1   What Impacts the Numbers of Collaborations Formed?

One goal for this chapter was to examine methods for increasing the likelihood of collaborations forming between academics. Regardless of experimental manipulation, the participants formed collaborations, and there was no significant change in collaboration rates arising from specifically targeted matches, varying research similarity of one's partners, or the availability of funding incentives compared to a typical, unpaired speed-networking event. The most critical aspect for forming new collaborations may not be matching, but simply attending an event with opportunities to meet like- and open-minded colleagues. This suggests that the "standard" randomly-paired speed-networking paradigm may be sufficient to foster the formation of collaborations, without the need for additional data collection and algorithmic matching (although added incentives may still be a useful lure to get greater numbers of participants to attend and collaborate). This should come as a relief to researchers in the field, given that the time and organization required to specifically pair participants prior to an event is far more than that needed for randomly paired speed-networking.

3.6.2   Is There No Magic Bullet for Collaboration?

It is tempting to look for the "magic bullet" or "serendipity factor" that predicts collaborations. No particular objective attribute stood out as the "collaboration" trait that can easily be calculated for a set of researchers prior to meeting. Whether other objective measures gleaned from publication and social network data can usefully predict future collaborations remains to be studied further, but my findings raise doubts about a "magic bullet" for matching potential collaborators solely on the basis of externally collected objective data.

The lack of clearly important factors may actually be beneficial. If there is no magic bullet, it may be that simply giving two people time to interact is enough to spark a

collaboration. Individuals generally prefer to interact with similar others, meaning those with greater social capital (e.g. those with more collaborations, contacts, and time at the university, and those with a more prestigious academic appointment) may only have opportunities to interact with similar others. These individuals will be less connected to populations of researchers that are typically disadvantaged (such as those entering new fields, new to the university, or traditionally underrepresented in their field) who would benefit most from access to those resources. If research similarity is not essential to collaboration formation, speed-networking events that structure interaction to prevent homophily could be used as a rapid intervention to link these two groups (but see also Curşeu, Kenis, Raab, & Brandes, 2010). Furthermore, providing greater opportunities for networking helps both individual researchers in terms of faculty career success (Peluchette, 1993) and their universities in terms of retention, as individuals who are highly connected within an organization are less likely to leave (McPherson, Popielarz, & Drobnic, 1992).

3.6.3 Limitations

Intentionally paired speed-networking is an intensive effort for both experimenters and participants. Pre-pairing participants requires extensive surveys and prevents last-minute participants from joining. As a research tool, speed-networking with assigned pairs is thus significantly hampered by participant attrition (resulting in unequal numbers of partners, or unintended changes in relative objective similarity) -- individuals who do not attend leave each of their assigned partners with a "free slot" when they were intended to meet. In Experiment 2, I addressed this issue by producing an algorithm to generate new schedules based on cancellations, which ensured an equal number of partners for each individual. However, future researchers

may well simply forego prior matching, given its lack of impact on collaborative outcomes, and just use random pairing instead.

This chapter's sample also may be subject to a self-selection bias. Because funding was listed as a potential outcome to the event, participants may have been more likely to collaborate than the average individual to gain funding.

Unexpectedly, some successful interactions managed to mask themselves from measurement. Some attending individuals, especially those who hit it off well, continued their conversations through breaks intended for filling out surveys, including one collaborative pair. Since some of the most "engrossing" conversations were less likely to produce trackable data, I consider the partner evaluation survey data to be conservative in terms of being able to measure the effects of high compatibility. I encourage future researchers to stay vigilant to the creative ways that academics and other subject populations behave given new opportunities for initiating and nurturing collaborations.

For participants, if intense sequential conversation with several partners (as in speed-dating) led to fatigue over time, then these results could be influenced by the order in which participants meet partners. However, some past work with speed-dating found no changes in matching rates over time in a session (Todd, personal communication, 2019). Similarly, in these speed-networking events, I found stability over time: participant ratings of partners in all experiments remained relatively level over the course of each event (see Supplemental Materials, Appendix 7.2.5).

3.7 Conclusion

I adopted speed-dating into an effective tool for promoting the collaboration formation process, speed-networking. This pairing method is a useful platform for the study of scientific interaction and team building. Surprisingly, the effectiveness of speed-networking for collaboration does not seem to depend on matching individuals based on providing knowledge or techniques one specifically sought out or based on research similarity—the collaborative "fit" may be less dependent on true research overlap than on the perceptions of participants.

3.8   References

Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2008). How are preferences revealed?. *Journal of Public Economics, 92*(8-9), 1787-1794.

Blau, J. R. (1974). Patterns of communication among theoretical high energy physicists. *Sociometry*, 391-406.

Cabanac, G., Hubert, G., & Milard, B. (2015). Academic careers in Computer Science: Continuance and transience of lifetime co-authorships. *Scientometrics, 102*(1), 135-150.

Chaiwanarom, P., Ichise, R., & Lursinsap, C. (2010). Finding potential research collaborators in four degrees of separation. *Advanced Data Mining and Applications*, 399-410.

Cook, D. A., Bahn, R. S., & Menaker, R. (2010). Speed mentoring: an innovative method to facilitate mentoring relationships. *Medical teacher*, *32*(8), 692-694.

Curşeu, P. L., Kenis, P., Raab, J., & Brandes, U. (2010). Composing effective teams through team dating. *Organization Studies*, *31*(7), 873-894.

Das, T. K., & Teng, B. S. (1998). Between trust and control: Developing confidence in partner cooperation in alliances. *Academy of Management Review*, *23*(3), 491-512.

Dasgupta, P. (2000). Trust as a commodity. *Trust: Making and Breaking Cooperative Relations*, *4*, 49-72.

Ellinger, A. E., Keller, S. B., & Hansen, J. D. (2006). Bridging the divide between logistics and marketing: facilitating collaborative behavior. *Journal of Business Logistics*, *27*(2), 1-27.

Hellerstein, J. K., & Neumark, D. (2008). Workplace segregation in the United States: Race, ethnicity, and skill. *The Review of Economics and Statistics*, *90*(3), 459-477.

Kroes, E. P., & Sheldon, R. J. (1988). Stated preference methods: an introduction. *Journal of Transport Economics and Policy*, 11-25.

Lane, C., & Bachmann, R. (1997). Co-operation in inter-firm relations in Britain and Germany: The role of social institutions. *British Journal of Sociology*, 226-254.

Levin, D. Z., & Cross, R. (2004). The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. *Management Science*, *50*(11), 1477-1490.

Liben-Nowell, D., & Kleinberg, J. (2007). The link-prediction problem for social networks. *Journal of the Association for Information Science and Technology*, *58*(7), 1019-1031.

McPherson, J. M., Popielarz, P. A., & Drobnic, S. (1992). Social networks and organizational dynamics. *American Sociological Review*, 153-170.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual review of sociology*, *27*(1), 415-444.

Muurlink, O., & Poyatos Matas, C. (2011). From romance to rocket science: Speed dating in higher education. *Higher Education Research & Development*, *30*(6), 751-764.

Newman, M. E. (2001). The structure of scientific collaboration networks. *Proceedings of the National Academy of Sciences*, *98*(2), 404-409.

Peluchette, J. V. E. (1993). Subjective career success: The influence of individual difference, family, and organizational variables. *Journal of Vocational Behavior*, *43*(2), 198-208.

Popper, K. R. (1972). *Objective Knowledge: An Evolutionary Approach.* Oxford: Clarendon Press.

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.

Tsai, W., & Ghoshal, S. (1998). Social capital and value creation: The role of intrafirm networks. *Academy of Management Journal*, *41*(4), 464-476.

Vaggi, F., Schiavinotto, T., Lawson, J. L., Chessel, A., Dodgson, J., Geymonat, M., ... & Csikász-Nagy, A. (2014). Cutting Edge: A network approach to mixing delegates at meetings. *eLife*, *3*, e02273.

Wang, W., Yu, S., Bekele, T. M., Kong, X., & Xia, F. (2017). Scientific collaboration patterns vary with scholars' academic ages. *Scientometrics, 112*(1), 329-343.

4   The Stated-Revealed Preference Gap in Canine Companion Animal Choice

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Todd, P.M. (2019). Stated and Revealed Preferences in Companion Animal Choice. *Behavior
Research Methods.*

   In this chapter, I use existing (found) and newly gathered field data about the dog
adoption process to study how people choose companion animals. I begin by analyzing what
traits people visiting an animal shelter say they are looking for in a pet dog, as well as what traits
they actually end up with in terms of the dogs they adopt and see whether the stated-revealed
preference gap appears. As in mate choice, even if people do know (and correctly state) what
traits they seek in a dog, their choices can be impeded by inability to judge those traits
accurately—either on the part of the adopter or of third parties (e.g. animal shelter employees)
who are trying to assess adoptable dogs to help people make better choices. In the second study,
I analyze the relationship between adopters' ratings of dog traits and the ratings of those dogs
produced by a standard dog behavior assessment tool used in animal shelters.

4.1.1   Choosing Dogs as Social Partners

   Just as in romantic partner choice, individuals have preferences for a canine companion.
When choosing a dog to adopt, individuals primarily consider appearance and aspects of
behavior including personality, behavior with people, and friendliness towards children (e.g.
Weiss, Miller, Mohan-Gibbons, & Vela, 2012). Light-in-color, purebred, small, and young dogs
are more likely to be adopted and/or stay in shelters for shorter periods of time prior to adoption
(DeLeeuw, 2010; Lepper, Kass, & Hart, 2002; Posage, Bartlett, & Thomas, 1998). Stray (as

opposed to owner-relinquished) animals are also often preferred, due to perceptions that owner-relinquished animals may be more prone to behavior problems (DeLeeuw, 2010, but see also Wells & Hepper, 1992).

Understandably, individuals report that behavior is strongly influential on their adoption choices (Marston, Bennett, & Coleman, 2005). Adopters often have several ways to observe canine behavior, including within the dogs' kennels or in a one-on-one interaction in a separate area (Weiss et al., 2012). Individuals choosing pets attend to behavioral factors such as prior training, friendliness, and response to household members including current pets and children (Siettou, Fraser, & Fraser, 2014). In terms of predicting adoption success, owners derive greater relationship satisfaction from pet dogs who are higher in openness and agreeableness (Cavanaugh, Leonard, & Scammon, 2008), but it is unclear whether dogs are chosen on these criteria. Several factors used in dog choice are idiosyncratically valued; for example, the importance of the dog's sex is bimodally distributed, with some adopters valuing it strongly but many viewing it as unimportant (Marston et al., 2005).

The choice of a pet is distinct from human partner choice in ways that can impact the occurrence of a stated-revealed preference gap. In particular, pets are purchased (or adopted) similar to a consumer good, unlike the typical selection process of human social companions. Dog choice is therefore more of a one-sided than two-sided (i.e. mutual) social choice problem, which simplifies concerns about reciprocity, and in some cases, prices are generally fixed across available dogs. Overall, adopters do not have to settle for an acceptable dog based on their budget or personal appeal to canines and can freely choose a dog that best fits all their preferences, mitigating one potential cause of the stated-revealed preference gap. However, there is a stigma attached to both the type and method of dog acquisition (e.g. breed, animal shelter vs

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other methods; Bir, Widmar and Croney, 2017; Patronek, Twining, & Arluke, 2000), which could produce a stated-revealed preference gap if the pattern is driven by demand effects.

Being able to identify which stated preferences are generally used when choosing dogs would allow for the development of an automatic recommender system that considers how well individual animals meet the stated preferences of visitors. An adopter−dog matching algorithm paired with a rapid survey for assessing adopter preferences (as developed in this work) would allow visitors to receive custom matches and recommendations for animals to meet, which would save time for both adopters and shelter staff. Such a system could expedite and possibly improve the adoption process, shortening the average length of stay, increasing the number of animals adopted, and decreasing the need for space-saving euthanasia.

4.1.2   Using Existing and Collected Data

I combine two datasets to answer my questions about human choices of dogs as social partners: one collected in the field over a year-long period and another existing dataset covering multiple years. I begin with a study of the stated-revealed preference gap in individuals intending to adopt a dog (Study 1). I compare the stated preferences of individuals to their ratings of their chosen pet. I then explore how well these subjective perceptions of their animals match the more objectively obtained trait ratings in a large existing dataset covering all animals within the shelter (Study 2). I also examine the adoption patterns that had been previously recorded over multiple years to see whether they can be predicted by the objective trait ratings. If individuals use preferences for those objective traits to choose a pet, those dogs with the most preferred trait values should be chosen fastest; that is, they will have the shortest *length of stay*. The mixed results demonstrate the challenges of using existing organizational data and trying to connect it

with purposefully collected data and provide insight into how to improve the use of both types of data.

4.2 Study 1: Stated and Revealed Preferences

To explore the stated-revealed preference gap in choosing dogs as social companions, I surveyed animal shelter visitors interested in viewing dogs about their (stated) preferences. I then approached those who decided to adopt (*adopters*) and asked them to describe their chosen pet (revealed preferences).

4.2.1 Method

I worked with a municipal animal care and control facility (hereafter *shelter*) for a county of around 144,000 people in the Midwestern United States during 2017 and 2018. The shelter placed approximately 2300 animals in homes in 2016, including dogs, cats, small pets, and stray livestock. At this shelter, animals primarily arrive as a stray (i.e. an animal not linked to an owner), an owner-relinquishment, or a transfer from another shelter. Shelter policies are available in the Supplemental Materials (Appendix 7.3.1).

The chosen field site has features that minimized selection bias on the data. The shelter is open intake, indicating that no animals brought to their care are turned away (meaning there is no selection bias in the animals involved in this study) and did not practice space-saving euthanasia of dogs during the study period. Adoption requests for animals are processed in order (rather than accepting several and choosing amongst them for the best fit) and are very rarely denied. Any similarity between adopters and canines can be assumed to be due to adopter behavior, rather than shelter screening.

4.2.1.1 Measures

Stated Preference Survey. Participants stated whether or not they had a preference on 13 different behavioral and physical traits for dogs (see Table 4.1 and 4.2). If they had a preference, they indicated the trait level(s) they preferred out of two or three possibilities. Individuals choosing all levels as preferred were coded as having no preference. This survey was completed by all shelter visitors interested in viewing dogs, including but not limited to adopters ($n = 1229$).

Revealed Preference Survey. After adopting a dog, participants assessed their chosen pet on 45 behavioral tendencies using a five-point Likert scale (1 = *Strongly Disagree*, 5 = *Strongly Agree*). I focus on eight measures corresponding to the behavioral items in the Stated Preference Survey[7]:

- Easily Excitable: 'Is easily excitable'
- Friendliness: 'Is sociable'
- Energy Level: 'Has a lot of energy'
- Playfulness: 'Is playful'
- Nervousness: 'Is anxious'

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[7]When possible, measures were drawn from the extensively validated Dog Personality Questionnaire (Jones, 2009). This includes:

- 'Dog is anxious' (Study 1)
- 'Dog behaves aggressively towards dogs' (Study 2)
- 'Dog ignores commands' (Study 2)
- 'Is affectionate' (Study 2)

- Previous Training: 'Is well-trained'

- Intelligence: 'Is intelligent'

- Protectiveness: 'Is protective'

In addition, individuals were asked to indicate the coloring of the dog they chose (light, medium, or dark) as well as the size (small, medium, or large). Shelter staff assessed the age, breed status, and sex of each dog at the time of intake. The age of one dog was missing. The five Likert levels on the Revealed Preference Survey were mapped to the three categorical Stated Preference levels as follows: Dogs on the high extreme (5) were coded as 'Very' high levels of a trait, dogs on the low extreme (1) were coded as 'Not at all' exhibiting that trait, and the remainder (2-4) were coded as displaying that trait 'Somewhat'. Energy level and training each had unique levels. For energy level, dogs rated at the high extreme were coded as 'High', the low extreme as 'Low', and the remainder as 'Medium'. For training, dogs rated at the high extreme were coded as 'Extensive Training', the low extreme as 'No Training', and the remainder as 'Some Training'.

4.2.1.2 Procedure

All visitors to the shelter (including non-participants) were greeted by a research assistant inside the entrance and asked whether they were looking at the available dogs. If so, they were asked to voluntarily complete the Stated Preference Survey. The opt-in rate was approximately 50%, and some participants only completed this survey later when they were approached for the main study. I collected 1229 responses from June 2017 to May 2018.

Visitors who began the adoption process for an animal (as measured by completing the initial step of filling out an adoption application) were eligible for the main study; research assistants approached the individual and asked them to participate. I refer to these individuals as

adopters, although some did not complete the adoption process or returned their pet after adopting (As a result, in some cases later participants could choose to adopt a dog that had also been previously included in the study sample. Because assessments of the same dog's qualities varied considerably between adopters, I include those multiple adopters of the same animal in these analyses, amounting to 8 duplicate dogs with 17 records). If multiple individuals were interested in adopting a dog at once, only the first applicant (i.e. the individual with the earliest application, who is the only one who could actively choose to adopt that animal) were eligible to participate.

Participants completed the Revealed Preference Survey along with several other questions unrelated to the current study (including describing their experience at the shelter and personal characteristics). On the Revealed Preference Survey, one participant did not provide a rating for their dog on the trait 'Is sociable' and another on the trait "Ignores commands", and seven participants did not provide a size rating for their dog. If individuals had completed the Stated Preference Survey earlier, it was paired with the corresponding Revealed Preference Survey; if they had not yet completed the Stated Preference Survey, participants completed it at this point, prior to the Revealed Preference Survey. The majority (59.0%) completed the Stated Preference Survey after completing adoption counseling but prior to adoption. Most participants completed the study in under 30 minutes, and most accepted payment of $5. The rated dogs were paired with their corresponding records including physical characteristics and any behavior evaluations in a shelter-run database system (see Study 2). The age of one dog was unavailable.

To minimize bias beyond that expected by asking individuals to explicitly state their preferences, the stated preference surveys were situated in a naturalistic context and followed expectations for the decision situation. Within the animal shelter, this meant presenting the

survey in terms of assisting in choosing a dog, as one might expect in a retail environment. Rather than ranking or rating their preferences, I asked visitors whether or not they have a preference for each trait, and then if so, what trait value(s) they prefer.

4.2.1.3 Participants

A total of 170 eligible adopters participated; analysis was limited to the 145 participants who passed attentional checks, completed the entire survey, and provided enough information to locate the records of their chosen dog. Most participants were 18-29 years old and identified as women. Over 40% of owners had been the primary owner of one or two dogs in the past.

4.2.2 Results

The traits with the highest levels of stated preferences (all visitors: Table 4.1; adopters: Table 4.2) were friendliness, playfulness, and energy level while the least common were sex, purebred status, and color (see Figure 4.1 for adopters, red bars). Among visitors with a preference on a given trait, many traits showed one highly preferred level (energy level, training, playfulness, friendliness, excitability, and protectiveness), meaning there could be more competition for dogs with that trait level, but a few showed a more even distribution of preferred levels (sex and coloring), indicating idiosyncratic preferences across visitors.

Adopters were less likely than visitors as a whole to have a preference for energy level, excitability, nervousness, and protectiveness. Comparing adopters with a preference to all visitors with a preference, adopters were relatively similar, except for less of a preference for a young dog, light- and medium- colored dogs, not-at-all nervous dogs, and very protective dogs, and a greater preference for mixed breed dogs, dark-colored dogs, and somewhat nervous dogs. On average, adopters had preferences for 7.4 (+/- 3.5) of the 13 traits (ranging from 0 to 13, with 50% of the data between 5 and 10 traits).

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Trait	Percentage with Any Preference	Trait Levels		
Color	14%	Light (White, Grey, Tan): 26%	Medium (Light Brown, Red): 46%	Dark (Black, Dark Brown): 39%
Purebred Status	28%	Purebred: 21%	Mixed Breed: 79%	
Sex	36%	Female: 56%	Male: 44%	
Previous Training	56%	No training: 8%	Some training: 91%	Extensive training: 9%
Nervousness	58%	Not at all: 48%	Somewhat: 57%	Very: 1%
Protectiveness	66%	Not at all: 16%	Somewhat: 72%	Very: 18%
Intelligence	67%	Not at all: 0.4%	Somewhat: 57%	Very: 53%
Easily Excitable	69%	Not at all: 19%	Somewhat: 68%	Very: 17%
Age (Years)	73%	Young (< 2): 65%	Adult (2 - 7): 45%	Senior (8+): 7%
Size	73%	Small: 34%	Medium: 59%	Large: 33%
Energy Level	74%	Low: 23%	Medium: 86%	High: 8%
Playfulness	75%	Not at all: 1%	Somewhat: 69%	Very: 37%
Friendliness	88%	Not at all: 0.0%	Somewhat: 24%	Very: 83%

Table 4.1. Percentage with a stated preference and distribution of preferred trait levels across dog traits for all shelter visitors ($n = 1229$). Percentages of preferred trait levels are amongst those individuals with a preference. Individuals could indicate more than one level of preference on three-level traits, so proportions may add to more than 100%.

Trait	Percentage with Any Preference	Trait Levels		
Color	12%	Light (White, Grey, Tan): 18%	Medium (Light Brown, Red): 35%	Dark (Black, Dark Brown): 47%
Purebred Status	30%	Purebred: 5%	Mixed Breed: 95%	
Sex	32%	Female: 60%	Male: 40%	
Nervousness	50%	Not at all: 31%	Somewhat: 72%	Very: 0.0%
Previous Training	54%	No training: 8%	Some training: 94%	Extensive training: 5%
Protectiveness	61%	Not at all: 16%	Somewhat: 76%	Very: 9%
Easily Excitable	63%	Not at all: 16%	Somewhat: 66%	Very: 21%
Size	66%	Small: 34%	Medium: 53%	Large: 34%
Energy Level	66%	Low: 17%	Medium: 90%	High: 11%
Intelligence	69%	Not at all: 1%	Somewhat: 62%	Very: 46%
Age (Years)	71%	Young (<2): 53%	Adult (2 – 7): 50%	Senior (8+): 9%
Playfulness	76%	Not at all: 1%	Somewhat: 73%	Very: 32%
Friendliness	88%	Not at all: 0.0%	Somewhat: 28%	Very: 78%

Table 4.2. Percentage with a stated preference and distribution of preferred trait levels across dog traits for the adopter subsample (*n* = 145). Percentages of preferred trait levels are amongst those individuals with a preference. Individuals could indicate more than one level of preference on three-level traits, so proportions may add to more than 100%.

I then calculated for each trait the proportion of all adopters with a stated preference whose preference was fulfilled by their chosen pet's trait level as indicated by the adopter's own rating of that trait of their dog on the Revealed Preference Survey (Figure 4.1, grey bars). In general, most stated preferences were fulfilled more likely than not. I compared this proportion to what would be expected if each individual had been randomly assigned a dog from the sample (using the results of a null model over 10,000 iterations; Figure 4.1, blue bars). While the proportion of individuals choosing a dog that met their stated preferences exceeded chance on all traits, this difference was significant only for sex (Cohen's $d = 1.05$), size ($d = 0.62$), intelligence ($d = 0.36$), age ($d = 0.55$), and playfulness ($d = 0.40$) (α adjusted to .003 for multiple comparisons), suggesting that the stated-revealed preference gap was smaller than what would have been produced by random choices and hence that stated preferences on these traits were used to varying degrees in the decision-making process.

Choosing According To Preference
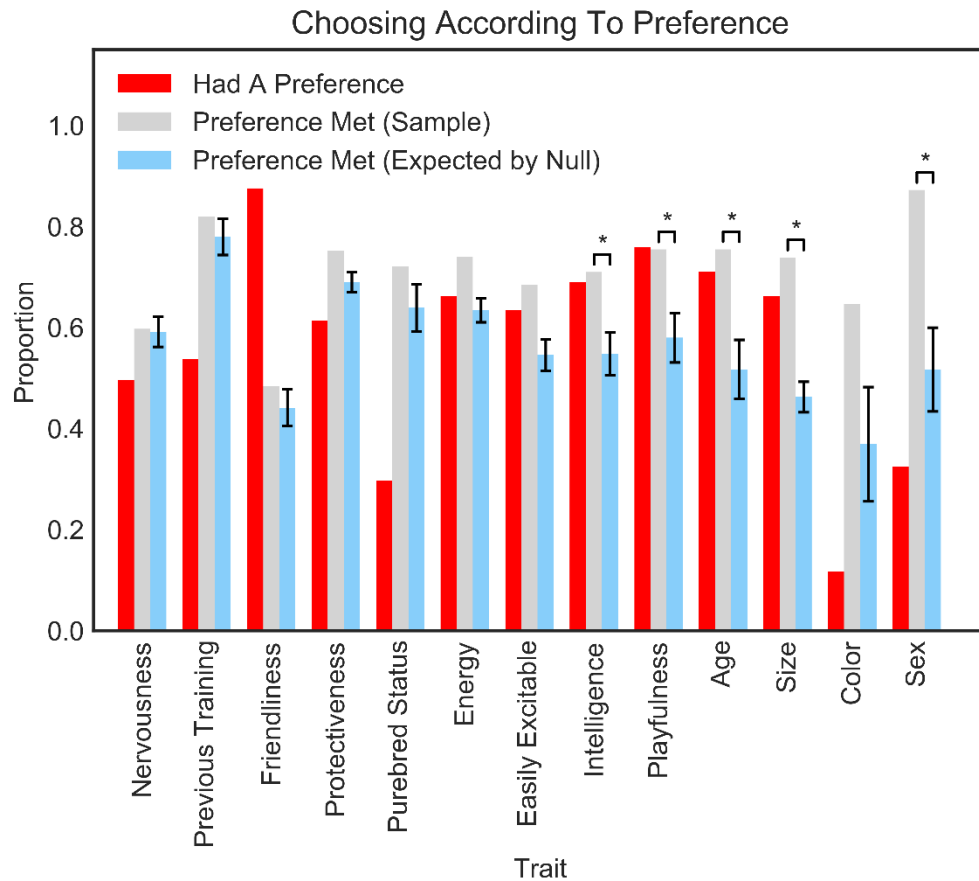
*: $p < 0.003$

Figure 4.1.Stated and met preferences in dog adoption. The 13 traits that adopters could state a preference for are shown on the x-axis. The proportion of adopters expressing a preference for that trait are shown in red. The proportion of those adopters who had a preference on that trait and chose a pet that fulfilled that preference is shown in grey, while the corresponding proportion of such matching choices expected through random choice (using a bootstrapping model of 10,000 iterations) is in blue. The x-axis is ordered according to the size of the difference between the grey and blue bars—that is, the difference between the proportion of adopters achieving a preference they held in their dog and the proportion who would achieve it due to chance. For all traits, the sample chose dogs that fulfilled their preferred levels on a trait more often than expected due to chance alone, though this result was significant for only five traits.

To assess the overall extent of the stated-revealed preference gap among these adopters, I also calculated the distribution of the proportion of preferred (stated) traits that each adopter found (revealed) in their chosen dog (i.e., how many people chose a dog meeting half of their stated trait preferences, how many chose a dog meeting all of their preferences, etc.) and compared this to the distribution of proportions of achieved preferences in a random-assignment null model (see Figures 4.2 and 4.3 for the distributions). In these distributions, the stated-revealed preference gap is the mean proportion of *unmet* trait preferences in their chosen dog (where individuals with no preference on a trait were considered to have their preference met).
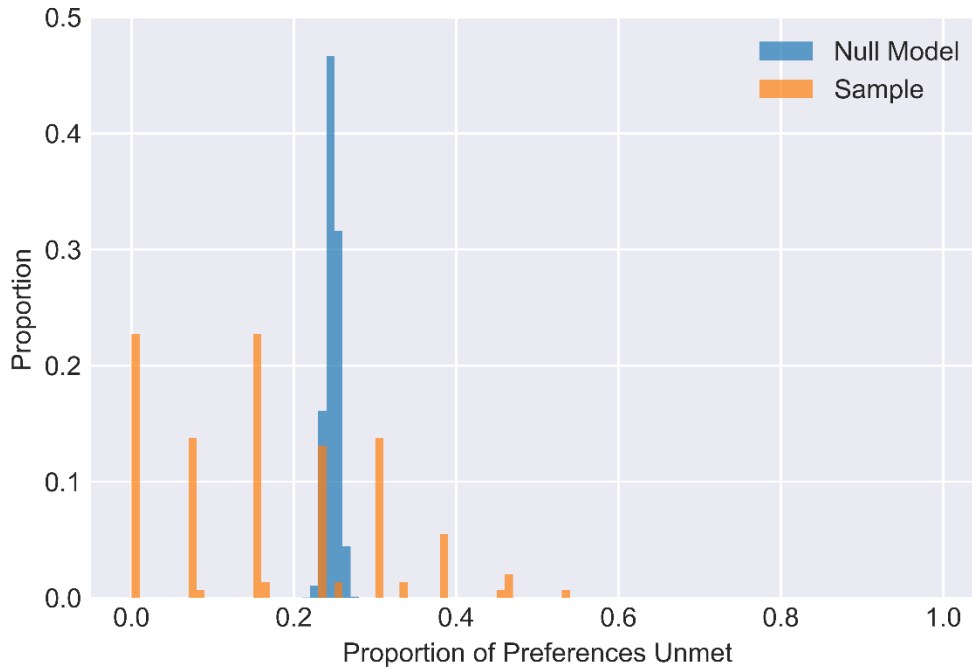
Figure 4.2. The size of the stated-revealed preference gap in Study 1 (orange), as measured by the proportion of preferences which were unmet (where individuals who had no preference on a trait automatically had their preference met) as compared to a bootstrapped null model of 10,000 simulations (blue)—see main text for details. Individuals typically had a smaller stated-revealed preference gap than expected due to chance.
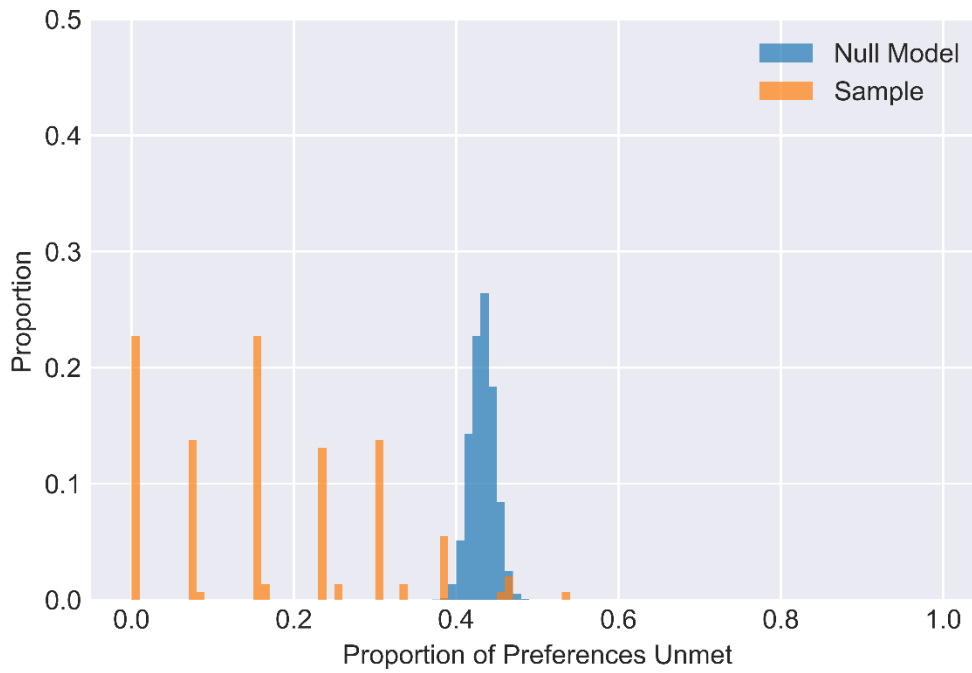
Figure 4.3. The size of the stated-revealed preference gap in Study 1 (orange), as measured by the proportion of preferences which were unmet (based only on the traits on which a participant had some preference) as compared to a bootstrapped null model of 10,000 simulations (blue)—see main text for details. Individuals typically had a smaller stated-revealed preference gap than expected due to chance.

Overall, adopters generally had a lower stated-revealed preference gap ($M = 17\%$ of traits unfilled, approximately 2 of 13 traits, $SD = 13\%$) than expected due to chance ($M = 25\%$, approximately 3 of 13 traits, $SD = 0.8\%$, One Sample t-test, $t(144) = 7.3$, $p < 0.001$, $d = 0.61$), indicating that they are picking dogs that are not inconsistent with most of the traits they say they want in a dog.

The above estimate reflects the stated-revealed preference gap but is potentially misleading because individuals vary in the total number of traits for which they had a preference. Some participants had no preferences whatsoever, meaning their stated-revealed preference gap would be 0; this is not an identical comparison to a participant who had preferences on all 13 traits, and had them all fulfilled, yielding an identical gap of 0. To control for variation in the number of traits on which individuals had a preference, I limited calculations of the stated-revealed preference gap to only the preferences on which an individual had some preference. On average, 29% ($SD = 21\%$) of an individuals' stated preferences were unfulfilled by their chosen dog, compared to 43% ($SD = 1\%$) by chance (One Sample t-test, $t(144) = 7.84$, $p < 0.001$, $d = 0.67$).

4.3 Study 2—Effect of Subjective and Objective Traits on Adoption

In the prior study, I found fairly consistent overlap between dog adopters' stated and revealed preferences on important traits. But accurately assessment of the stated-revealed preference gap was limited by having to use the adopters' own ratings of their new dog's traits, which they may have adjusted toward their original stated preferences to maintain appropriate coherence between those preferences and their choices (Riefer, Prior, Blair, Pavey, & Love 2017). Objective third-party ratings of the traits of all adoptable dogs at the shelter would enable more accurate comparison of stated preferences and chosen traits. Moreover, such ratings could

be used by shelters to automatically suggest dogs that match a new adopter's preferences, speeding up and improving the adoption process.

Most shelters already use some sort of system to assess basic characteristics of their animals. But how well these third-party ratings of canine behavior traits reflect what adopters are actually looking for must be assessed before those objective traits can be used. In this study, I compare the experimentally collected subjective trait ratings by adopters from Study 1 with a large existing dataset of behavior traits assessed in a more "objective" manner using in-shelter behavior assessments, to see if the latter can be used to predict dogs that would meet the former set of adopters' revealed preferences. I also examine how the objective traits relate to dogs' length of stay at the shelter before adoption, which is a proxy for the overall attractiveness of the dog within a choice set. Dogs that best fit more adopters' underlying preferences should be desired by more individuals, leading to shorter length of stay. The traits most predictive of length of stay constitute revealed preferences at a population level, which can be compared with stated preferences also at a population level as captured in Study 1. Furthermore, if I have both subjectively stated preferences and *objectively* revealed preferences for particular dogs, I can assess the stated-revealed preference gap at the individual level in a way that gets around the problem of adopters rating their own dogs encountered in Study 1.

4.3.1 Method

4.3.1.1 Data

The objective dog traits at the field site (collected January 2016 to March 2018) come from Match-Up II, a shelter data management software with proprietary behavioral testing maintained by the Animal Rescue League of Boston (http://matchupii.arlboston.org). Match-Up II includes physical trait information and measures of behaviors exhibited in the prior home,

within the shelter, and on an in-shelter behavior evaluation. The last is a battery of 16 subtests which was specifically designed to follow scientifically rigorous standards for testing behavioral differences (see Supplemental Materials, Appendix 7.3.2 for discussion of the tests and Appendix 7.3.3, Table 7.7 for descriptive statistics). The assessments are generally intended to define dog behavior (that is, responses to specific stimuli; Mirko, Doka, & Miklosi, 2013), rather than to assess personality (the dog's overall response to the environment), though Match-Up II does attempt to calculate six measures of personality (see below).

4.3.1.2   Procedure

On each Match-Up II subtest administered to the dogs in the dataset, shelter staff recorded the presence or absence of each of up to 63 relevant behaviors, movements, or postures, 16 of which were not exhibited by any dog in these data. The occurrences of the 47 behaviors seen in these dogs is shown in Appendix 7.3.3, Table 7.7 in the Supplemental Materials. I excluded subtests dealing with food possessiveness, canine interaction, and leash manners, as adopters were unlikely to view their new dog in those situations before giving their own subjective trait ratings (see also Mohan-Gibbons et al., 2018, on the limited benefits of food-guarding tests). Some subtests may not have been completed in full (e.g. if the dog snaps and growls during the Strange-Looking Individual subtest, the test may be discontinued for handler safety). If a dog had multiple records within Match-Up II, only the last was kept. Dogs with a stated outcome of "Other" or those transferred to another organization were excluded. Occasionally, demographic variables (e.g. coloring) were missing or coded as 'Don't Know'.

Pre-Defined Personality Measures. Match-Up II algorithmically calculates Friendliness (with a possible range of 0 to 34), Fearfulness (0 to 36), Excitability (0 to 33), Playfulness (0 to 21), Trainability (0 to 15), and Aggressiveness (0 to 36). I excluded Aggressiveness due to known

methodological issues in "diagnosing" aggressive behavior (Patronek & Bradley, 2016) and replaced Trainability with a less subjective measure, Total Commands Followed.

Total Commands Followed. I counted the total number of commands completed on the 'Cues' subtest (up to five). The five cues on the test include Come, Sit, Sit/Stay, Paw/Shake, and Down. Each dog is given up to three chances to complete a cue successfully. Dogs completing zero cues were rated as having 'No Previous Training', those completing one to three cues were rated as 'Some Training', and dogs completing four or five cues were rated as 'Extensive Training'.

Coloration. Coloration was obtained using separate techniques for the sample of dogs chosen by the adopters in Study 1 and the remaining dogs adopted for analysis of length of stay (see below). For the dogs from the Study 1 sample, coloration was obtained using existing photographs of those animals ($n = 120$ of 136 unique animals) taken by shelter staff during the animals' shelter stay. Each photo was evaluated by one of two research assistants provided with the three color groups and examples described in Study 1 and asked to provide a primary, and if different a secondary, coloration group. If no photos were available, coloration was based on primary and secondary (if any) coloration stored within the shelter management database, Animal Shelter Manager.

4.3.1.3 Measures for Predicting Length of Stays

I also examine an extended sample of all dogs adopted during the Study 2 period (January 2016 to March 2018) to determine what traits predict length of stay. A total of 1746 dogs were adopted during the study period, of which 1461 had at least one complete and clear length of stay resulting in adoption (see below). Of these 1461 dogs, 904 had Match-Up II records including behavior evaluations. Procedures varied slightly for the extended sample

compared to the adopted dogs from Study 1. The limited number of dogs who entered the shelter through confiscation or had an unspecified 'Other' method of intake were excluded.

Coloration. Lacking photos, I used the primary and secondary (if any) coloration provided within Match-Up II. Colors were simplified to the three groups used by adopters in Study 1: Dark (Black, Chocolate, Brindle, or Liver), Medium (Brown, Gray, Red, Tricolor, or Blue/Red Merle), and Light (Cream, White, Tan, Gold, Fawn, Buff, Gray, or Apricot). One animal had a secondary coloration of "Other", and this record was excluded from analysis of secondary coloration.

Size. In Match-Up II, size is not directly measured, and weight was rarely included in records by staff, so instead I approximate size using the dog's closest-resembled breed and AKC estimates of the typical weight of a purebred male of that breed: A dog up to 15 pounds (6.8 kg) was classified as Small, one from 15 pounds(6.8 kg) up to 49 pounds (22.2 kg) was Medium, and over 49 pounds (22.2 kg) was Large.

Length of Stay. The total length of stay at the shelter was calculated as the length in days from intake to adoption. Days spent in foster care were then subtracted from total length of stay; however, dogs in the system prior to April 2016 utilized a different foster care system which obscured the date the foster animal returned to the shelter, and so dogs in foster care prior to this date were excluded ($n = 152$), as were 47 dogs whose entrance and exit dates were chronologically unclear and 86 with no completely observed period from intake to adoption (i.e. a dog entered the shelter prior to the study period, but exited during it). Dogs who entered as strays had their relinquishment hold (during which an owner could reclaim a lost pet, five days) also subtracted from their total length of stay. Two outliers with a length of stay beyond 150 days were excluded, leaving 1461 dogs with 904 completing Match-Up II behavior evaluations. Those

animals with multiple visits to the shelter (i.e. returns; $n = 136$) were included as two or more separate observations and had each visit paired with the same behavioral record, producing an additional 156 records, for a total of 1060 records.

4.3.2   Results

4.3.2.1   Comparison Between Subjective and Objective Trait Ratings

Of the sample of 145 adopted dogs in Study 1, a total of 103 dogs had a Match-Up II behavioral evaluation completed, and I limit the analysis to this subset. I ran Spearman's correlations between the subjective (revealed) personality trait ratings of dogs by their adopters and the objective measures of those traits in Match-Up II for the traits Friendliness, Fearfulness, Excitability, and Playfulness, shown in the top four rows of Table 4.3. There was a significant positive correlation between objective and subjective Excitability and a sizable (but not significant) *negative* correlation for Fearfulness. All other correlations were not significant at an adjusted α of 0.005 for multiple comparisons.

Adopter Perceived Trait (Revealed Preference Survey)	Match-Up II Calculated Trait	Spearman's r	p	n
Is anxious	Fearfulness	-0.23	0.021	103
Is easily excitable	Excitability	0.32	**0.0009**	103
Is playful	Playfulness	-0.002	0.98	103
Is sociable	Friendliness	0.15	0.1408	102
Is well-trained	Total Commands Followed	-0.05	0.601	103
Barks frequently	Number of subtests where 'bark' was exhibited.	0.08	0.43	103
Behaves aggressively towards other dogs	Total behaviors present on the Dog-to-Dog subtest from Growl, Piloerection, Inhibited Bite, Uninhibited Bite, Show Teeth, Snap, and Head Whip.	0.03	0.93	102
Ignores commands	Total Commands Followed	-0.07	0.45	102
Is affectionate	Number of subtests where 'lick' was exhibited.	0.14	0.17	103

Table 4.3 Correlation between trait levels as rated by adopters and assessed by Match-Up II behavior evaluation. Significant values at α = 0.005 in bold.

To test whether this surprising lack of correspondence between the subjective and objective measures of these four traits was due to imprecision in the definitions of adjectives such as 'Friendly' or 'Fearful', I chose five additional items on the Revealed Preference Survey with fairly straightforward interpretations to simple behaviors measured in Match-Up II (see bottom five traits in Table 4.3). I again calculated Spearman's correlations between each revealed preference rating by adopters and the corresponding Match-Up II behavioral criteria. No correlation was significant at the 0.005 level. Together these results suggest that the correspondence between how adopters and Match-Up II evaluate a dog's behavior is far from clear.

Lastly, I tested whether there is greater correspondence between what adopters and Match-Up II raters say about presumably clear and constant appearance traits in contrast to the potentially variable behavioral traits above. Comparing the primary color of a dog's coat indicated by their adopters ($n = 139$) with the primary (and if available, secondary) color from shelter records, 16% of adopters categorized their pet's primary coloring differently from the Match-Up II raters (i.e. not matching either the primary or secondary coloring), again indicating a surprising level of mismatch between adopters' and third-party raters' assessments of dog traits.

4.3.2.2 Predicting Length of Stay

While the Match-Up II ratings did not match directly with individual adopters' own revealed preferences, this could have been because adopters did not accurately assess their chosen dog's traits or clearly reveal their preferences for those traits. Thus the more objective ratings given by the trained raters using Match-Up II could still be a useful way to get at traits that are important for adopters making their dog choices. To find out whether the large existing

dataset of Match-Up II ratings could be used to identify traits that matter to adopters at a population level, I tested the strength of various traits from Match-Up II to predict the length of stay of dogs at the shelter until adoption

Here, inverse length of stay is taken as a proxy for desirability of (and hence revealed preference for) a dog. I ran an ordinary least squares regression model in Python 3 using the Statsmodels module (Seabold & Perktold, 2010), dropping any canine stays that did not have all traits defined ($n = 41$), yielding a total of 1019 stays. I included as numeric predictors Age, Total Commands Followed, Friendliness, Fearfulness, Excitability, and Playfulness (see Table 4.4). I also included the following binary predictors (as dummy variables): Coloring (Dark and Medium relative to Light), Sex (Male), Purebred, Stray, and Size (Large and Small, relative to Medium).

Variable	β Coefficient	SE	t	P>|t|	95.0% CI
Constant	14.862	1.623	9.159	**>0.001**	11.678 to 18.046
Friendliness	-0.1659	0.072	-2.306	0.021	-0.307 to -0.025
Playfulness	1.6813	0.331	5.077	**>0.001**	1.031 to 2.331
Age	0.2553	0.135	1.886	0.06	-0.01 to 0.521
Large (Dummy)	3.5507	0.897	3.958	**>0.001**	1.79 to 5.311
Small (Dummy)	-2.5819	1.291	-2.0	0.046	-5.116 to -0.048
Excitability	-0.101	0.167	-0.605	0.546	-0.429 to 0.227
Total Commands Followed	0.0075	0.24	0.031	0.975	-0.464 to 0.479
Fearfulness	0.1945	0.139	1.395	0.163	-0.079 to 0.468
Dark Coloring (Dummy)	-0.6674	0.861	-0.775	0.439	-2.357 to 1.022
Medium Coloring (Dummy)	-0.1969	0.983	-0.2	0.841	-2.125 to 1.731
Male (Dummy)	1.0554	0.751	1.405	0.16	-0.419 to 2.53
Purebred (Dummy)	-0.0154	0.832	-0.019	0.985	-1.648 to 1.617
Stray (Dummy)	-3.0355	0.938	-3.235	**0.001**	-4.877 to -1.194

Table 4.4. Results of Ordinary Least-Squares Regression predicting length of stay; significant values at $\alpha = 0.003$ (for multiple comparisons) in bold. Variables are ordered according to importance to visitors, as measured by the proportion of visitors with a preference on the variable (excluding stray, which was available in the dataset but not included on the Stated Preference Survey as a preference dimension for visitors).

The model was a poor fit overall, with an adjusted $R^2 = 0.08$, $F(13, 1005) = 6.2$, $p < 0.001$. Friendliness weakly reduced length of stay, while surprisingly playfulness *increased* length of stay. Stray dogs, which are often preferred to owner-relinquished dogs due to a lower perceived rate of behavior issues, also exhibited shorter lengths of stay. Lastly, large dogs had significantly longer stays and smaller dogs had shorter stays relative to medium dogs. Coat color did not significantly impact length of stay; I failed to replicate the Black Dog effect, where dogs with dark coloring have longer lengths of stay (Note that not all preferences were expected to linearly affect length of stay, because as found in Study 1, some traits showed greatest preference for the middle level, including age, size, energy level, previous training, excitability, and protectiveness). Based on these results, it is difficult to argue for the usefulness of Match-Up II ratings to predict much about dog desirability at the population level.

4.4   Discussion

4.4.1   Summary of Results

I examined how the stated preferences of individuals adopting a dog from a shelter compared with their revealed preferences as expressed through their own ratings of their chosen dog. On every trait, individuals with a preference were more likely to fulfill that preference than would be expected through chance alone (although not always significantly), indicating that they were able to match their stated preferences to their choices reasonably well (especially for age, sex, size, playfulness, and intelligence). Surprisingly, the most valued traits were not necessarily fulfilled at significantly above-chance levels (e.g. friendliness).

However, using an individual's own ratings of their chosen dog is not an objective way of establishing their revealed preferences, so I next examined how well adopters' perceptions of personality and behavior matched those made using a common objective behavior evaluation

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tool, Match-Up II. There was little clear relationship between the two, which makes it difficult to use the objective system for recommending adoptable dogs to potential adopters based on trying to match their preferences. Furthermore, I tested whether any of the traits measured by Match-Up II can predict the choices of adopters at the population level in terms of length of stay, a measure of canine desirability. Stray and small dogs had shorter lengths of stay, but most behavioral traits did not have much effect. Interestingly, increased playfulness, a desirable trait that was fulfilled above chance for the adopters, *increased* length of stay on average. Adopters generally indicated they wanted a somewhat playful dog, rather than a very playful dog—it may be that high Match-Up scores on playfulness indicated very high levels of play, which could be indicative of both young age and high energy level (which could be unattractive to many adopters). The unclear relationship between stated preferences for certain trait levels and outcomes within the shelter calls into question just what those shelter tests are measuring and whether they are useful for guiding adoption decisions.

Surprisingly, despite an expectation of a stated-revealed preference gap, most individuals with a preference tended to think their dog fulfilled their preferences, and on average, only about 30% of trait preferences were unmet—but even choosing randomly, a given dog fulfilled an average of 57% of any individual adopters' trait preferences. Using the typical definition of a stated-revealed preference gap including traits on which individuals had no preference, the stated-revealed preference gap in the sample dropped to about two of thirteen traits, which means that most dogs fulfilled about eleven traits while a random dog would have fulfilled about ten. These findings are in line with positive findings of a real-ideal gap in existing dog-owner dyads in terms of appearance, including size, color, breed type, and age of acquisition (Diverio, Boccini, Menchetti, & Bennett, 2016; King, Marston, & Bennet, 2009). This work extends this

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literature by demonstrating that a gap in stated preferences and chosen dog qualities exists even at the time of selection.

One could argue that the small stated-revealed preference gap may be because I compared a subset of adopters' stated preferences to their statements about their chosen dog, rather than the dogs' objective traits-- two separate measurements of stated preferences, subject to similar biases, and therefore less of a gap may exist. However, this perspective ignores a key methodological constraint when working with non-human animals: there is no "objective" method for gathering statements about the personality of a dog. The dog is not able to communicate ratings about itself to the experimenters, meaning any revealed statements about the qualities of the dog must come from a human observer. These ratings could come from a third-party (for example, Match-Up II), but it is unclear that the participant actually perceives the dog in a similar way to that third-party, and in the end, it is the perceiver, rather than the third-party, which makes the decision to adopt the dog.

Patronek and Bradley (2016) eloquently note that despite the widespread use of behavior evaluations, it is unclear why one would expect the dog's performance in the evaluation situations to translate into regular interactions with adopters. Indeed, there was little relationship between the ratings of a dog's friendliness, trainability, or playfulness by the dog's adopter and the corresponding Match-Up II ratings. Practically, attempting to match individuals with dogs that meet their preferences according to Match-Up II's calculations is unlikely to result in the feeling that one's preferences have been satisfied. Why might a disconnect occur between trait assessments of adopters and Match-Up II?

Non-experts often confuse different types of dog behavior (e.g. friendliness, playfulness, and submission), report behaviors that are not present (such as growling or nuzzling) or mistake

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basic characteristics of animals such as age (Tami & Gallagher, 2009). Adopters also showed

differences from shelter records for even basic qualities of their chosen pets such as coat color.

Similarly, when non-experts evaluate dogs, they attend to a limited number of cues and associate

them with a single emotional state, although experts use these cues in tandem with others to

differentiate between multiple different dispositions—for example, tail wagging is commonly

thought of by non-experts as a clear indicator of friendliness, when empirically, it is associated

with aggression, confidence, defensiveness, and friendliness (Tami & Gallagher, 2009).

Interestingly, in Match-Up II (a purported scientifically driven behavior evaluation), tail wagging

is limited to predicting friendliness, matching the non-expert conception but in the process

missing out on the other traits it could be signifying. The simplification of this cue in the

behavior evaluation suggests that practical limitations of implementing a test in a real-world

environment may impede the quality or accuracy of behavioral results.

4.4.2   Stated-Revealed Preference Gap in Dogs: Comparisons to Mate Choice

In this work, I utilized both stated and revealed preferences to elucidate what matters in

choosing dogs. As in mate choice, I found similar tendencies for some traits to be relatively

universally preferred and so subject to competition in revealed preference choice situations (in

dogs: friendliness; in humans: kindness and attractiveness—Buss, 1989) and some which are

idiosyncratic (in dogs: sex; in humans: religiosity—Shackelford, Schmitt, & Buss, 2005).

However, dog choice differs from romantic partner choice in several ways which may

elucidate the cause of the stated-revealed preference gap. Humans often have extensive

experience choosing and observing potential mates, starting in adolescence (e.g. Furman, 2002;

Penke, Todd, Lenton, & Fasolo, 2007). It is unclear whether most individuals have the same

plethora of experience in dog ownership, meaning they may have a poor idea of how particular

traits would impact their pet satisfaction and so may make revealed choices inconsistent with their stated preferences. Furthermore, at the time of choice, adopters have only experienced a dog's behavior for a short period in a novel setting, which may not provide an accurate representation of how that behavior would manifest in day-to-day life or how it may change over time (and hence may not give enough information for adopters to tell if this dog meets their stated preferences). For example, short exposure to the typical puppy behavior of chewing on hands may be tolerable or endearing, but on a daily basis may lose its charm and develop into a life-long habit.

Overall, compared to other social choices, individuals may lack the same quantity of experience in the dog domain and with it useful feedback to revise their stated preferences, both of which could produce unsatisfactory choices and unexpected problems. First-time dog owners are more likely to experience certain canine behavioral problems, especially dominance-related aggression, separation-related concerns, and over-excitability (Jagoe & Serpell, 1996). It may be that individuals choose dogs that go on to exhibit those behaviors because they do not recognize them at the time of adoption, or they are unaware of the challenges such behaviors can pose in daily life.

4.4.3 Limitations

One of the largest challenges working with existing data is the lack of control over the research setting. For example, the shelter's Match-Up II evaluations are used as a form of triage to identify behavior that may need correction and so affect what is done with the dog, which can change its behavior by the time of adoption from what was originally assessed. Dogs exhibiting severe responses will likely be recommended for an intensive intervention to correct negative

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responses, meaning their behavioral tendencies shift from intake to adoption, which could explain some of the mismatch I found between Match-Up II ratings and adopters' ratings.

Similarly, I was only able to assess adopters at one time point—the time of adoption. Many participants noted that they had "just met this animal" or were unsure in their choices—that is, participants felt they had only observed some limited behavior rather than gained an understanding of the dog's overall personality. Given that this impression was sufficient to bring a new animal into one's home, it is still important to test how these initial impressions impact adoption choices. But future research should also examine whether the stated-revealed preference gap impacts satisfaction by doing follow-up assessment with adopters—that is, even if individuals choose animals inconsistent with their stated preferences at the time of adoption, does that matter, in terms of adopter satisfaction, after a period of time together at home has passed? Furthermore, follow-ups could evaluate whether individuals actually do succeed in choosing a dog that, in terms of its behavior in the home, meets their initial stated preferences.

Another challenge of field research is selection bias limiting the total range of behaviors seen. The dogs included in this work were those that were eventually adopted, and not every dog in the chosen field site shared that outcome. While this shelter did not practice space-saving euthanasia on dogs during the study period, animals with behavior that would endanger the public may have been removed from the population prior to a Match-Up II assessment, eliminating some of the extreme variation I would expect on a behavior evaluation, especially in terms of aggression. Match-Up II also limits the amount of aggressive behaviors exhibited by ending a subtest once one of five behaviors deemed aggressive are shown, meaning the range of aggression on the test is highly limited. I further found a substantial floor effect in many

behaviors, where most dogs do not exhibit the majority of behaviors available, which also limits predictive power.

4.5   Conclusion

Adopting dogs is an important and relatively common real-world decision which seems ripe for enrichment using big data. In this study, adopters exhibited relatively small stated-revealed preference gaps, but it remains unclear whether this conclusion is well-supported. Much of the data available within shelters may only offer limited insight into what behaviors impact the choice to adopt an animal, suggesting a more complicated pattern than can be captured through big or existing data alone and pointing to the need to combine such data with purposely-collected measures.

4.6   References

Baisly, D. (2017, May 01). Shelter Canine Behavior Evaluations: Why The Animal Rescue

League of Boston Uses MATCH-UP II. Retrieved from

http://spring2017.iaabcjournal.org/shelter-canine-behavior-evaluations/

Bir, C., Widmar, N., & Croney, C. (2017). Stated preferences for dog characteristics and sources

of acquisition. *Animals*, *7*(8), 59.

Buss, D. (1989). Sex differences in human mate preferences: Evolutionary hypotheses tested in

37 cultures. *Behavioral and Brain Sciences, 12*(1), 1-14. doi:10.1017/S0140525X00023992

Cavanaugh, L. A., Leonard, H. A., & Scammon, D. L. (2008). A tail of two personalities: How

canine companions shape relationships and well-being. *Journal of Business Research*, *61*(5),

469-479.

DeLeeuw, J. L. (2010). *Animal Shelter Dogs: Factors Predicting Adoption Versus Euthanasia*

(Doctoral dissertation, Wichita State University).

Diverio, S., Boccini, B., Menchetti, L., & Bennett, P. C. (2016). The Italian perception of the

ideal companion dog. *Journal of Veterinary Behavior*, *12*, 27-35.

Dowling-Guyer, S., Marder, A., & D'Arpino, S. (2011). Behavioral traits detected in shelter dogs

by a behavior evaluation. *Applied Animal Behaviour Science*, *130*(3), 107-114.

Furman, W. (2002). The emerging field of adolescent romantic relationships. *Current Directions*

in Psychological Science, *11*(5), 177-180.

Jagoe, A., & Serpell, J. (1996). Owner characteristics and interactions and the prevalence of

canine behaviour problems. *Applied Animal Behaviour Science*, *47*(1), 31-42.

Jones, A. C. (2008). *Development and Validation of a Dog Personality Questionnaire* (Doctoral dissertation, The University of Texas at Austin).

King, T., Marston, L. C., & Bennett, P. C. (2009). Describing the ideal Australian companion dog. *Applied Animal Behaviour Science*, *120*(1-2), 84-93.

Lepper, M., Kass, P. H., & Hart, L. A. (2002). Prediction of adoption versus euthanasia among dogs and cats in a California animal shelter. *Journal of Applied Animal Welfare Science, 5*(1), 29-42.

Marston, L. C., Bennett, P. C., & Coleman, G. J. (2005). Adopting shelter dogs: owner experiences of the first month post-adoption. *Anthrozoös*, *18*(4), 358-378.

Mirko, E., Doka, A., Miklosi, A., 2013. Association between subjective rating and behavior coding and the role of experience in making video assessments on the personality of the domestic dog (*Canis familiaris*). *Applied Animal Behaviour Science*, *149*, 45-54

Mohan-Gibbons, H., Dolan, E. D., Reid, P., Slater, M. R., Mulligan, H., & Weiss, E. (2018). The Impact of Excluding Food Guarding from a Standardized Behavioral Canine Assessment in Animal Shelters. *Animals*, *8*(2).

Patronek, G. J., & Bradley, J. (2016). No better than flipping a coin: Reconsidering canine behavior evaluations in animal shelters. *Journal of Veterinary Behavior: Clinical Applications and Research*, *15*, 66-77.

Patronek, G., Twining, H., & Arluke, A. (2000). Managing the stigma of outlaw breeds: A case study of pit bull owners. *Society & Animals, 8*(1), 25-52.

Penke, L., Todd, P. M., Lenton, A. P., & Fasolo, B. (2007). How self-assessments can guide

    human mating decisions. In: *Mating Intelligence: Sex, Relationships, and the Mind's*

    Reproductive System, 37-75.

Posage, J. M., Bartlett, P. C., & Thomas, D. K. (1998). Determining factors for successful

    adoption of dogs from an animal shelter. *Journal of the American Veterinary Medical*

    Association, 213, 478-482.

Riefer, P.S., Prior, R., Blair, N., Pavey, G., & Love, B.C. (2017). Coherency-maximizing

    exploration in the supermarket. *Nature Human Behaviour, 1*, Article number: 0017.

    doi:10.1038/s41562-016-0017

Seabold, S., & Perktold, J. (2010). Statsmodels: Econometric and statistical modeling with

    python. *Proceedings of the 9th Python in Science Conference,* 57-61.

Shackelford, T. K., Schmitt, D. P., & Buss, D. M. (2005). Universal dimensions of human mate

    preferences. *Personality and Individual Differences*, *39*(2), 447-458.

Shelter Animals Count, Haston, R., ……& Zeidman, S. (2016). 2016 Animal Sheltering

    Statistics. Retrieved May 6, 2018, from https://shelteranimalscount.org/docs/default-

    source/DataResources/2016animalshelteringstatistics.pdf?sfvrsn=12

Siettou, C., Fraser, I. M., & Fraser, R. W. (2014). Investigating some of the factors that influence

    "consumer" choice when adopting a shelter dog in the United Kingdom. *Journal of Applied*

    Animal Welfare Science, *17*(2), 136-147.

Tami, G., & Gallagher, A. (2009). Description of the behaviour of domestic dog (*Canis*

    familiaris) by experienced and inexperienced people. *Applied Animal Behaviour*

    Science, *120*(3), 159-169.

Weiss, E., Miller, K., Mohan-Gibbons, H., & Vela, C. (2012). Why did you choose this pet?:

    Adopters and pet selection preferences in five animal shelters in the United

    States. *Animals*, *2*(2), 144-159.

Wells, D., & Hepper, P. G. (1992). The behaviour of dogs in a rescue shelter. *Animal Welfare, 1*,

    171-186.

5   Positive Assortment of Personality in New Dog-Owner Dyads

As discussed in Chapter 1, humans show a marked preference for interacting with similar others (*homophily*), with the preference expressed in terms of relationship development or satisfaction. Dogs serve as human social partners, just as fellow humans do. If humans choose dogs using similar decision-making techniques to those demonstrated in other social domains, it is reasonable to expect that humans and dog owners would demonstrate similarity on a number of traits. While the stated-revealed preference gap did not manifest at above-chance levels in Chapter 4, positive assortment is a much more common pattern in both other human social partners and other species, suggesting a higher likelihood that this pattern would manifest in dog choice.

Beyond easily assessed traits such as appearance and generally fixed traits such as sex, it is otherwise difficult to make homophilic comparisons across species. Non-human animals typically have difficulty communicating complex internal traits to humans, meaning assessments are typically based on human perception. Additionally, not all traits are shared between humans and dogs (e.g. tails), and those that are shared may vary qualitatively and in distribution between species: For example, a thirteen-year-old dog is much further in its relative lifespan compared to a thirteen-year-old human.

One trait that does appear to be shared between dogs and humans is personality (Fratkin, Sinn, Patall, & Gosling, 2013)--consistent behavioral tendencies in an individual that vary between individuals (sometimes referred to in non-human animals as temperament—in this work, where I make comparisons between humans and non-human animals, I use personality for consistency). While personality structure varies between dogs and humans (e.g. Gosling & John,

1999; Jones & Gosling, 2005), when humans judge the personality of dogs, they display similar levels of agreement/accuracy and similar-to-less projection than when judging other humans (Gosling, Kwan, & John, 2003; Kwan, Gosling, & John, 2008), suggesting comparisons can be made between species.

Humans and their chosen romantic partners demonstrate weak homophily of personality (e.g. Botwin, Buss, & Shackelford, 1997; Escorial & Martin-Buro, 2012), although this effect is inconsistent across studies (e.g. Watson, Hubbard, & Weise, 2000). This variability and overall weakness of correlation may be due to reference effects (that is, ratings traits relative to a limited comparison group serving as a baseline, rather than overall absolute experienced levels of variation); with correction, correlations in personality traits range in coefficient size from 0.2 to 0.47 in romantic couples and to a lesser extent in other human social relationships (Youyou, Stillwell, Schwartz, & Kosinski, 2017; c.f. Funder, Kolar, & Blackman, 1995). If similarity of personality is exhibited between human social partners, it may also be present when comparing humans and their chosen dogs and may be the result of active choice of a similar dog (homophilic selection).

5.1.1 Measuring Canine Personality

In contrast to the widely accepted model of human personality, the Five Factor Model (FFM; Goldberg, 1992), there is currently no standard model for canine personality. In a meta-analysis, Jones and Gosling (2005) found the most common personality factors in dogs included responsiveness to training, reactivity to new situations, general activity level, general fearfulness, sociability, aggression, and submissiveness. While dogs share many *behavior tendencies* with humans, the same overarching personality factors do not best describe overall behavior variation within the species. Some factors in canines resemble those in humans, especially extraversion

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and neuroticism. Others differ significantly from their human counterparts (in terms of underlying structure as well as level of explanation of variance in conspecific behavior), such as canine self-assuredness, training focus, and amicability (Ley, Bennet, & Coleman, 2008). Conscientiousness may be unique to human and non-human primate species (Gosling & John, 1999; Gosling et al., 2003). Even within shared factors, identical subcomponents deviate—for example, all human aggression is likely categorized by one common factor, while different types of aggressive behavior in dogs vary in co-occurrence (Mirkó, Kubinyi, Gácsi, & Miklósi, 2012).

5.1.2 Relationship Between Human and Canine Personality

Several studies have examined the relationship between human and dog personalities. These comparisons have primarily been done using FFMs for dogs (e.g. Draper, 1995; Gosling et al., 2003; Kubinyi, Turcsán, & Miklósi, 2009) based on the human Big Five Inventory (John & Srivastava, 1999). FFMs are useful for specifically examining similarity of personality between dogs and humans as the personality factors are composed of very similar behavioral tendencies.

Anchoring on human personality traits allows for easy between-species comparison, but likely does not accurately describe canine personality structure (Rayment, De Groef, Peters, & Marston, 2015). In the literature, the mapping between dog personality factors and human FFMs is not exact: Energy is treated synonymously with Extraversion, Affection as Agreeableness, Emotional Reactivity as Neuroticism and Intelligence/Trainability as Openness/Intellect; Conscientiousness is often discarded (Gosling et al., 2003). Even with analogous factors, humans may not show the same variation on factors and items as dogs—for example, with identical wording, dogs are generally rated as more energetic, less cooperative, and less withdrawn than humans (Podberscek & Gosling, 2000). Similarly, the questions themselves may vary in definition or construct between humans and dogs. For example, 'Talks frequently' in humans may

be translated to 'Barks frequently' in dogs. This indicates the behavior--vocalization--but not the underlying personality construct, as vocalization varies in purpose between the two species.

Methodological considerations aside, how do existing human-dog dyads compare in personality on similar five-factor models? Turcsán and colleagues compared the personality of existing dog-owner dyads using the human FFM and a canine-adapated Big Five Inventory, achieving cross-correlations of 0.318 on analogous personality dimension, which generally remained significant even when a human third-party rated both human owner and dog (Turcsán, Range, Virányi, Miklósi, & Kubinyi, 2012). Kwan et al. (2008) achieved a similar average correlation of about .38 on 11 personality factors in existing dog-owner dyads. Interestingly, a near-identical design found that only Extraversion was significantly and positively correlated between species, while canine and human Neuroticism was negatively correlated, and non-identical factors also correlated between species (Cavanaugh, Leonard, & Scammon, 2008). Overall, the relationship between human and canine personality factors is far from settled.

Most studies comparing the personalities of dogs and current owners imply individuals choose dogs that resemble them. However, these studies almost exclusively study existing dyads, meaning they fail to discriminate whether this effect occurred as a result of selection—that is, whether the dog was chosen based on personality similarity. Positive assortment can also occur in long-term relationships through convergence (similarity increasing over the course of the relationship) or deselection (ending relationships between dissimilar partners). Turscán et al. (2012) reported that relationship length does not impact the strength of positive assortment between dogs and owners but ignored the fact that almost all relationships in the study were quite long, averaging at almost half the lifespan of the average dog (3.2 to 7.2 years). Humans of different personalities, behavioral tendencies, and home lives often own dogs with different

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behavior tendencies and problems (e.g. Kubinyi et al., 2009; Podberscek & Serpell, 1997), suggesting humans may influence the behavioral tendencies of their dog. Therefore, convergence in behavior (and therefore personality) could occur early in the relationship, rather than at the time of selection, as assumed.

Walker (2014) took strides towards this problem by examining personality of the owner and dog at a much closer interval to choice—two months after adoption—and using a well-validated canine personality measure, the revised Monash Canine Personality Questionnaire (MCPQ-R; Ley & Bennett, 2008; Ley, Bennett, & Coleman, 2009; Ley, McGreevy, & Bennett, 2009). The MCPQ-R is not directly based on a FFM, but the personality factors it measures resemble those in humans (Fratkin et al., 2013). There was no significant correlation between the personalities of adopters and their dogs, emphasizing that personality homophily may not be present early in the relationship (i.e., is not the result of selection). Walker appears to be the only example of a study using a well-validated species-specific questionnaire, rather than using an adapted human FFM for dogs. Unfortunately, in Walker's work, the formatting of the human and dog personality inventories chooses a single factor best representing the individual rather than providing separate scores on each factor, which could prevent the emergence of the weak-to-moderate correlations expected.

In sum, the results of prior work encourage the central hypothesis that dog-human pairs exhibit similar social patterns as human-human pairs, including shared personality in long-term pairs. To date, none have assessed perceived personality homophily at the time of choice—that is, whether homophily of personality is present at selection and therefore a potential influencer on the dog chosen—which the current work attempts to answer.

5.1.3 The Current Work

In this chapter, I examine whether humans exhibit perceived similarity of personality at the time of choice in an animal shelter, allowing me to isolate the influence of selection on positive personality assortment in dog-owner pairs. In order to make appropriate comparisons to human personality assortment, several methodological constraints must be considered: in particular, the instrument, who completes the ratings and when the ratings are collected.

As in prior work, I chose to use a FFM measure of personality for humans and an adapted FFM model for canine personality. A five-factor model may not accurately characterize canine personality, but to make an appropriate comparison to humans, the ideal instrument would be as similar in wording as possible between both subjects. I use the Big Five Inventory-44 (John & Srivastava, 1999) for humans, and adapt it for canines in a similar manner to Gosling et al. (2003).

Homophily of personality between human social partners is typically measured using an identical instrument in three ways: one individual rates both dyad members (either a member of the dyad or a third party), both individuals rate themselves separately, or one individual rates themselves and a third-party rates their partner. To date, no work has developed a method for dogs to self-rate themselves on personality, suggesting the appropriate method is to have a human dog owner rate themselves, and either the dog-owner or a third party rate the dog. Third parties (e.g. experts, prior owners) may provide more accurate ratings, but the current question of interest is how individuals incorporate personality into their decision-making process. The true nature of the dog's personality is not necessarily used in judgment, but rather *perceptions* of the dog's personality match to self-held definitions (a personality-judgment approach; Funder,

1999). Therefore, it must be the adopter, rather than an expert, who completes the ratings of the dog.

Typically, judgements of canine personality are completed by the owner long after relationship establishment, once a great deal of behavior has been observed, leading to presumably more accurate assessments. However, this approach is inappropriate for studying selection effects, as the individual was not privy to these observations when choosing a dog. Ratings at relationship initiation may be inaccurate because they are based only on the time spent with the dog prior to choice, but these are the only judgements of personality that can influence the choice made. Therefore, in this study, ratings are taken at the time of choice.

In summary, this design relies on two FFMs of personality, where the human adopter completes the ratings of both dog and canine personality at the time of choice. Based on prior work and the central hypothesis of this dissertation, it is expected that there will be a weak positive correlation on identical personality factors for dogs and their human owners.

5.2 Method

The procedure for data collection and participant sampling is identical to Chapter 3. The current work focuses on a different portion of the measures and therefore has different inclusion criteria, detailed below.

5.2.1 Participants

Unlike in Chapter 3, participants in the pilot were included (as the only difference between the pilot and main study was the Stated Preference Survey, which is not used in this chapter). Including the pilot, 190 responses were collected from eligible participants. Participants were excluded if they demonstrated a clear lack of understanding of Likert-type scales, as

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evidenced by using two or fewer points of the scale (prior to reversal) for either of the two main instruments or if the survey was largely incomplete ($n = 22$). In total, 168 participants were included. Subjects were primarily female (61.0%) and in the 18-29 years age group (47.9%).

5.2.2   Measures

Big Five Inventory-44. Humans completed the Big Five Inventory-44 (BFI-44; John and Srivastava, 1999), a survey of 44 items of personality using a Likert scale ranging from 1 (Disagree strongly) to 5 (Agree strongly). Each item was part of one factor of the FFM. Items were reversed appropriately, and then all items corresponding to a factor were summed for a total factor score.

Dog Perception Survey. This survey was designed to mirror the BFI-44 in structure, length and wording (see Supplemental Materials, Appendix 7.4.1 for the survey). Each item and subtrait on the BFI-44 was evaluated by the author to see whether it could appropriately be applied to dogs. Canine items corresponded with the same singular FFM factor as their human equivalent. For example, the item "Is generally trusting", paired with Agreeableness on the human BFI-44, was also asked on the Dog Perception Survey and used to calculate canine Agreeableness. Only one item associated with the human factor Openness was judged to be applicable to canines (cf. Gosling et al., 2003), which was included in the survey but omitted from current analysis of personality factors (leaving four canine factors, rather than five). When possible, rather than keeping original human-based wording, identical measures were drawn from the Dog Personality Questionnaire (DPQ; Jones, 2008). Each item was kept at an identical valence to the corresponding human item (and reversed identically).

A total of 45 items were included on the Dog Perception Survey: 26 items of personality used in the current study (nine of which were from the DPQ), the Revealed Preference Survey

items used in Chapter 3 ($n = 8$, 4 items overlapping with personality items) and 15 additional items unrelated to the current study (e.g. "Likes children"). Of the 26 personality items, ten items were associated with Extraversion, six with Neuroticism, three with Conscientiousness, one with Openness (omitted from current analysis), and six with Agreeableness. 13 items were identical or near-identical to items on the BFI-44 (including the dropped Openness question), nine were derived from BFI-44 subtraits, two were closely related concepts from the DPQ ("Able to focus on a task in a distracting situation (e.g. loud or busy places, around other dogs)" and "Adapts easily to new situations and environments", both associated with Conscientiousness), and two additional questions were worded for work outside this dissertation, but closely related to the BFI-44 ("Is calm" and "Is laid back", both associated with Neuroticism) .To calculate canine scores on each personality factor, all items corresponding to that factor were reversed if needed (see Supplemental Materials, Appendix 7.4.1) and summed. If an item corresponding to a factor was not completed (for both humans and dogs), that personality factor was excluded from analysis.

5.3 Results

A large portion of participants reported the study packet, in particular the personality items, was long and cumbersome, feedback also received by Walker (2014) in their similar design. Two items were often left blank by a sizable portion of the sample: "Is aloof" and "Is boisterous." These individuals' data are excluded from analysis of these items.

5.3.1 Validation of Dog Perception Survey

Prior to analysis, I explore the validity of the canine personality factors developed using a FFM. Inter-item correlations measure the internal consistency of a scale; Cronbach's alpha also measures internal consistency but is sensitive to variation in the number of items composing a

scale. Because the number of items varied between humans and canines, I include both measures of internal consistency, and both raw and scaled scores of each factor are presented. The inter-item correlation and Cronbach's alpha for each of the four personality factors are shown in Table 5.1; the distribution of raw, unscaled total scores on each factor are shown in Figure 5.1. All inter-item correlations fell within the acceptable range of 0.2 and 0.4, but using the traditional Cronbach cut-off of 0.7, only Neuroticism and Extraversion demonstrated acceptable or good internal consistency. These results suggest the most reliable results will derive from Neuroticism and Extraversion.

Trait	Average Inter-Item Correlation	Cronbach's α	Associated Items
Agreeableness	0.30	0.53	6
Conscientiousness	0.39	0.20	3
Neuroticism	0.40	0.70	6
Extraversion	0.36	0.81	10

Table 5.1: Internal consistency of the four canine personality factors. Each factor varies in terms of the number of associated Dog Perception Survey items.
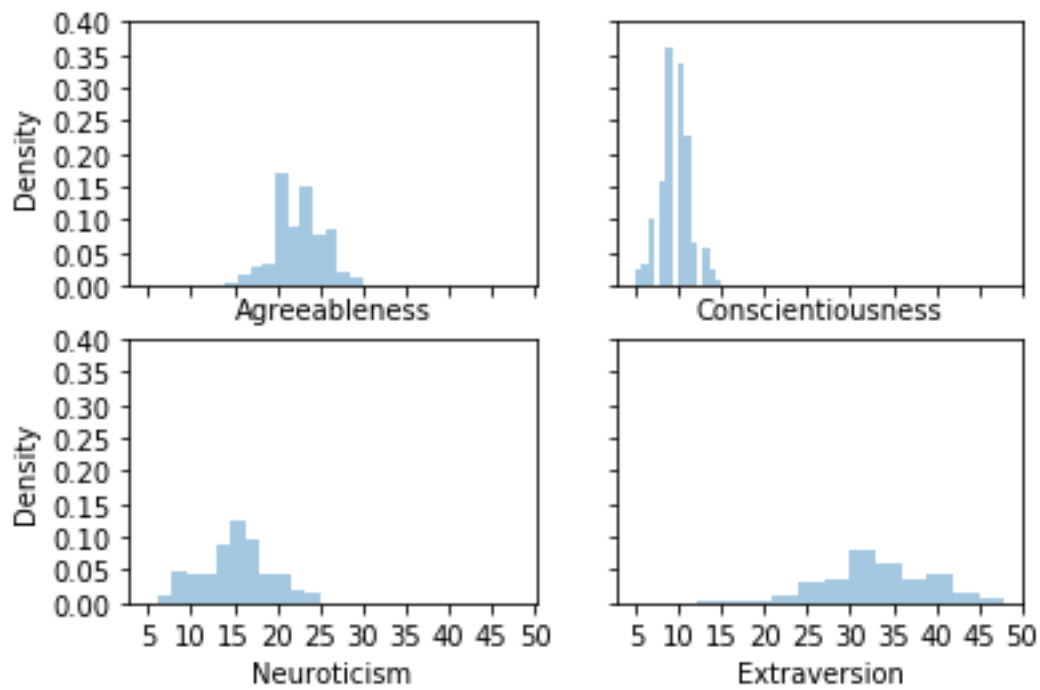
Figure 5.1 Normalized density histogram showing the raw distribution of scores on canine personality factors. Each factor varies in number of items, leading to the large differences in variance.

5.3.2 Relationship Between Human and Canine Perceived Personality

The descriptive statistics of the five human personality factors (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism) and four canine personality factors are shown in Table 5.2. In general, humans rated themselves (as scaled) more strongly than their dogs (as scaled) on all traits but Neuroticism.

		A	C	N	E	O
Human	*n*	165	167	165	163	161
	Raw *M*(*SE*)	38.4 (0.34)	37.3 (0.37)	17.6 (0.40)	28.7 (0.48)	36.8 (0.46)
	Scaled *M*(*SE*)	0.85 (0.008)	0.83 (0.008)	0.46 (0.011)	0.72 (0.012)	0.74 (0.009)
Canine	*n*	162	167	165	162	N/A
	Raw *M*(*SE*)	22.7 (0.23)	9.6 (0.14)	15.3 (0.31)	32.5 (0.51)	N/A
	Scaled *M*(*SE*)	0.76 (0.008)	0.64 (0.009)	0.61 (0.012)	0.68 (0.011)	N/A

Table 5.2 Descriptive statistics of each of the personality factors in the five-factor model for humans and canines. Questions related to the Openness personality factor were omitted for canines. A: Agreeableness; C: Conscientiousness; N: Neuroticism; E: Extraversion; O: Openness.

I next examined how the factors of personality covaried between species. All correlations are between the score of the dog and their corresponding adopter. Correlations are run for all dog-owner pairs where every associated item for the factors of interest were completed unless otherwise noted, meaning sample size varies between tests.

I correlated the raw scores of humans to the raw scores of their chosen dogs on the same personality factor (four comparisons, Pearson's r, $\alpha = 0.0125$; see Table 5.3). There were significant positive correlations between dog and human Conscientiousness ($r = 0.20$, $p = 0.009$, $n = 166$), Agreeableness ($r = 0.24$, $p = 0.003$, $n = 160$), and Neuroticism ($r = 0.22$, $p = 0.005$, $n = 163$), but not Extraversion ($r = 0.14$, $p = 0.09$, $n = 157$). In addition to correlating identical factors, I also compared items with identical wording (e.g. "Is generally trusting", which was asked for both humans and dogs) between species. Among the 12 items with identical or near-identical wording, the average correlation was 0.14. Both these results support the hypothesis of slight positive assortment of personality.

I also conducted additional exploratory analyses between all personality factors of dogs and their humans (20 comparisons of 4 dog traits and 5 human traits, $\alpha = 0.0025$; see Table 5.3). At this significance level, none of the prior comparisons remained significant, but an additional weak, positive relationship between Canine Agreeableness and Human Conscientiousness emerged ($r = 0.27$, $p = 0.0006$, $n = 162$).

		A		C		N		E	
		Human	Dog	Human	Dog	Human	Dog	Human	Dog
A	Dog	0.237**							
C	Human	0.448***	0.265***						
	Dog	0.058	0.385***	0.202**					
N	Human	-0.50***	-0.05	-0.37***	-0.05				
	Dog	-0.08	-0.44***	-0.13	-0.25***	0.216**			
E	Human	0.195*	0.086	0.103	0.154	-0.23**	-0.09		
	Dog	0.12	0.201*	0.064	0.12	-0.01	0.192*	0.137	
O	Human	-0.1	-0.08	-0.05	-0.1	-0.02	0.022	0.153	0.032

*: $p < 0.05$; **: $p<0.01$; ***: $p<.001$

Table 5.3: Correlation between canine and personality factors. Openness was not calculated for dogs. A: Agreeableness; C: Conscientiousness; N: Neuroticism; E: Extraversion; O: Openness.

5.3.3 Principal Components Analysis

As shown in Table 5.3, factors within both species covaried with one another, which may be driving correlations between human and dog scores. For dogs, I extracted independent factors using Principal Components Analysis (PCA). Analysis was run on all individuals where each of the 25 utilized personality items were defined ($n = 156$) using Python 3's scikit-learn PCA module (Pedregosa et al., 2011). All items were centered at a mean of 0 and a standard deviation of 1. The threshold for component retention was set *a priori* at an explained variance ratio of at least 0.05; a total of five components were retained. The item loadings on the components are shown in Table 5.4, organized by each item's association in the BFI-44. Component 1 is composed of items related to activity and energy (with the highest loading items coming from both Neuroticism and Extraversion). Component 2 is composed of items related to Neuroticism and disposition towards others—being warm, trusting, and calm. Component 3 is composed primarily of assertiveness. Component 4 relates to aspects of Agreeableness, primarily being aloof and stubborn. Component 5 draws from several components: warmth, ignoring commands, not being aloof, and inability to focus during distracting situations. Each of the five components is primarily derived from 1 or 2 FFM factors, which suggests that adopters may be relying on norms of a human FFM when rating their dog, but the individual subcomponents may vary. There were no significant correlations between each human factor and the five canine PCA components ($\alpha = 0.002$; Table 5.5).

FFM Factor	Component / Item	Activity	Amicability/ Neuroticism	Assertiveness	Aloofness/ Stubborn-ness	Warmth/ Distraction
	Explained Variance Ratio	0.231	0.156	0.062	0.057	0.540
A	Has a warm personality	0.133	**0.488**	0.0934	0.0548	**0.4224**
A	Reverse - Ignores commands	-0.1208	**0.4690**	0.3405	-0.2104	**-0.4478**
A	Is generally trusting	0.2134	**0.7017**	0.0123	0.2049	0.1165
A	Reverse - Is aloof	0.0466	0.2554	0.0179	**-0.5726**	**0.4756**
A	Reverse - Is stubborn	-0.2372	0.2697	0.2425	**-0.4247**	-0.0127
A	Is eager-to-please	0.3657	0.3993	0.2863	0.0259	-0.0900
C	Reverse - Tends to be lazy	**0.6585**	-0.0059	0.3170	-0.1237	0.1495
C	Able to focus on a task in a distracting situation (e.g. loud or busy places, around other dogs)	-0.2355	**0.4714**	0.3864	0.0511	**-0.49679**
C	Reverse - Is easily distracted	-0.3925	0.3815	0.2311	-0.2849	-0.0934
N	Reverse - Is laid back	**0.6577**	**-0.4509**	-0.0166	-0.1779	-0.1447
N	Reverse - Is calm	**0.7077**	**-0.4216**	0.0960	-0.1966	-0.0115

N	Reverse - Is relaxed	**0.5873**	**-0.5497**	0.0065	-0.2188	-0.1061
N	Reverse - Is confident	**-0.4343**	**-0.6082**	0.2545	-0.1324	0.1556
N	Is anxious	-0.1634	**-0.5512**	0.3883	0.1342	0.2315
N	Reverse - Adapts easily to new situations and environments	-0.1573	**-0.5544**	-0.2138	-0.3951	-0.1234
E	Reverse - Is shy	**0.5304**	0.3635	-0.2923	-0.3875	-0.0695
E	Is outgoing	**0.6568**	0.3878	-0.1771	-0.0216	0.1043
E	Reverse - Is reserved	**0.6625**	0.1459	-0.1983	-0.2751	-0.2127
E	Is boisterous	**0.5426**	-0.0705	0.0413	0.3289	0.0002
E	Is easily excitable	**0.6802**	-0.0783	0.2761	0.0461	0.0297
E	Has a lot of energy	**0.7293**	0.0913	0.3360	0.0377	-0.0023
E	Reverse - Is quiet	**0.5416**	-0.2615	0.0483	0.2077	-0.0228
E	Seeks constant activity	**0.7403**	-0.0021	0.1752	0.1663	-0.0129
E	Is sociable	0.2226	**0.4943**	-0.3284	0.0382	0.3113
E	Is assertive	0.2127	0.0136	**-0.4920**	0.1375	-0.3979

Table 5.4 Loadings of Dog Perception Survey personality items onto independent principal components. Items are organized by original categorization of each item into the FFM. Loadings greater than 0.4 or less than -0.4 are bolded for ease of interpretation. A: Agreeableness; C: Conscientiousness; N: Neuroticism; E: Extraversion; O: Openness.

	A	C	N	E	O
Activity	0.168	0.062	-0.01	0.113	0.022
Amicability/Neuroticism	0.227	0.197	-0.13	0.139	0.003
Assertiveness	0.059	0.137	0.027	0.085	-0.11
Aloofness/Stubbornness	0.041	0.012	-0.11	0.033	0.074
Warmth/Distraction	0.109	<0.001	0.08	-0.02	-0.09

Table 5.5 Correlation coefficients between extracted principal components of dogs (row stubs) and the BFI-44 factor scores of their adopters (column stubs). No correlations were significant at $\alpha = 0.002$. A: Agreeableness; C: Conscientiousness; N: Neuroticism; E: Extraversion; O: Openness.

5.4   Discussion

5.4.1   Summary of Results

To date, no works have examined how perceptions of shared personality influence the choice of dogs. In this experiment, humans rated their dogs similarly to their own scores on identical or closely related items and associated factors, suggesting perceived positive assortment of personality shown in existing dog-owner dyads is present at the time of initial selection. This finding supports the central hypothesis that humans choosing social partners in other social domains (dogs) exhibit similar patterns as they do when choosing romantic partners. Notably, this work did not examine whether the *true* personality of adopters and their adopted dogs relate, but rather whether adopters *perceive* their dog's personality to be similar to their own. This is a necessary (but not sufficient) step towards testing whether perceived similarity of personality has the potential to influence which dog is chosen.

The average correlation between identical human and canine personality factors was 0.20 at the time of selection, consistent but smaller than coefficients from long-term dog-owner pairs of 0.318 - 0.38 (Kwan et al., 2008; Turcsán et al., 2012). This suggests that similarity of personality may be present at the time of selection and grow over time with convergence. However, the current results contrast with Walker (2014), who found no personality assortment in adopter-owner pairs of two months. The discrepancy in significance may be the result of instrument differences, the accuracy of perceptions of canine personality, or changes due to convergence or deselection. Walker's instrument choice (the MCPQ-R) may have masked small effects. Alternatively, the new adopters in this study may not have an adequate understanding of their dogs' personalities, meaning they may be more inclined to project their own personalities onto the dogs (however, humans project their personalities onto their human relationship partners

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as well; Kwan et al., 2008), which would inflate ratings of personality similarity. In Walker's two-month-follow-up period, individuals have had more time to accurately assess their dogs' personality and rely less on projection, but not enough time to converge in personality. These discrepancies suggest not only that similarity is not present at selection (in contrast to our study), but also that any convergence may occur sometime after two months.

Because dogs cannot be assumed to have identical personality structure to humans, I also examined the relationship of personality questions outside the traditional human FFM using Principal Components Analysis. The model that best described the data was in fact a FFM, consisting of Activity, Amicability/Neuroticism, Assertiveness, Stubbornness/Aloofness, and Warmth/Distraction. Amicability/Neuroticism, Assertiveness, and Activity are consistent with other personality factors in traditional models of non-human animal personality (Jones and Gosling, 2005; Ley et al., 2008). Notably, the purpose of this chapter is not to develop a model of dog personality, and the PCA model simply describes how these human-FFM-based personality items tend to co-vary, rather than providing a new, accurate model for describing dog personality.

The correlations between identical personality factors were generally weak. This finding is in line with studies of both human-human dyads and existing human-dog dyads. Although similarity is generally valued in a social companion, this may not always be the case. If a dog possesses an undesired behavior (e.g. high neuroticism), feeling similar to that dog may lead to a negative self-comparison (e.g. Lerner & Agar, 1972). If a human possesses a trait considered negative by themselves or others, they may instead purposely seek out a dog varied in that trait (complementarity): for example, a high-Neuroticism human may desire a low-Neuroticism dog. Cavanaugh et al. (2008) found that dogs who exceed their owners on Openness and

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Agreeableness have more satisfied owners. This suggests that satisfaction may not simply be predicted by similarity on facet scores but may instead depend both on the personality factor and the relative values of each member of the human-canine dyad. However, the general lack of relationship between any personality factor of humans and dogs (both from the FFM and PCA) also suggests minimal complementarity, excluding the positive relationship between Canine Agreeableness and Human Conscientiousness.

5.4.2   Limitations and Future Work

While perceived canine personality was assessed very close to the time of selection, it still occurred after the fact. Ideally, personality assessments should be made prior to the time of selection, so that selection itself does not lead to similarity of ratings. Each participant rated both themselves and their chosen dog (i.e. they are not necessarily independent). The adopters generally noted they did not have extensive knowledge of their dog yet, meaning their ratings may have been influenced by other factors beyond the actual qualities of their dog. If participants believe (consciously or otherwise) that their human social partners (or humans at large) generally resemble themselves in personality, they may have the same expectations for their new dog. That is, individuals may rate the dog closer to themselves just after selection (now that it is "their dog") than they would if they had rated the dog in a neutral environment before beginning the search for a dog. This is a difficult methodological issue to overcome. When looking at the choice of human social partners, researchers can rely on self- or third-party ratings of each potential social partner prior to the experiment. Dogs cannot rate their own personalities, and as shown in Chapter 4, standardized behavior assessments of dogs do not relate strongly to the ratings by new owners. If we are particularly interested in how a dog adopter incorporates canine personality into their judgement, we must rely on the assessment of the potential owner. Future

research could utilize Gosling et al.'s (2003) round-robin design, such that each participant would rate every dog as well as themselves prior to selection (to gather a baseline on consensus and projection); if any of those individuals adopted a dog within the group, the ratings of adopters to non-adopters could then be compared. However, given the rarity of adoption amongst visitors and the number of dogs from which they can choose, this is highly impractical to implement. At best, in this work we can only claim that individuals perceive their chosen dog to be similar to themselves at the earliest stages of relationship formation.

Despite using near-identical procedure to produce the scale, the dog personality items in this work varied in structure and reliability from other canine-adapted FFMs. Gosling et al. (2003) was able to successfully translate Openness and more items in general on the canine BFI compared to this work. The current scales also had much lower internal consistency (Cronbach's alpha) ratings on all traits excluding Extraversion and Neuroticism. This is likely based on the variation in number of items for each of these factors as well as Gosling et al.'s intent to study personality consistency (with appropriate language), rather than personality homophily as in this work (and therefore striving to minimize changes in wording). Low internal consistency suggests that the personality items in this chapter, although derived from a five-factor model, are not similarly clustered in dogs for Conscientiousness and to an extent, Agreeableness, consistent with past work of the generalizability of FFMs in non-human animals (Gosling & John, 1999).

5.4.3 Implications for Shelters

If adopters tend to adopt dogs they perceive as similar in personality, temperament could be used to pair visitors with dogs. The current finding of assortment of personality at selection suggests this may be a viable path, with important caveats.

Firstly, the correlation coefficients of human and canine personality were positive but low, suggesting other factors may more strongly influence the likelihood of choice. In particular, appearance (e.g. size, coloring, age) is very predictive of likelihood of adoption in general (e.g. Diesel, Smith, & Pfeiffer 2007; Posage, Bartlett, & Thomas, 1998). Identifying broadly attractive traits like appearance may help shelters locate the dogs most likely to get adopted, but not by whom, which does not lend itself to matching particular dogs with adopters. For individuals searching for a dog, personality may help to narrow the search but is unlikely to be the largest influence. Adopters report that while personality and social behavior factor into their choices, appearance is usually the most important factor (Weiss, Miller, Mohan-Gibbons, & Vela, 2012).

As designed, the current Dog Perception Survey also does not provide a viable way to pair adopters with a dog. Presumably, if personality were used to pair dogs and adopters, all dogs in a shelter would need to be rated by someone and then compared to the personality of an individual visitor. The current procedure measures the subjective impressions of dog personality by a single individual after a short period of time, meaning every dog in the sample was rated by a separate visitor. As shown in the prior chapter and other works (Walker, 2014), ratings of identical dogs by non-experts and well-validated systems or by two owners of the same dog often do not agree. Therefore, pairing an adopter with a dog based on the personality assessment completed by another is unlikely to lead to perceptions of homophily of personality by the adopter and therefore contribute to the decision to adopt. Unfortunately, Walker's (2014) study tested the suggested approach and showed no relationship between canine personality ratings of a prior owner or shelter owner and the personality of a new adopter, which suggests this approach may also face difficulties to successfully pair dogs to new owners. Perhaps this is as a result of projection—if both owners rate their dog as similar to themselves, large differences may

be expected; alternatively, the separate home environments of each owner may promote different behavior in the same dog.

Interestingly, besides Walker (2014), I am aware of no other studies using surveys specifically developed for accurately capturing canine personality, instead of relying on an adapted human FFM, to compare dog and owner personality. Future research could explore the relationship between the personalities of dog-owner dyads using species-specific questionnaires and could assess what personality factors tend to correlate between the two, rather than examining solely homologous constructs.

In the human literature, an important feature is not just whether positive assortment exists between pairs, but also whether it encourages the continuation of that relationship through satisfaction. Though this study stops at the time of selection, an alternative method for testing these hypotheses would be to see how the magnitude of personality overlap influences satisfaction with the relationship, especially the possibility of returning a dog (deselection). Curb and colleagues (2013) found no significant correlation between satisfaction and personality overlap as a whole, but their study used a convenience sample which may not generalize. Future work could expand on this concept and test not just whether overlap exists, but whether it influences satisfaction and the likelihood of return.

5.5   Conclusion

I found evidence of weak but significant perceived assortment of personality between newly adopted shelter dogs and their human adopters. This pattern mirrors similar findings between human romantic partners. This suggests that assortment of personality in existing dog-owner pairs could be caused at least partially by selection, in addition to convergence and deselection, and as a result of homophily.

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5.6 References

Botwin, M. D., Buss, D. M., & Shackelford, T. K. (1997). Personality and mate preferences: Five factors in mate selection and marital satisfaction. *Journal of Personality*, *65*(1), 107-136.

Cavanaugh, L. A., Leonard, H. A., & Scammon, D. L. (2008). A tail of two personalities: How canine companions shape relationships and well-being. *Journal of Business Research*, *61*(5), 469-479.

Curb, L. A., Abramson, C. I., Grice, J. W., & Kennison, S. M. (2013). The relationship between personality match and pet satisfaction among dog owners. *Anthrozoös*, *26*(3), 395-404.

Diesel, G., Smith, H., & Pfeiffer, D. U. (2007). Factors affecting time to adoption of dogs re-homed by a charity in the UK. *Animal Welfare*, *16*(3), 353-360.

Draper, T. W. (1995). Canine analogs of human personality factors. *The Journal of General Psychology*, *122*(3), 241-252.

Escorial, S., & Martín-Buro, C. (2012). The role of personality and intelligence in assortative mating. *The Spanish Journal of Psychology*, *15*(2), 680-687.

Fratkin, J. L., Sinn, D. L., Patall, E. A., & Gosling, S. D. (2013). Personality consistency in dogs: a meta-analysis. *PLoS One*, *8*(1), e54907.

Funder, D. C. (Ed.). (1999). *Personality judgment: A realistic approach to person perception*. Elsevier.

Funder, D. C., Kolar, D. C., & Blackman, M. C. (1995). Agreement among judges of personality: Interpersonal relations, similarity, and acquaintanceship. *Journal of Personality and Social Psychology*, *69*(4), 656.

Goldberg, L. R. (1992). The development of markers for the Big-Five factor structure. *Psychological Assessment*, *4*(1), 26.

Gosling, S. D., & John, O. P. (1999). Personality dimensions in nonhuman animals: A cross-species review. *Current Directions in Psychological Science*, *8*(3), 69-75.

Gosling, S. D., Kwan, V. S., & John, O. P. (2003). A dog's got personality: a cross-species comparative approach to personality judgments in dogs and humans. *Journal of Personality and Social Psychology*, *85*(6), 1161.

John, O. P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. *Handbook of personality: Theory and research*, *2*(1999), 102-138.

Jones, A. C. (2008). Development and validation of a dog personality questionnaire (Doctoral dissertation).

Jones, A. C., & Gosling, S. D. (2005). Temperament and personality in dogs (*Canis familiaris*): a review and evaluation of past research. *Applied Animal Behaviour Science*, *95*(1-2), 1-53.

Kubinyi, E., Turcsán, B., & Miklósi, Á. (2009). Dog and owner demographic characteristics and dog personality trait associations. *Behavioural Processes*, *81*(3), 392-401.

Kwan, V. S., Gosling, S. D., & John, O. P. (2008). Anthropomorphism as a special case of social perception: A cross–species social relations model analysis of humans and dogs. *Social Cognition*, *26*(2), 129-142.

Lerner, M. J., & Agar, E. (1972). The consequences of perceived similarity: Attraction and

    rejection, approach and avoidance. *Journal of Experimental Research in Personality, 6*(1),

    69-75.

Ley, J. M., Bennett, P. C., & Coleman, G. J. (2009). A refinement and validation of the Monash

    Canine Personality Questionnaire (MCPQ). *Applied Animal Behaviour Science*, *116*(2-4),

    220-227.

Ley, J. M., McGreevy, P., & Bennett, P. C. (2009). Inter-rater and test–retest reliability of the

    Monash Canine Personality Questionnaire-Revised (MCPQ-R). *Applied Animal Behaviour*

    Science, *119*(1-2), 85-90.

Ley, J., & Bennett, P. (2008). Measuring personality in dogs. *Journal of Veterinary Behavior:*

    Clinical Applications and Research, *3*(4), 182.

Ley, J., Bennett, P., & Coleman, G. (2008). Personality dimensions that emerge in companion

    canines. *Applied Animal Behaviour Science*, *110*(3-4), 305-317.

Mirkó, E., Kubinyi, E., Gácsi, M., & Miklósi, Á. (2012). Preliminary analysis of an adjective-

    based dog personality questionnaire developed to measure some aspects of personality in the

    domestic dog (*Canis familiaris*). *Applied Animal Behaviour Science*, *138*(1-2), 88-98.

Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., ... & Vanderplas,

    J. (2011). Scikit-learn: Machine learning in Python. *Journal of Machine Learning*

    Research, *12*(Oct), 2825-2830.

Podberscek, A. L., & Gosling, S. D. (2000). Personality research on pets and their owners: Conceptual issues and review. *Companion Animals and Us: Exploring The Relationships Between People and Pets*, 143-167.

Podberscek, A. L., & Serpell, J. A. (1997). Environmental influences on the expression of aggressive behaviour in English Cocker Spaniels. *Applied Animal Behaviour Science*, *52*(3-4), 215-227.

Posage, J. M., Bartlett, P. C., & Thomas, D. K. (1998). Determining factors for successful adoption of dogs from an animal shelter. *Journal of the American Veterinary Medical Association*, *213*(4), 478-482.

Rayment, D. J., De Groef, B., Peters, R. A., & Marston, L. C. (2015). Applied personality assessment in domestic dogs: Limitations and caveats. *Applied Animal Behaviour Science*, *163*, 1-18.

Turcsán, B., Range, F., Virányi, Z., Miklósi, Á., & Kubinyi, E. (2012). Birds of a feather flock together? Perceived personality matching in owner–dog dyads. *Applied Animal Behaviour Science*, *140*(3-4), 154-160.

Walker, S. L. (2014). Human and canine personality assessment instruments to predict successful adoptions with shelter dogs (Doctoral dissertation).

Watson, D., Hubbard, B., & Wiese, D. (2000). Self–other agreement in personality and affectivity: The role of acquaintanceship, trait visibility, and assumed similarity. *Journal of Personality and Social Psychology*, *78*(3), 546.

Weiss, E., Miller, K., Mohan-Gibbons, H., & Vela, C. (2012). Why did you choose this pet?: Adopters and pet selection preferences in five animal shelters in the United States. *Animals*, *2*(2), 144-159.

Youyou, W., Stillwell, D., Schwartz, H. A., & Kosinski, M. (2017). Birds of a feather do flock together: Behavior-based personality-assessment method reveals personality similarity among couples and friends. *Psychological Science*, *28*(3), 276-284.

6 Discussion

In this dissertation, I examined four domains of choice and compared search patterns exhibited. This includes a foraging perspective on romantic relationship search; the stated-revealed preference gap, an effect observed consistently in economics and consumer choice, which I studied in people's choices of dogs; as well as assortment, a social pattern primarily studied in romantic partner choice, which I explored in collaborators and dogs. Each of these choice environments varies in their constraints upon the decision-maker. The central hypothesis of this work was that individuals display common patterns of choice across search domains. A summary of the results is shown in Table 6.1.

Domain	Food Foraging (Chapter 2)	Collaborator Choice (Chapter 3)	Dog Choice (Chapters 4 &5)
Exhibited Mate Choice Phenomenon	Shared sensitivity to search costs in both mate choice and food foraging	Assortment based on perceived similarity of research, but not overlap in research areas or complementarity of needs	Weak assortment of personality; smaller than expected stated-revealed preference gap
Choice constraints	• No rejection • No social constraints • Universal strategies • Competition (implied or specifically modelled) • Cost of exploration • Benefits are modelled as one-sided.	• Bi-directional choice • Non-exclusive • Professional • Preferred qualities not universal: both overlapping knowledge and complementarity of needs for project • Experience level varies	• Unidirectional choice; no rejection costs • Unidirectional exclusivity: Dogs usually have one human family group or owner, but humans can have multiple dogs. • Flexible relationship: activity partner, companion, team member • Minimal genetic relatedness • Limited experience • Fixed costs

Table 6.1: Summary of the major findings of similarities between mate choice and other choice domains found in this dissertation, as well as the unique choice constraints of each domain.

6.1   Review of Results

6.1.1   Social Choice and Foraging Perspectives

In Chapter 2, I examined the commonalities in searching for a romantic partner and searching for other discrete non-social resources using the framework of Optimal Foraging Theory (Stephens and Krebs, 1986). Humans can influence the search for romantic partners more than they can food search, as they can control their search time by choosing not to search at all or to invest only a portion of their time into search, a luxury not afforded for most animals searching for food. Theory suggests the most appropriate comparison between these domains is the time spent within a monogamous relationship, gaining its resources, until one is facing a decreasing rate of return from the relationship below what one expects from an alternative relationship. A notable exception between these domains is the bidirectionality of mate choice as compared to food choice, as well as the assumption of significant duration in a romantic relationship rather than the ephemeral relationship one expects with food choice. Using a large dataset, I derived the duration and length between cohabitations and marriages and tested hypotheses that mate search would resemble food choice in that following a long period of singledom, individuals would stay in relationships longer by examining the influence of time spent single on the relative risk of relationship dissolution.

Individuals searching longest for their first marriage had a decreased risk of dissolution, although this effect was not significant for cohabitations and was trumped by the influence of age of first sexual intercourse. Following the dissolution of the first relationship, an extended first search period also significantly reduced the probability of entering a second relationship, and women's first cohabitation duration also significantly reduced the likelihood of entering a second cohabitation. The first finding is in line with the optimal foraging hypothesis, but the

second is not. These differences may be the result of the legal interdependencies between spouses and cohabitations, as compared to less committed relationships which can be ended with fewer monetary or legal ramifications.

6.1.2 The Choice of a Collaborator

In Chapter 3, I took the speed-dating designs typically used to study homophily and the stated-revealed preference gap in romantic partners (Todd, Penke, Fasolo, & Lenton, 2007) and adapted them to introduce academics to potential collaborators. Individuals could report specific preferences for the expertise or skillset of a collaborator (which could be compared to other attendees) so that they could be paired with individuals filling that idiosyncratic preference. I tested whether complementarity of desired expertise and professional homophily would influence collaboration rates.

I found that the best predictor of collaboration was similarity (i.e. assortment)—but not in terms of research as defined by an algorithm. The *perceived* similarity of a partner was significantly higher in collaborative pairs, rather than the amount of overlap between the specific expertise an individual was seeking and the expertise a potential collaborator could provide or the overlap in their current research programs. These two concepts—objective and perceived similarity—do correlate weakly, suggesting that overlap as measured algorithmically does relate to participant's perceptions of similarity of their partner but does not entirely explain them. As in Chapter 4, perceptions of a potential social partner do not always align with algorithmic assessments. Homophily is indeed likely an important predictor of collaboration as in other social domains, but this work suggests that future work should not focus solely on *professional* similarity, but also consider dyadic-level factors which can promote relationship formation in general.

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6.1.3 Dog Choice

In Chapters 4 and 5, I turned to a different type of relationship partner: companion canines. Dogs fill aspects of many social relationships such as a child, friend, and co-worker; elicit similar behaviors as human partners; and share an evolutionary history and environmental niche as humans (Hart, 1995). However, dogs lack the ability to communicate complex thought and share much fewer genes compared to human partners. For the first time in the literature, I measured how individuals assess their pets at the time of choice, rather than after their relationship forms, to see which attributes of the dog and human influence the likelihood of adoption.

6.1.3.1 Stated-Revealed Preference Gap

In Chapter 4, I began by examining the stated-revealed preference gap in the qualities that new adopters said they wanted and the qualities they assessed in their recently chosen dogs. Dogs present a unique comparison case for producing a gap by controlling for the effects of two variables hypothesized to produce it: bidirectional choice and competition (eliminating individual quality and rejection sensitivity as potential influencers of the gap). However, most individuals likely lack experience in this unique domain, which could prevent revealed preferences from reflecting normative preferences (Beshears, Choi, Laibson, & Madrian, 2008).

First, I found that preferences for dogs contain both near-universal preferences (e.g. friendliness) as well as idiosyncratic preferences (both in terms of whether any preference was held as well as the preferred level, e.g. for sex). With these similarities to mate choice, shared standards can produce competition for dogs on these qualities, enhancing the likelihood of a stated-revealed preference gap.

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Of the preferences that individuals held, the only traits which were fulfilled at above-chance levels were sex, size, intelligence, age, and playfulness, a mix of universally and idiosyncratically valued traits. This may be because for almost every trait, individuals had at least a 50% chance of having their preference fulfilled by a random dog. One could argue that this could indicate a lack of diversity in preferences by adopters, but this was not supported, given the idiosyncratic preferences of visitors to the shelter. The stated-revealed preference gap was smaller than expected due to chance, suggesting individuals perceive fulfillment of their stated preferences by the dogs they choose, at least partially. This conclusion is strengthened given that on each trait, most individuals had their preference fulfilled (which could also indicate that individuals tend to rate dogs that they own positively in general).

Taking an alternative approach to studying the stated-revealed preference gap, I examined which dogs were adopted most quickly (in terms of lengths of stay) using a database of dog traits, Match-Up II. Using both behavioral and appearance data to predict length of stay produced a very poor fit, suggesting that most of dogs' lengths of stays are not influenced by these traits as measured by the database. This is not unexpected—most of the traits that are available (e.g. sex, coloring) were shown to be relatively unimportant to potential adopters, to vary in the preferred level on the trait, or to not correspond with adopters' perceptions on identical constructs (as demonstrated by a lack of correlations between adopters' ratings of their dog and the same ratings by the Match-Up II system).

6.1.3.2 Homophily and Dogs

In Chapter 5, I examined whether the sample collected in Chapter 4 exhibited assortment of personality. Though positive assortment is common through the animal kingdom, it is rarely examined between species. Studying interspecies homophily varies from other domains on both

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the underlying composition and variability of shared traits. However, testing interspecies assortment provides a unique test for theories assuming homophily is a preference for *genetically* similar others. I expected correlations to be slightly lower than in human friendships, where correlation coefficients are typically between 0.12 and 0.31 (Youyou, Stillwell, Schwartz, & Kosinski, 2017).

When canine personality questions were assigned to identical personality factors as humans, there were significant positive correlation coefficients ranging from 0.20 to 0.24 for Agreeableness, Neuroticism, and Conscientiousness, but not for Extraversion, which was the item with the highest internal consistency; the average correlation coefficient between identical single items was 0.14. The achieved correlations were on the low end of similar relationships in human friendship pairs (Youyou et al., 2017) and existing dog-owner pairs (Kwan, Gsosling, & John, 2008; Turcsán, Range, Virányi, Miklósi, & Kubinyi, 2012). The low internal consistency relative to other personality measures led me to instead pull out underlying personality factors, which could be organized in a non-identical structure to humans and I found a five-factor model of Activity, Amicability/Neuroticism, Assertiveness, Aloofness/Stubbornness, and Warmth/Distraction. None of these factors covaried with the human Five Factor Model scores.

Notably, all these measures of canine attributes are subjective perceptions and at the time of choice, which may be inaccurate compared to ratings by experts or after longer ownership periods, given that adopters may only have sampled a dog's behavior for a short period of time. However, this is the behavior information available to adopters at the time of choice, making it appropriate for examining whether perceived similarity of personality influenced selection, as opposed to convergence. As perceptions, this work cannot definitely say that humans select dogs of similar personality, but rather than humans believe their dog weakly resembles them on

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identical personality items when they adopt it, which could also be due to a projection of their personality onto their dog (Gosling, Kwan, & John, 2003; Kwan et al. 2008; Turcsán et al., 2012). Overall, while not definitively showing that homophily of personality influences dog adoption, this study demonstrated perceived similarity of personality between dog and owner is present at the time of selection, which may have influenced which dog was chosen.

6.2   Broader Discussion

In this work, I demonstrated commonalities in the byproducts of human choice and search in several domains, both social and non-social, in domains that are typically understudied. I chose patterns of choice that can result from a range of conditions, not only as a result of a single, generalized cognitive mechanism. Overlapping patterns of search length were shown in both food and romantic partner search. Positive assortment was seen in two types of partners: dogs, highly-integrated partners with minimal genetic overlap, under uni-directional choice and in a consumer setting; as well as professional colleagues with bi-directional choice and non-exclusivity. A lower-than-expected stated-revealed preference gap appeared in dog choice, but not all preferences were fulfilled at above chance rates. In academics, fulfilment of one's desire for new knowledge or techniques had no impact on the chance of collaborating, suggesting that preferences on these traits, at the least, were not the best predictors of relationship formation and that a stated-revealed preference gap may exist in collaborator choice. As the patterns observed appeared in social partners with highly varied social constraints, suggesting that the cause of these patterns may not be dependent on the choice constraints of social problems.

6.2.1   Field Studies and Lab Controls

The studies included in this dissertation were done almost exclusively in real-world settings. A key critique of studies of romantic choice in the lab is task artificiality, such that mates are often

presented as traits on a piece of paper or confederate text chats. The results of such lab studies may not be representative of what occurs in naturalistic mating environments. The speed-networking experiments in this dissertation were real-world opportunities with one's peers and with a very real potential reward of potential grant money. Chapter 2's relationship foraging examined real-world data of individuals entering and exiting relationships in a representative sample. My work on dog choice was conducted within a real animal shelter with actual adoptable dogs and only amongst adopters who could actively choose to adopt a particular dog. This choice of methodology increases the likelihood that the results of this dissertation have high external validity.

However, field studies come with downsides. In these studies, I could not control many key variables which have been shown in controlled studies to influence choice patterns. I could not control the range of collaborator traits available to speed-networking participants (Chapter 3), nor the dogs available to adopters (Chapters 4 and 5). In Chapter 2, I could not observe all the potential partners a relationship forager experienced prior to choosing their partner nor present several sets of potential partners and see which were chosen in countless trials. As a result, this dissertation is unequipped to provide definitive explanations of the cognitive mechanisms used by participants nor to experimentally control the choice sets to see which factors influenced revealed preferences.

As this work contains pseudo-experimental and field studies, I cannot confirm that individuals are using identical cognitive mechanisms such as homophily. Future work can explore whether individuals use identical decision-making mechanisms by employing a within-subject approach exposing participants to numerous search problems and stimuli. Alternatively, researchers could combine these two approaches by conducting field studies and experimentally

manipulating the choices—for example, examining patterns of homophily in online inquiries for animal shelters in when photos are or are not provided, controlling for the influence of physical similarity, attractiveness, or perceived personality from photos.

6.2.2   What Cognitive Mechanisms Produced These Results?

What do the current set of results mean for cognitive scientists specifically examining decision-making mechanisms? While these results suggest that some patterns, such as assortment, are robust across several mating systems and social settings, it remains unclear whether there are separate mechanisms or strategies for choosing romantic and non-romantic social partners.

However, this dissertation can help eliminate some potential explanations of why assortment occurs. Scholars have long grappled with what causes positive assortment, as the pattern can occur both due to an active search for similarity (homophily) or several choice strategies or simply environmental constraints (Burley, 1983; Kalick & Hamilton, 1986; McPherson, Smith-Lovin, & Cook, 2001). Human positive assortment in mates involves bidirectional choice and competition, where a number of traits vary between individuals not just in terms of individual value, but the importance and preferred value by each individual. Romantic partners are also relatively singular in that the intended social tie is typically intended to be long-term and exclusive with the possibility of offspring.

Positive assortment was demonstrated at the time of selection in two domains of choice with very different choice constraints: dogs and academics. Dogs lack substantial genetic overlap with humans, are highly integrated into the family, serve as both companions and team-members, and are often the only social partner of their type (i.e. the only household pet). Shelter dogs, with a lack of ownership, are also in no way integrated into a social network that could produce

induced homophily of dyads. In contrast, academics are typically linked professionally and may maintain many of these ties within a shared social network. In the choice of both dogs and collaborators, there are both universally and idiosyncratically valued traits, which can produce assortment based not on homophily, but as a byproduct of bidirectional choice or competition. Competition is minimal in both these domains (as all individuals at the speed-networking events were seeking out collaborators, suggesting availability for more ties of this type, and dogs could be adopted on a first come, first serve basis). Dog choice is unidirectional, while academic choice is bidirectional. That positive assortment occurred in both of these domains suggest that assortment can occur without competition and regardless of bidirectionality—therefore suggesting homophily or a tendency to project similarity onto their chosen partner that may not exist. However, these field studies cannot definitely state that dogs or academics are chosen for their similarity, nor state that other search problems with similar but varied constraints will also exhibit assortment.

It is still interesting to understand the extent of sensitivity of humans' approach to social problems and whether this sensitivity exceeds that present in a domain less essential to human survival (e.g. gambling). Cooperating and acting in social groups have been adaptive to the success of the human species. While social partners are beneficial to human fitness, this does not imply that humans have specifically evolved to search for relationships or other social partners in the same way that animals forage for food in patches. In particular, dogs (let alone collaborators!) are relatively new social partners in the evolutionary scheme of things. Rather than specifically evolved strategies for searching for a particular social partner, 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, 2017—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). So too might strategies like homophily, which could be beneficial in terms of kin selection or finding cooperative partners, be usefully applied to the choice of other social partners.

6.2.3   Should Individuals Use Identical Decision-Making Mechanisms?

Whether using similar strategies is *effective* in these domains is another dissertation entirely. The results of this work do not suggest that these patterns of choice improve general fitness or perform best across search domains. As noted, both social and non-social search problems vary in their constraints on the searcher. Indeed, some argue that even the base case of how individuals approach the search for a romantic partner, a social choice with intense evolutionary significance, is far from optimal (Frey & Eichenberger, 1996).

This is not to say that these patterns are never appropriate. The studied patterns could be beneficial in some domains: the stated-revealed preference gap may allow one to choose according to normative preferences but avoid consequences if they are negatively stigmatized; homophily can ease relationship formation in friends and romantic partners; and optimal foraging search rules allow searchers to efficiently gather food. But if these patterns generalize to other social domains, the benefits may disappear. For example, if senior academics choose to collaborate only with similarly advanced partners, new faculty members may struggle to attain professional guidance and resources, and more advanced faculty members may be isolated from

new scientific ideas. Humans choosing pet dogs inconsistent with their stated preferences may be less satisfied. Individuals using foraging rules to decide when to end a relationship may re-enter a depleted mating market. Understanding whether these patterns are exhibited in other domains is the first step in determining both what causes them and the consequences of their appearance.

6.3   Conclusion

It appears that, in terms of the byproducts of search, similar patterns are exhibited in both social and non-social domains. The current work leveraged two well-studied research areas, optimal foraging theory and romantic partnership formation, to predict similar patterns in understudied but theoretically similar domains. Overall, this dissertation emphasizes that cross-domain approaches to studying search can provide strong theoretical foundations as humans and our social world continue to evolve.

6.4 References

Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2008). How are preferences revealed?. *Journal of Public Economics*, *92*(8-9), 1787-1794.

Burley, N. (1983). The meaning of assortative mating. *Ethology and Sociobiology*, *4*(4), 191-203.

Frey, B. S., & Eichenberger, R. (1996). Marriage paradoxes. *Rationality and Society*, *8*(2), 187-206.

Gosling, S. D., Kwan, V. S., & John, O. P. (2003). A dog's got personality: a cross-species comparative approach to personality judgments in dogs and humans. *Journal of Personality and Social Psychology*, *85*(6), 1161.

Hart, L. A. (1995). Dogs as human companions: a review of the relationship. *The Domestic Dog: Its Evolution, Behaviour and Interactions with People*, 161-178.

Hills, T. T., Jones, M. N., & Todd, P. M. (2012). Optimal foraging in semantic memory. *Psychological Review, 119*(2), 431-440.

Hills, T. T., Todd, P. M., Lazer, D., Redish, A. D., Couzin, I. D., & the Cognitive Search Research Group (2015). Exploration versus exploitation in space, mind, and society. *Trends in Cognitive Science, 19*(1), 46-54.

Kalick, S. M., & Hamilton, T. E. (1986). The matching hypothesis reexamined. *Journal of Personality and Social Psychology*, *51*(4), 673.

Kwan, V. S., Gosling, S. D., & John, O. P. (2008). Anthropomorphism as a special case of social perception: A cross–species social relations model analysis of humans and dogs. *Social Cognition*, *26*(2), 129-142.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, *27*(1), 415-444.

Pirolli, P. (2007). *Information Foraging Theory: Adaptive Interaction with Information.* Oxford University Press, New York, NY.

Stephens, D. W., & Krebs, J. R. (1986). *Foraging theory*. Princeton, NJ: Princeton University Press.

Todd, P. M. & Miller, G. F. (2017). Cognitive exaptations for extra-terrestrial intelligence. To appear in D. Vakoch (Ed.), *Cognition and Communication in Extraterrestrial Intelligence*.

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.

Turcsán, B., Range, F., Virányi, Z., Miklósi, Á., & Kubinyi, E. (2012). Birds of a feather flock together? Perceived personality matching in owner–dog dyads. *Applied Animal Behaviour Science*, *140*(3-4), 154-160.

Youyou, W., Stillwell, D., Schwartz, H. A., & Kosinski, M. (2017). Birds of a feather do flock together: Behavior-based personality-assessment method reveals personality similarity among couples and friends. *Psychological Science*, *28*(3), 276-284.

7   Supplemental Materials
7.1   Appendix Chapter 2

7.1.1   Hazard Rate Analysis

Here I examine how relationship dissolution hazard rates are altered by various covariates in addition to search duration and age at first sex as covered in the main text. First, it is useful to consider the baseline risk of dissolution for marriages and cohabitations. This can be done in terms of the proportion of surviving relationships at any given time point. To estimate this proportion, the data was fit to a Kaplan-Meier model (Kaplan & Meier, 1985), shown in Figure 7.1. As analyzed in Table 2.1 in the main text, the first marriage data included ,3916 observations, 2,482 of which were censored; the first cohabitation data included 2,669 observations, 679 of which were censored. The proportion of marriages surviving at any duration is higher than the proportion of cohabitations surviving that long, indicating the greater stability of marriages.
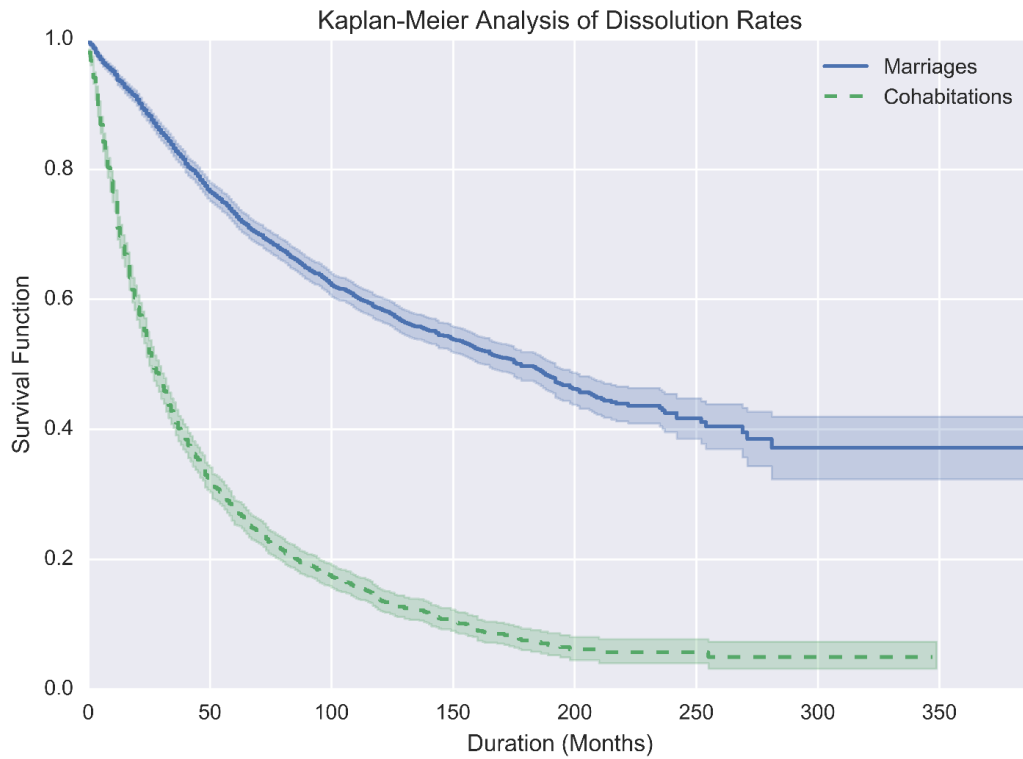
Figure 7.1 Estimated survival function of first marriages (solid and blue online /dark grey in print) and first cohabitations (dashed and green online /light grey in print) from the CDC data using a Kaplan-Meier model. Shaded area represents 95% confidence intervals.

7.1.2 Extended Models

The primary model focused on the main variables needed to test the foraging and romantic relationship research hypotheses. However, many other factors also influence when relationships will dissolve or form. Some of the strongest predictors of the dissolution of relationships are dyadic (e.g. love, trust). A variety of individual-level factors are also plausible influencers, including those related to life history theory and the ways that various tradeoffs change the pace of important life events. As seen in Table 2.1, later age of first sexual intercourse, an indicator of lower attractiveness and slower life history strategy, had a very strong impact on lessening the likelihood over time of one's marriage ending. The CDC data source I analyzed includes a number of other life history related factors, so I ran additional models with indicators of attitudes toward marriage and cohabitation, life history in terms of an intact family from birth to age 18, and personal variables such as religiosity and education level.

Having an intact family is likely associated with later age of first sexual encounter; for example, women from intact families generally have lower rates of early intercourse than those from non-ntact families (Hogan & Kitagawa, 1985). Similarly, religiosity is also generally linked to lower rates of adolescent sexual behavior (e.g. Miller & Olson, 2012). Educational aspiration has been inversely linked to age at first sexual intercourse (Schvaneveldt, Miller, Berry, & Lee, 2001), meaning that individuals with greater educational attainment may also have waited longer prior to sex, in line with life history theory (for a thorough review, see Bingham, Miller & Adams, 1990).

In the first extended Cox Proportional Model predicting the risk of marriage dissolution I included the two variables from the original model in Table 2.1 (first marriage gap and age at first sex), and added the following predictors: whether one had an intact family (as compared to

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not having an intact family) from birth to age 18; highest level of education level completed (11-point ordinal scale ranging from 1 for 9th grade or less to 11 for a Doctorate Degree); religiosity ("Currently, how important is religion in your daily life? Would you say it is very important, somewhat important, or not important?" with 3 options of "Not", "Somewhat" or "Very" important on a ranked ordinal scale); and attitudes toward 6 statements related to cohabitation and marriage shown in Table 7.1, rated on a 5-point Likert scale ranging from "Strongly disagree" (1) to "Strongly agree" (5), where the midpoint of "Neither agree nor disagree" was permitted only if the respondent insisted.

Of the original 3,916 person subsample, 3,071 had complete data for these additional variables (with others removed due to question applicability restrictions, refusal to answer, or "Don't know" responses). As in the analyses in the main text, all items were normalized prior to analysis and passed the assumption of proportional hazards. Analysis was completed in R (2.15.1) using the OIsurv library (Therneau & Grambsch, 2000). The results are shown in Table 7.2.

Individuals with an intact family were at lower risk of dissolving their marriage, as expected. Education level slightly *increased* the risk of dissolution, while religiosity did not have an impact, both perhaps surprisingly. Attitudes towards cohabitation (No Non-Marital Cohab) did not significantly impact marriage dissolution risk. Finally, individuals who considered divorce the best solution when couples could not work out marriage problems (Divorce Best) were more likely to dissolve their relationship, as were those who said marriage had not worked out for most people they knew (Marriage Failure). However, the improvement of this model over the two-factor model in the main text was minimal, raising concordance from 0.650 to 0.674.

I also repeated this analysis for the second marriage gap (for the 1,068 individuals with complete data from the original 1,434 person subsample), in Table 7.3. As in the original model in Table 2.2 in the main text, I exclude first marriage duration, which again failed the Assumption of Proportional Hazards. Concordance rose to 0.598 with additional variables included (compared to 0.550 for the original), with education level increasing the likelihood of entering a second marriage and attitudes supporting divorce during marital difficulties decreasing that likelihood.

Variable Name	Question Text
No Non-Marital Cohab	A young couple should not live together unless they are married.
Marriage Failure	Marriage has not worked out for most people I know.
Cohabs Prevent Divorce	Living together before marriage may help prevent divorce.
Divorce Best	Divorce is usually the best solution when a couple can't seem to work out their marriage problems.
Unmarried Mother	It is okay for a young, unmarried woman to have and raise a child.
Children while Cohab	It is okay to have and raise children when the parents are living together but not married.

Table 7.1 Additional variables used in extended model, along with corresponding question prompts.

Predicted event: End of…	Events/ Observations	Concordance	Variable	β Coefficient	e^{β}
First Marriage	1068/3071	0.674	First Marriage Gap	−0.305	0.737***
			Age of First Sexual Intercourse	−0.611	0.543***
			Intact Family	−0.352	0.703***
			Education Level	0.076	1.079*
			Religiosity	0.008	1.008
			No Non-Marital Cohab	0.004	1.004
			Marriage Failure	0.155	1.167***
			Cohabs Prevent Divorce	0.050	1.052
			Divorce Best	0.192	1.211***
			Unmarried Mother	0.023	1.023
			Children while Cohab	0.041	1.041

¹: $p < 0.07$ *: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Table 7.2: Results of extended Cox proportional hazards survival regression analysis of effect of base model plus nine additional covariates on hazard rate of the end of the first marriage.

Predicted event: End of…	Events/ Observations	Concordance	Variable	β Coefficient	e^β
Second Marriage Gap	439/1068	0.598	First Marriage Gap	−0.238	0.788***
			Age of First Sexual Intercourse	−0.208	0.813***
			Intact Family	0.111	1.117
			Education Level	0.198	1.218***
			Religiosity	−0.026	0.974
			No Non-Marital Cohab	0.082	1.085
			Marriage Failure	−0.063	0.939
			Cohabs Prevent Divorce	0.080	1.083
			Divorce Best	−0.164	0.849**
			Unmarried Mother	−0.045	0.956
			Children while Cohab	−0.044	0.957

¹: $p < 0.07$ *: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Table 7.3: Results of extended Cox proportional hazards survival regression analysis of effect of base model plus nine additional covariates on hazard rate of the end of the second marriage gap (i.e. entering one's second marriage).

7.2 Appendix Chapter 3

7.2.1 Experiment 1, Potential Techniques and Research Areas of Attendees for Objective Similarity

Techniques:

- Using a new organism model (indicate in other)
- Archival/historical
- Big data and data mining
- Bioinformatics
- Cognitive and behavioral modelling
- Computational modeling and simulations
- Group, population, and complex system modelling.
- Content analysis
- Correlational
- Descriptive/Non-experimental
- Drug testing and treatment
- Epidemiological
- Ethnographic
- Genetics: behavioral, epigenetic, modification, etc
- Imaging: neurological, structural, and functional
- Interview and case study
- Meta-analysis
- Naturalistic observation, immersion, field study
- Network analysis
- Program evaluation and policy
- Quasi- and Experimental
- Statistical modelling
- Survey design

Research Areas

- Aging and lifespan
- Auto-immune, infectious, and other bodily disease
- Child and developmental health
- Deafness and communication disorders
- Drug abuse and addictive behavior
- Health economics, disparities, and systems
- Medicine
- Mental health and neurological disease
- Health Behavior: nutrition, exercise, and obesity
- Disability, rehabilitation and physical activity

- Sexual and reproductive health and behavior
- Biological sciences
- Computer and informational science
- Health education and human resources
- Geosciences and international affairs
- Math and physical sciences
- Social, behavioral, and economic sciences
- Other: _____

7.2.2 Objective Similarity Calculation and Limitations

In contrast to Experiment 1, which had *overall* similar and dissimilar groups, I attempted to ensure that in both 2C and 2E met the *individual* most similar partners, in the hopes of producing more collaborations. Since perceived similarity was most predictive of collaboration in Experiment 1, I created a new objective similarity equation based on which components predicted perceived similarity. The intended manipulation was for each participant to meet the 3 other participants in the group with the highest objective similarity scores (according to the new equation) for that individual, and 6 more partners chosen (from a large set of random samples as in Experiment 1) to yield the highest mean objective similarity scores across the group. Members of 2C also met 9 partners, in this case meaning that they met every other individual within their group, including their best partners.

A regression analysis was run to determine the relationship between each component of the objective similarity equation and the mean perceived similarity of each pair of participants who met. I also included two additional components (AREA WANT: AREA WANT and TECHNIQUE WANT: TECHNIQUE WANT) to assess whether they could be useful in predicting perceived similarity in future research direction. R^2 was 0.074 (see Table 7.5); with such a low R^2, there is a very weak relationship between objective similarity and perceived similarity. The components of objective similarity that matched one partner's interests with the

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other partner's knowledge/skills (AREA HAVE: AREA WANT, AREA WANT: AREA HAVE, TECHNIQUE HAVE: TECHNIQUE WANT, and TECHNIQUE WANT: TECHNIQUE HAVE) had little influence on ratings of perceived similarity, but this pattern is understandable given that participants were asked only about perceived similarity, not complementarity, of their partner's research interests.

However, several errors in this procedure prevent me from discussing the benefit of a particular matching scheme (H1b). First, there was no correction for multiple comparisons; none of the components are significant influences on perceived similarity at a corrected $\alpha = 0.008$. In addition, since generation and use of this formula, the author found an artefact in the data that changed the resulting regression. Recent replications with the individual level perceived similarity and objective similarity components from Experiment 1 have given highly similar results (Table 7.6) with a similarly significant but poor fit, $F(6, 282) = 4.079$, $p = 0.001$, $R^2 = 0.08$. However, the three highest objective similarity partners were not necessarily identical for equation 2 and as calculated using the coefficients on AREA HAVE: AREA HAVE and TECHNIQUE HAVE: TECHNIQUE HAVE; in the case of the later equation, 4 of 16 individuals in 2E met only 2 of their top 3 partners. Although partners were assigned non-randomly according to Equation 2 in 2E, there was still no significant difference in objective similarity (as defined by Equation 2) between 2C and 2E, as discussed in the main text. Therefore, in this study, I do not discuss the benefits of a particular matching scheme.

	Regression Statistics			
	Coefficients	*SE*	*t*-stat	*p*-value
Intercept	2.447	0.111	22.120	<.001
AREA HAVE: AREA HAVE	0.204	0.079	2.596	0.010
AREA WANT: AREA WANT	0.116	0.136	0.848	0.397
AREA WANT: AREA HAVE (Mean)	-0.032	0.040	-0.804	0.422
TECHNIQUE HAVE: TECHNIQUE HAVE	0.086	0.045	1.903	0.058
TECHNIQUE WANT: TECHNIQUE WANT	0.268	0.171	1.561	0.120
TECHNIQUE WANT: TECHNIQUE HAVE (Mean)	-0.004	0.074	-0.056	0.955

Table 7.4 Regression model showing relation between specific components of the objective similarity function (Equation 1) and mean perceived similarity assessed for both individuals in a pair, where x:y measures the number of matching selected answers between question x for the first participant and question y for the second participant, and AREA HAVE = current areas of study, TECHNIQUE HAVE = current techniques, AREA WANT = desired new areas of study, and TECHNIQUE WANT = desired new techniques.

	Coefficients	Standard Error	*t*-Stat	*p*-value
Intercept	2.500	0.111	22.524	**0.000**
AREA HAVE: AREA HAVE	0.199	0.078	2.548	0.011
AREA WANT: AREA WANT	0.281	0.149	1.888	0.060
AREA WANT: AREA HAVE (Mean)	-0.079	0.045	-1.753	0.081
TECHNIQUE HAVE: TECHNIQUE HAVE	0.102	0.045	2.254	0.025
TECHNIQUE WANT: TECHNIQUE WANT	-0.035	0.107	-0.328	0.743
TECHNIQUE WANT: TECHNIQUE HAVE (Mean)	0.003	0.041	0.082	0.934

Table 7.5 Regression model showing relation between specific components of the objective similarity function (Equation 1) and individual perceived similarity assessed for both individuals in a pair, where x:y measures the number of matching selected answers between question x for the first participant and question y for the second participant, and AREA HAVE = current areas of study, TECHNIQUE HAVE = current techniques, AREA WANT = desired new areas of study, and TECHNIQUE WANT = desired new techniques.

7.2.3 Experiment 2 Method Details

The speed-networking session was run in a large meeting room over a 3-hour period during which participants received breakfast, lunch, and coffee. The timeframe for filing a grant application for new collaborations was limited to 1 week, which is not expected to have significantly affected collaboration rates. Due to a smaller sample, participants met 9 partners, compared to 10 in Experiment 1—unlike in Experiment 1, there were no dropouts, so all participants had an identical number of partners.

7.2.4 Experiment 2, Potential Techniques and Research Areas of Attendees for Objective Similarity

Techniques:

- Using a new organism model (indicate in other)
- Archival/historical
- Big data and data mining
- Bioinformatics
- Cognitive and behavioral modelling
- Computational modeling and simulations
- Group, population, and complex system modelling.
- Content analysis
- Correlational
- Descriptive/Non-experimental
- Drug testing and treatment
- Epidemiological
- Ethnographic
- Genetics: behavioral, epigenetic, modification, etc
- Imaging: neurological, structural, and functional
- Interview and case study
- Meta-analysis
- Naturalistic observation, immersion, field study
- Network analysis
- Program evaluation and policy

- Quasi- and Experimental
- Statistical modelling
- Survey design
- Text mining
- Computer vision
- Machine learning algorithms
- Learning analytics
- Population models
- Neuroimaging
- Multi-level Mathematical models
- Social media
- Biological assays
- Genomic sequencing
- Supercomputing
- Big data
- Biometrics
- Other

Research Areas:

- Aging and lifespan issues.
- Disease and treatment
- Child and developmental health
- Deafness and communication disorders
- Drug and alcohol abuse and addictive behavior
- Health environments, disparities, and systems
- Mental health and neurological disease
- Health behavior: nutrition, exercise, and obesity
- Disability, rehabilitation and physical activity
- Sexual and reproductive health and behavior
- Biological sciences
- Computer and informational sciences
- Health education and human resources
- Geosciences and international affairs
- Social and economic sciences
- Cognition and behavior
- Animal behavior and ecology
- Other

7.2.5 All Experiments Order Effects

One potential concern for any speed-networking event is participant fatigue. Anecdotal comments from across experiments suggests that participants engaging in these rapid, intensive encounters may quickly tire over the course of the event. In addition, over the course of an experiment, participants may shift their standard for assessing the similarity of any particular partner. To examine whether fatigue or standards influence ratings of similarity, I calculated the mean rating and standard error at each round for each event (Table 7.4). There was no apparent fatigue effect.

	Round	1	2	3	4	5	6	7	8	9	10
Event 1	M	2.87	2.68	2.77	2.41	2.90	3.15	2.89	2.65	2.57	2.61
	SE	0.18	0.19	0.19	0.19	0.22	0.21	0.24	0.24	0.21	0.25
Event 2C	M	3.50	3.60	3.80	3.80	3.50	3.50	3.50	3.50	2.90	-
	SE	0.40	0.45	0.33	0.20	0.31	0.27	0.40	0.22	0.41	-
Event 2E	M	3.63	3.19	3.63	3.63	2.73	4.07	3.25	3.71	3.71	-
	SE	0.27	0.32	0.29	0.30	0.34	0.29	0.22	0.24	0.29	-
Event 3	M	3.00	3.50	3.28	3.21	2.94	2.07	3.07	-	-	-
	SE	0.32	0.23	0.30	0.33	0.34	0.30	0.43	-	-	-

Table 7.6: Mean ratings and standard error of partner perceived similarity by individuals at each round. No consistent trend was demonstrated. Experiment 1 had 10 rounds; Experiments 2C and 2E had only 9. Note that since all but one individual in Experiment 3 had 7 or fewer partners, data past round 7 is not reported for this experiment only.

7.3   Appendix Chapter 4

Author Note This appendix includes material from the following peer-reviewed manuscript: Cohen, S.E., & Todd, P.M. (2019). Stated and Revealed Preferences in Companion Animal Choice. *Behavior Research Methods.*

7.3.1   Field Site Policies

Animals that come into the shelter as strays are held for a mandatory five days to allow owners to reclaim their pets (this period is subtracted from the length of stay measure within the study prior to analysis). Animals that are relinquished by their owner bypass this holding period, and at the time of relinquishing the previous owner(s) can provide a behavioral history for their pet, including reports of aggression, training, and behavior with household members and other animals. Following any holding period, dogs are tested for heartworm, provided with their first round of vaccinations excluding rabies, de-wormed (as necessary), microchipped, and spayed or neutered if not previously altered (note that animals may be made available prior to alteration, but will not be released to an adopter until they have been altered). All canines typically complete behavior testing through Match-Up II. After a positive assessment from staff based on behavior and health, animals are made available for adoption and are placed in kennels where they may be visited by the public (although due to space constraints, some available animals are occasionally not in a public-facing area). The public can view animals in these kennels freely during open hours and request to meet any available dog during that period. A list of adoptable dogs in book form and online is made available and regularly updated with photos. Volunteers and staff are available to potential adopters to provide additional information on any animal and provide suggestions.

Visitors are given access to any existing behavioral records from a prior owner, as well as a medical assessment of an animal, and on very rare occasions, any related behavioral assessments. At the shelter, individuals may request an adoption application for a dog in person or complete an application online (this second option ended in April 2018). Each application is processed in order. Applications are approved at the discretion of the staff, and while statistics are not available on the rate of approval, it is very rare for adopters to be denied, as long as the individual can provide verification they can legally reside with a dog. Applications are generally denied only due to extreme concern for the health and safety of adopter and/or canine.

In terms of outcomes within the shelter, animals can be reclaimed by their previous owner (within 5 days of intake), adopted, transferred to rescues or other shelters, or euthanized. Euthanasia is generally applied to animals with serious medical concerns that cannot be resolved or serious behavioral issues posing a risk to the public, representing 10% of all intakes in 2016 (below the national average of approximately 12.8%; Shelter Animals Count et al., 2016).

7.3.2 Chapter 4, Study 2 Method Details

Match-Up II (http://matchupii.arlboston.org/) is a unique behavior evaluation implementing best practices within behavior scoring and touting scientifically driven measures. Basic reliability measures of Match-Up II suggest relatively strong reliability across raters for 82% of behaviors but have not been published in a peer-reviewed outlet (Baisly, 2017). The development and validation of the original Match-Up II evaluation has been peer-reviewed. Dowling-Guyer, Marder and D'Arpino (2011) ran principal components analysis on the individual behaviors exhibited across Match-Up II subtests by 669 dogs to produce a 4 component (aggressiveness, fearfulness, playfulness/friendliness, and general alertness) model accounting for 45.3% of the total variance. However, this cannot be a complete account of how

the personality facets in Match-Up II came into use, as two of them, excitability and trainability, are not components in the PCA, and two others, playfulness and friendliness, appeared as a single component in the PCA (See the manual showing the scoring scheme for Match-Up II on the Animal Rescue League of Boston's webpage: https://www.arlboston.org/services/match-up/). Indeed, the Match-Up II behavior evaluation provided to shelters and used in this paper has obvious differences from the validated model described in Dowling-Guyer et al., including the removal and addition of subtests and behavior terms.

Personality scores are calculated as follows within the evaluation. On most subtests, a subset of available behaviors is assigned to a single personality facet (e.g. Friendliness) and each of these behaviors is given a score from one to three. On each subtest, the scores of all exhibited behaviors associated with a trait are compared and the highest score is retained. The final personality facet score is the sum of the maximum behavior scores exhibited on each subtest. It is unclear how the behaviors per facet were chosen and rated and whether/how this scoring system has been validated as a personality measure.

7.3.3 Descriptive Statistics of Match-Up II

Behavior	Median	*M*	*SD*	Minimum	Maximum
Approach Person/Doll/Dog	6	6.13	1.78	0	10
Approach Toy	2	1.35	0.80	0	2
Back Away	0	0.37	0.69	0	3
Bark	0	0.17	0.62	0	8
Bring Toy Back	0	0.24	0.55	0	2
Cower	0	0.07	0.40	0	7
Crouch	0	0.07	0.35	0	3
Did Not Come When Called	0	0.07	0.25	0	1
Drop	0	0.35	0.68	0	3
Ears Back	2	2.56	2.68	0	10
Grab	0	0.01	0.15	0	3
Growl	0	0.05	0.25	0	2
Hard Mouth	0	0.01	0.11	0	2
Head Whip	0	0.04	0.19	0	1
Hide	0	0.06	0.40	0	5
Jump Up (Not on Person/Dog)	0	0.42	0.76	0	4
Jump Up On	1	1.02	1.32	0	7
Lick	1	1.01	1.18	0	6
Lie Down/Lie on Side	0	0.05	0.21	0	1
Lip Lick	0	0.51	0.84	0	6
Mount	0	0.00	0.03	0	1
Did Not Recover From Fear	0	0.08	0.33	0	2
Nudge	0	0.23	0.51	0	4
Paw	0	0.09	0.33	0	2
Pick Up	0	0.58	0.78	0	2
Play Growl	0	0.05	0.25	0	3
Play Tug	0	0.17	0.38	0	1
Playbow	0	0.17	0.53	0	4
Playful With	0	0.02	0.16	0	2
Reluctant To Trade	0	0.02	0.18	0	3
Roll On Back	0	0.03	0.18	0	1
Run Away	0	0.01	0.10	0	1
Show Teeth	0	0.01	0.08	0	1
Sit	0	0.01	0.12	0	1

Snap	0	0.01	0.08	0	1
Sniff	3	3.24	1.04	0	7
Soft Mouth	0	0.20	0.57	0	4
Stay Near	1	1.56	1.37	0	5
Stiff	0	0.07	0.38	0	7
Take Toy	0	0.33	0.47	0	1
Trade Toy	0	0.19	0.54	0	3
Tremble	0	0.18	0.90	0	10
Tuck Tail	0	0.37	1.00	0	8
Wag Tail	8	6.91	3.06	0	10
Come When Called	1	0.93	0.25	0	1
Whine	0	0.35	0.93	0	9
Yelp	0	0.01	0.08	0	1

Table 7.7 Chapter 4, Study 2 descriptive statistics of frequencies summed across all subtests of behaviors shown by dogs within the Match-Up II behavioral evaluation. This covers the 1019 records (including multiple records for dogs with multiple stays) in the analysis of length of stay in Chapter 4, Study 2.

7.4 Appendix Chapter 5

7.4.1 Dog Perception Survey

We'd like to know what you think about **the dog you have you indicated you wish to adopt**. Please rate your agreement with the following statements about this dog, where **1 indicates disagreeing strongly** (that is, the statement does not at all describe the dog you're interested in adopting), and **5 is agreeing strongly** (that is, the statement describes this dog very well). If you are unsure, take your best guess.

1	2	3	4	5
Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly

In general, this dog…

___1. Barks frequently
___2. Is reserved
___3. Adapts easily to new situations and environments
___4. Is relaxed
___5. Is curious
___6. Has a lot of energy
___7. Behaves aggressively towards other dogs
___8. Is easily excitable
___9. Is quiet
___10. Is generally trusting
___11. Tends to be lazy
___12. Is assertive
___13. Is shy
___14. Able to focus on a task in a distracting situation (e.g. loud or busy places, around other dogs)
___15. Is calm
___16. Is sociable
___17. Is outgoing
___18. Is anxious
___19. Is easily distracted

___20. Seeks constant activity
___21. Is stubborn
___22. Is confident
___23. Ignores commands
___24. Has a warm personality
___25. Is laid back
___26. Is playful
___27. Is eager-to-please
___28. Is aloof
___29. Seeks companionship from people
___30. Is a "special needs" dog
___31. Is comfortable being left alone for long periods of time
___32. Is boisterous
___33. Is affectionate
___34. Would be considered a "handsome" or "good looking" dog compared to most
___35. Is potty-trained/house-trained
___36. Is well-trained
___37. Is healthy
___38. Is destructive
___39. Gets along well with my other pets (if applicable)
___40. Gets along well with other members of my household (if applicable)
___41. Likes children
___42. Learns commands easily
___43. Is intelligent
___44. Is protective
___45. Resembles another dog I've owned

Personality Factor Calculation:

(R) indicates the item score is reversed prior to calculation. Bolded items were derived from the DPQ (Jones, 2009). The following items are unused in factor calculation:1, 5(corresponding to Openness), 7, 29, 30, 31, 33, 33-45.

Agreeableness: 10, 21(R), **23**(R), 24, 27, **28**(R)

Conscientiousness: 11(R), **14**, 19(R)

Extraversion: 2(R), 6, 8, 9(R), 12, **13**(R), 16, 17, **20**, **32**

Neuroticism: **3**(R), 15(R), 18, 25(R), 4(R), **22**(R)

Current Curriculum Vitae

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EDUCATION AND EMPLOYMENT

Doctor of Philosophy   06/2019
    Indiana University
    Joint Ph. D. in Cognitive Science Program and Department of Psychological and
    Brain Sciences
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    Dissertation Title: Mate Choice Biases in Non-Romantic Social Decision-Making
    Domains

Bachelor of Science   12/2011
    University of Illinois at Urbana-Champaign
    Department of Psychology
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RESEARCH INTERESTS AND APPROACHES

Social Search Behavior: Search mechanisms, judgement and decision-making, romantic partnerships, collaborative and academic partnerships, algorithmic measures of similarity, emergent behavior, environmental influences of behavior, sequential search paradigms.

Mate Choice: Strategies under competition, judgements of quality, attraction, partner choice, variations in choice in natural and digital environments, natural and sexual selective pressures on human behavior.

Human-Animal Interaction: Canine behavior in animal shelters, canine personality and behavior consistency, interpersonal factors influencing adoption outcomes, human perceptions of canines, animal-computer interaction, dyadic influences in dog-human relationships.

Digital Methods for Studying Human Behavior: Computer-human interaction, machine learning, big data, computational models, agent-based modelling, topic modelling, photo analysis, Python 3, R, Matlab, repurposed and found data, non-profit tool development, automatic data munging, web scraping, statistics for non-profits and social good.

PEER-REVIEWED PUBLICATIONS

Cohen, S.E. & Todd, P.M. The stated-revealed preference gap in canine companions. *Behavior Research Methods* (in press).
Press:
- [Outreach Video](#), Inside IU.
- Skipper, R. (2017, November 14). [Seeking Canine Companions, A Study of Decision-Making](#) *SciIU Science Blog.*
- Inside IU. (2018, January 18). [IU student studies decision-making process used for choosing canine companions.](#) *Inside IU Bloomington.*

Cohen, S. E., & Todd, P. M. (2018). Relationship foraging: Does time spent searching predict relationship length? *Evolutionary Behavioral Sciences, 12*(3), 139-151. http://dx.doi.org/10.1037/ebs0000131

Cohen, S. E. & Todd, P. M. (2017). Expected Utility in Romantic Relationships: Satisfaction as a Cue for Romantic Partnership Dissolution. In G. Gunzelmann, A. Howes, T. Tenbrink, & E. J. Davelaar (Eds.), *Proceedings of the 39th Annual Conference of the Cognitive Science Society* (pp. 234-239). Austin, TX: Cognitive Science Society. [Public Link](#)

Cohen, S.E., Todd, P.M., Garcia, J.R., Fisher, H.E. Reproduction Expediting: Singles of Both Sexes Shift Sexual-Timing Strategies Before and After the Typical Age of Female Menopause. Manuscript in revision.

ONGOING PROJECTS

Cohen S.E. & Todd, P.M. Paired speed-networking as a simple collaboration mechanism. Manuscript in preparation.
Press:
- Inside IU Bloomington (2015, March 5). [Featured spotlights: Speed-networking study speeds campus toward new research](#). *Inside IU Bloomington.*
- [Outreach Video](#), IU Provost

Cohen, S.E. & Todd, P.M. Just the two of us: similarities between canine temperament and adopter personality. Manuscript in preparation.

Cohen S.E. Choice overload in pet choice: evidence from real choices in animal shelters.

Cohen, S.E. **& Todd, P.M.** Unattractive individuals benefit more from misrepresentative photos in online dating.

Cohen, S.E., Zaman, I., Crandall, D., & Todd, P.M. Do dogs resemble their people at the time of choice?

Cohen, S.E. & Todd, P.M. Searching for love in all the new places: shifts in behavior following relationship transitions.

Cohen, S.E. & Todd, P.M. Swipe left, then what? Sequence effects in binary judgements of attractiveness.

Brander, J. & Cohen, S.E. Mate choice experience affects future mate choice strategy.

Cohen, S.E. & Brander, J. The impact of mate choice experience on the stated-revealed preference gap in humans

GRANTS, AWARDS, AND FELLOWSHIPS

GRANTS

Pet Choice in Animal Shelters—A Cognitive Approach (*$1000*)   Summer 2017
    Indiana University, Graduate and Professional Student Group Research Award
    10/80 applications accepted

Speed-Networking for Producing Academic Collaborations *($1500)*   04/2014
    Indiana University, Office of the Vice Provost for Research

AWARDS

Cognitive Science Graduate Research Award   4/2018
    Indiana University Cognitive Science Program

Three Minute Thesis Competition, First Place   3/2017
    Indiana University Graduate School

2015 Best Poster Award   05/2015
    Human Behavior and Evolution Society (of 80 posters)

Best Graduate Lightning Talk 3/2015
    Indiana Women in Computing

FELLOWSHIPS

Dissertation Research Fellowship Fall 2018-Spring 2019
    Indiana University, College of Arts and Sciences

NIH Central Themes in Reproductive Diversity Trainee Fall 2017-Summer 2018

Evolution of Human Cognition Research Fellow Spring 2017

Supplemental Research Fellowship Summer 2017
    Indiana University, Cognitive Science Department

Supplemental Research Fellowship Summer 2015
    Indiana University, Cognitive Science Department

PRESENTATIONS

ORAL PRESENTATIONS

Cohen, S.E. (2019, Invited). Choosing Fido: Social Decision-Making Patterns in Animal Shelters. Biocomplexity Institute, University of Virginia.

Cohen, S.E. (2019). Choosing Fido: Social Decision-Making Patterns in Animal Shelters. Cognitive Lunch Seminar, Indiana University.

Cohen, S.E. (2018). Unattractive Individuals Use More Flattering Photos for Online Dating. Midwest Cognitive Science Conference, Bloomington, Indiana.

Cohen, S.E., & Todd, P.M. (2017). Expected Utility in Romantic Relationships: Satisfaction as a Cue for Romantic Partnership Dissolution. Cognitive Science Conference, London. (Acceptance Rate: 29%)

Cohen, S.E., Mark, K. & Todd, P.M. (2017). Do Humans Forage Optimally For Relationships? A Model Proposal. Human Behavior and Evolution Society, Boise, Idaho.

Cohen, S.E., Mark, K. & Todd, P.M. (2017). Foraging for Love: Predicting Relationship Dissolution

Through Ratings of Dyadic Quality. International Association for Relationship Research, Syracuse, New York.

Cohen, S.E., & Todd, P.M. (2017). Expected Utility in Romantic Relationships: Satisfaction and Time as Cues for Romantic Partnership Dissolution. Cognitive Lunch Seminar, Indiana University.

Cohen, S.E., Holmes, L., & Todd, P.M. (2017). Foragers Alter Resource Distribution of the Environment and With It, Their Strategy Efficacy. Midwest Ecology and Evolution Conference, Champaign-   Urbana, Illinois.

*Galang, M., **Cohen, S.E.,** & Todd, P.M. (2016). Effects of Sex Education via Self-Esteem and Sexual Risk-Taking Behaviors. Indiana University McNair Symposium.

*Galang, M., **Cohen, S.E.,** & Todd, P.M. (2016). Effects of Sex Education via Self-Esteem and Sexual Risk-Taking Behaviors. MKN McNair Heartland Research Conference.

Cohen, S.E. (2016, Invited). Change Your Words, Change the World: A Woman's Guide to Being Heard in Male-Dominated Environments. Celebration of Women in Computing Spring Banquet, Indiana University.

Cohen, S.E., & Todd, P.M. (2015). Speed-Networking: An Academic Equalizer for Under-represented Individuals. Computational Social Science Summit, Northwestern University.

Cohen, S.E., & Todd, P.M. (2015). Speed-Networking is an Efficacious Tool to Produce Academic Collaborations in Under-Represented Populations. Midwestern Cognitive Science Conference, Mackinac Island.

Cohen, S.E., Todd, P.M., Garcia, J.R., & Fisher, H.E. (2015). Variations in Mate Search across Gender, Age, and Sexual Orientation. Midwestern Psychological Association Conference, Chicago.

Cohen, S.E., & Todd, P.M. (2015). Getting Your High Heels through the Door with Speed-Networking. Indiana Women in Computing, Purdue University.
Award: Best Graduate Lightning Talk

Cohen, S.E., & Todd, P.M. (2015). Speed-Networking Produces Novel and Stable Interdisciplinary Academic Collaborations. Anthropological Graduate Student Association Symposium on Digital Communication, Collaboration and Preservation, Indiana University.

Cohen, S.E., & Todd, P.M. (2014). Using Network Theory to Introduce Stable Cross-Cluster Ties in Academic Contexts. Midwestern Cognitive Science Conference, Wright State University.

Todd, P.M. & **Cohen, S.E.** (2013). Finding the one: What are you really searching for? Hutton Honors College, Indiana University

*: Indicates undergraduate first author

POSTER PRESENTATIONS

Cohen, S.E., & Todd, P.M. (2018). Unattractive Individuals Use More Flattering Photos for Online Dating. Human Behavior and Evolution Society, Amsterdam.

Cohen, S.E., & Todd, P.M. (2018). No Changes in Speed and Selectivity in Mobile Dating Choices Over Time. Cognitive Science, Madison, Wisconsin, USA.

Marghetis, T., **Cohen, S.E**., Todd, P.M., Goldstone, R.L., & Landy, D. (2018). The embodied, interaction origins of systematic inequality in conversation. Cognitive Science, Madison, Wisconsin, USA.

*Exline, E., **Cohen, S.E.,** & Todd, P.M. (2018). The Impact of Race on Reaction Times in Online Dating Applications. Midwest Undergraduate Cognitive Science Conference, Bloomington, Indiana.

*Lindahl, K., **Cohen, S.E.**, & Todd, P.M. (2018). Canine Behaviors on a Standardized Assessment and Their Impact on Length of Stay. Animal Behavior Conference, Bloomington, Indiana.

*Gits, M., **Cohen, S.E.**, & Todd, P.M. (2018). Canine Behavior: Disparities between Human Perceptions and Levels on a Standardized Behavior Assessment. Animal Behavior Conference, Bloomington, Indiana.

*Mysliwy, S.N., **Cohen, S.E.**, & Todd, P.M. (2018). Aggression across Environments in Owner-Relinquished and Stray Dogs in Animal Shelters. Animal Behavior Conference, Bloomington, Indiana.

*Xu, C., **Cohen, S.E., &** Allen, C. (2016). Gendered Language in Popular Music Lyrics. Indiana Celebration of Women in Technology.

*Galang, M., **Cohen, S.E.,** & Todd, P.M. (2016). Effects of Sex Education via Self-Esteem and Sexual Risk-Taking Behaviors. McNair Heartland Research Conference.

Cohen, S.E., & Todd, P.M. (2015). Simple Mate Choice Heuristics in Novel
 Environments   .
 Summer Institute on Bounded Rationality, Berlin, Germany.

Cohen, S.E., Todd, P.M., Garcia, J.R., & Fisher, H.E. (2015). Temporal
 Reproductive Pressures on Human Sexual Strategies in a Large,
 Representative Dataset. Human Behavior and Evolution Society,
 University of Missouri.
 Winner: Best Poster Award

Cohen, S.E., & Todd, P.M. (2014). Cluster-Busting: Using Network Theory to
 Introduce Stable Cross-Cluster Ties in Academic Contexts. Psychological
 and Brain Sciences Graduate Student Symposium, Indiana University.

*: Indicates undergraduate first author

TEACHING EXPERIENCE

Animal Behavior Special Topics: Animal-Computer Interaction   9/2018
 Indiana University, Guest Lecturer: "Data-Driven Adopter-Dog Matching"

Animal Behavior A501: Techniques in Reproductive Diversity   4/2018
 Indiana University, Guest Lecturer: "Behavioral Scoring: From
 Animals to Humans"

Psychology K300: Statistics and Simulations in Psychology   Fall 2016
 Indiana University, Affiliated Instructor, Lab Instructor

Animal Behavior A501: Techniques in Reproductive Diversity   4/2016
 Indiana University, Guest Lecturer: "Agent-Based Simulations to
 Simulate Evolution and Behavior"

Psychology P324: Abnormal Psychology   Summer 2016
 Indiana University, Teaching Assistant

Psychology P319: Personality Psychology   Spring 2016
 Indiana University, Teaching Assistant

Psychology P211: Research Methods in Psychology   Fall 2015
 Indiana University, Affiliated Instructor

Psychology P335: Cognitive Psychology   Fall 2013
 Indiana University, Teaching Assistant, Guest Lecturer

STUDENT MENTORSHIP

Impact of Prior Behavioral Issues on Canine Lengths of Stay   Fall 2018-Spring 2019
    in Animal Shelters.
    Sarah Mysliwsy (Co-supervised with Peter Todd)
    Undergraduate Student Honors Thesis

Comparisons of Hookup Attitudes between Eastern and   Summer 2017
    Western cultures.
    Devika Devesh (Co-supervised with Peter Todd)
    Undergraduate Student Independent Research Project

Sexual Risk-taking and the First Year Experience.   Summer 2016
    Miranda Galang(Co-supervised with Peter Todd)
    Undergraduate Student Independent Research Project

Cross-Generational Gendered Language in Musical Lyrics.   Summer 2016
    Catherine Xu (Co-supervised with Colin Allen)
    Undergraduate Student Independent Research Project

SERVICE

PEER REVIEW

Cognition   2018

Midwestern Psychological Association Conference   2017

Evolutionary Behavior Science   2017

ACM Computer-Human Interaction Conference Proceedings   2015

Evolutionary Psychology   2015-2018

CONFERENCE COMMITTEES

Midwestern Cognitive Science Conference Student Organizer   2018
    Indiana University

Animal Behavior Conference Student Organizer, Indiana University   2014-2018
    2014: Conference Organizer

2015: Conference Organizer, Promotions Committee
2016: Conference Organizer, Program Committee, Undergraduate Poster Judge
2017: Conference Organizer
2018: Conference Organizer, Program Committee, Moderator: "Social Behavior"

Indiana University Preparing Future Faculty Conference   2014-2018
2014: Panel Lead, "Communicating Your Work"
2015: Panel Co-Organizer, "Navigating the Job Market"; Welcoming Committee
2016: Panel Moderator: "Career Options"; Welcoming Committee
2017: Conference Organizer
2018: Conference Organizer

ETCETERA

Guest Speaker, Cognitive Science Senior Seminar, Indiana University.   2019

Panelist, Graduate School Preparation   2018
Midwest Undergraduate Cognitive Science Conference

Lead Research Scientist, Canine Perceptions and Adoption Behavior   2017
Bloomington Animal Care and Control

Poster Judge, Psychology First Year Graduate Symposium, Indiana University   2016

Research Grant Reviewer, Graduate and Professional Student Government,   2016
Indiana University

Science Fest Volunteer, Indiana University   2015

Poster Judge, Achievements of Women in STIM, Indiana University   2015-2017

Research Scientist, Faculty Speed-Networking Series, Indiana University   2014-2015

Graduate Student Ambassador, Indiana University   2014, 2017
GU2IU Underrepresented Student Recruitment Program

Panel Moderator, Undergraduate Honors Research Symposium   2014
Hutton Honors College, Indiana University

Student Research Award Reviewer, APS Student Caucus   Spring 2014

Panelist, Careers in Psychology Graduate School Preparation Panel,   03/2014
Indiana University

Volunteer, Bloomington Animal Care and Control   1/2015-5/2018
Dogwalker, Adoption Counselor

342 hours of service