

# Computational Courtship: Understanding the Evolution of Online Dating through Large-scale Data Analysis

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## Abstract

Have we become more tolerant of dating people of different social backgrounds compared to ten years ago? Has the rise of online dating exacerbated or alleviated gender inequalities in modern courtship? Are the most attractive people on these platforms necessarily the most successful? In this work, we examine the mate preferences and communication patterns of male and female users of the online dating site eHarmony over the past decade to identify how attitudes and behaviors have changed over the past decade. While other studies have investigated disparities in user behavior between male and female users, this study is unique in its longitudinal approach. Specifically, we analyze eHarmony's user data to determine how men and women differ in their preferences for certain traits in potential partners and how those preferences have changed over time. The second line of inquiry investigates to what extent physical attractiveness determines the rate of messages a user receives, and how that relationship varies between men and women. Finally, we explore whether online dating practices between males and females have become more equal over time or if biases and inequalities have remained constant (or increased). This work could have broader implications for shifting gender norms and social attitudes, reflected in online courtship rituals. Apart from the data-based research, we connect the results to existing theories that concern existing theories that concern the role of ICTs in societal change. As searching for love online becomes increasingly common across generations and geographies, these findings may shed light on how people can build meaningful relationships through the Internet.

## Introduction

As online dating grows in influence as a business and cultural institution, it will become imperative that researchers understand the type of data being collected and the valuable social insights we can glean from the interactions on these platforms. This paper presents a longitudinal study of online dating over an ten-year period, using statistical methods to uncover changes in mate preferences and communication patterns between men and women over time.

A relatively recent phenomenon, online dating is becoming an increasingly relevant site of investigation spanning disciplines as varied as sociology, economics, evolutionary biology, and anthropology. Foundational work on mate preferences in online dating, matching markets, and the role of physical attractiveness in online dating has been done by Finkel et. al, Hirstch, et. al, and Fiore respectively, all of whom we reference heavily in my work. In addition, relevant work by Zheng and Yasseri explored the latent asymmetries in messaging between men and women on these platforms. Though the aforementioned literature is rich and sets a foundation for robust discussion of online dating, no existing study presents a longitudinal approach to online dating. The contribution of this work is the expansive dataset which encompasses over twelve years of user activity, allowing us to better

understand not only how these phenomena of interest work in extraordinary detail, but how they have changed over time.

As the internet rose as a social medium used to facilitate communication, it eventually adapted to specialist functions including online dating sites. Online dating is the practice of using dating sites—made specifically for users to meet each other for the end goal of finding a romantic partner (Finkel et.al, 2012). As Michael Norton put it, “Finding a romantic partner is one of the biggest problems that humans face and the invention of online dating is one of the first times in human history we’ve seen some innovation” (Harford, 2016). In fact, online dating has emerged as one of the most widely used applications on the Internet. Online dating has an annual growth rate of 70% in the United States (Kaufman, 2012). It has also developed into a highly profitable business with growing numbers of people worldwide willing to pay for access to services that will find them a romantic partner. Online dating is now a \$2.1 billion business in the US and is expected to continue growing in the foreseeable future (Ortega and Hergovich, 2017). Considering three-quarters of US singles have tried dating sites and up to a third of newly married couples originally met online Ansari & Klinenberg (2015), online dating seems to have shed its old stigma, ostensibly here to stay as the new normal.

Despite the proliferation of online dating and its emergence as a particularly rich data source for social scientists, there remains a considerable gap in existing literature. While disciplines as diverse as psychology to evolutionary biology have examined online dating, few studies have investigated how mate preferences and user activity in online dating have evolved over time.

When considering online dating, it may be useful to think of these platforms and marriage in general as markets (Roth, 2015). As economist Alvin Roth explains in his book *Who Gets What and Why*, there can be thick and thin matching markets where thick markets have lots of buyers and sellers (single people in this case) and little differentiation, while thin markets have fewer buyers and sellers and considerable differentiation (Roth, 2015.) For instance, we can imagine that there was a thick market for marrying your high school sweethearts before women started going to college. But as more and more women decided to pursue higher education and enter the workforce, the market shifted to a wider selection of potential spouses for each side of the market. The increased variety of potential mates gave way to dating phenomena like speed dating, which was a pre-internet predecessor to any modern app with a market design where singles meet many people very quickly, indicate who they’re interested in, and only receive each other’s contact information if there is mutual interest. But with the rise of the internet, there is now a thick market for finding love online. More specifically, we can think of these internet-based dating platforms as two-sided matching markets (if we exclude niche platforms for polyamory and non-traditional relationships). This means that there are two sides of the market to be matched, participants on both sides care about to whom they are matched, and money cannot be used to determine the assignment (Azevedo & Leshno, 2016). This model includes high-end management consulting firms competing for college graduates that must attract candidates who also choose them, home buyers and sellers, and many more important markets. Two-sided matching markets have been extensively studied, with the literature splitting them into two categories: the “marriage” model and the “college admissions” model (Azevedo & Leshno, 2016).

Becker’s 1973 marriage model assumes simple preferences, with men and women ranked vertically from best to worst. This model and its assumptions have been applied to diverse problems such as explaining gender differences in educational attainment, changes in chief executive officer wages, and the relationship between the distribution of talent and international trade (Grossman 2004; Gabaix and Landier 2008; Terviö 2008; Chiappori, Iyigun, and Weiss 2009; Galichon, Kominers, and Weber 2016; Bojilov and Galichon, 2016). Another line of research follows Gale and Shapley’s 1962 college admissions model which allows for complex heterogeneous preferences. This model is a cornerstone of market design and has been applied to the study and design of market clearinghouses such as matching residents to hospitals and students to charter schools. This begs the question: who gets matched with whom in the online dating matching market? Are differences in dimensions of type mostly horizontal (e.g., some pairs make better matches than others, following the college admissions model), or vertical (e.g., there are some people that we can universally agree are more desirable mates than others, following the marriage model)?

There are “superstar” users who attract lots of attention and matches on any given platform. In some cases, the top 5 percent of all men on a platform receives twice as many messages as the next 5 percent and several times as many messages as all the other men (Oyer, 2014). But it would be incorrect to assume these superstars would be universally appealing to all users and that popularity alone determines matches. Instead, it could be useful to

consider the economic concept of assortative mating observed in offline marriage markets, and how online matching reflects or deviates from this behavior.

Positive assortative mating or matching occurs when people choose mates with similar characteristics. Empirical evidence strongly suggests that spouses tend to be similar in a variety of characteristics, including age, education, race, religion, physical characteristics and personality traits (Becker, 1991; Dupuy and Galichon, 2012; Orece and Quintana-Domeque, 2010; Qian, 1998; Silventoinen et al., 2003; Weiss and Willis, 1997). This phenomenon can be measured and observed in online dating markets when we inspect the pairs we end up with. Using data from an online dating site, Hirsch et al. found that although physical attractiveness and income are largely vertical attributes, preferences concerning a partner's age, education, race, and height tend to sort assortatively. Likewise, the examination of "bounding" characteristics shows that life course attributes, including marital status, whether one wants children, and how many children one has already, are much more likely than chance to be the same across the two users in a dyadic interaction (Fiore, 2002). In other words, mate preferences are not simply vertical, meaning we always want mates with the highest level of education, income, etc. Rather, horizontal preferences and preferences for similarity in particular, play an important role (Hitsch, Hortaçsu, & Ariely, 2010). Overall, users with similar education levels are three times as likely to match. As we can observe, assortative mating occurs in both online and offline contexts and can partially help explain why these markets still tend to be efficient.

Newer niche dating apps that only admit users from certain echelons of society may be changing the way we sort and actually exacerbate existing assortative tendencies. A recent Bloomberg report argues that dating apps, particularly elite ones like the League and Luxy, may be worsening economic inequality by making it easier for couples to pair by socioeconomic status. The League famously only admits graduates from top universities, while Luxy purports that the median income of users on its platform is \$500,000. Instead of meeting someone at a bar or other social setting, singles can now use apps to find their economic and educational equivalent. While one might argue that this phenomenon already occurs offline, according to Bloomberg, "these services help facilitate unions between educated, affluent Millennials who are clustering in such cities as San Francisco and New York" — indirectly intensifying economic inequality.

While those may be exceptional cases, some combination of an individual's attributes and potential partners' preferences dictate market dynamics both in online and offline contexts. This means that an agent may have high desirability for one person and low desirability for another, and the preferences may not necessarily be monotonically related to their attributes. Efficient matching in this market thus relies on the existence of pairs of mutually desirable agents in a setting where preferences are heterogeneously distributed. As Hitsch, et al. note, these markets tend to naturally resolve into pairs of mutual desirability (Hirsch et. al, 2010). This might seem somewhat obvious, but is remarkably observed, measured, and explained in the online dating environment. Indeed, these platforms provide us with a unique opportunity to study the economic and evolutionary concepts of sorting and matching. While part of this is due to the ability to observe and classify user attributes, preferences, and behavior in great detail, it is also due to the unique lack of search frictions in online dating markets. Certainly, a main reason for the existence of online dating sites is to make the search for a partner as easy as possible (Hirsch et. al, 2010). Yet despite the wealth of insight user-generated data online dating has revealed about latent and stated mate preferences, there remains significant uncertainty regarding the way these preferences have evolved over time.

Sociologists often assume that society has become more egalitarian, and that these pluralist ideals have translated into a more equal quest for love (Ferrante, 2007). It would then follow that people's mate preferences have become more pluralist, switching from sorting based on ascribed traits to sorting based on acquired traits. Ascribed characteristics, as used in the social sciences, refers to properties of an individual attained at birth. The individual has very little, if any, control over these characteristics. In other words, based on the progress we have reportedly seen over the past decade in social integration, we would expect to observe users placing less importance on inherited traits like ethnicity and height, and more importance placed on characteristics achieved through merit such as education.

**RQ1:** This research explores how stated and revealed mate preferences have evolved over the last decade and whether these claims of a more egalitarian society are in fact reflected in online dating and mate selection.

In mate selection and especially in online dating, there seems to be a preoccupation with physical beauty. Historically, theories of interpersonal attraction and interpersonal judgments have emphasized the importance of physical attributes over other factors such as personality and intelligence (e.g., Dion et al. 1972; Walster et al. 1966). Accordingly, online dating sites often urge their users to post photos of themselves to increase the chances that potential dates will contact them. Dating services like Grindr and Tinder have gone even further by doing away with detailed profile descriptions altogether, allowing users to base their dating decisions on physical appearance alone (Hannah Fry, 2015). Indeed, 85% of interviewees in a study of Australian online dating users said they would not contact someone without a photo on his or her profile (Whitty and Carr, 2006).

Only a few studies so far have considered how users judge attractiveness online generally or in online dating in particular and how this translates into messaging strategy. Ellison describes the strategies employed by online dating users to interpret the self-presentations of others. Primarily, the participants they interviewed made substantial inferences from small cues, lending support to Walther's theory of Social Information Processing (Walther, 1992). For example, one woman felt that people who were sitting down in their online dating profile photos were trying to disguise that they were overweight (Ellison et al. 2006). Fiore found that in line with past research on the psychology of attraction, the attractiveness of the photograph were the strongest predictors of whole profile attractiveness in online dating (Fiore, 2008).

But while it is evident that the attractiveness of one's photo is important in determining overall perceived attractiveness of an online dating profile as a whole, predicting popularity based on looks alone is much more ambiguous. Christian Rudder explored the importance of attractiveness in online dating and found that how good-looking you are does not dictate how popular you are on an online dating website. In fact, having some people think that you are ugly can work in your favor (Fry, 2015). To try and test how attractiveness might predict popularity, the OkCupid team took a random sample of 5,000 female users and compared the average attractiveness scores they each received from other users with the number of messages they were sent in a month. They found it is not just the better-looking people who receive lots of messages. Using the spread of attractiveness ratings, they identified people who divide opinion on their attractiveness. These polarizing users ended up being far more popular on internet dating sites than universally attractive people. Users rated 4 out of 5 were penalized, while people at the extremes of the spectrum at 1 and 5 received were much more likely to receive messages. In essence, the most beautiful users will always do well but users whose attractiveness divides opinion are better off than those who everyone agrees is just quite cute.

Fiore and Donath (2005) also explored this question of predicting popularity, but used self-reported attractiveness instead of attractiveness scores given by other users. They found that men received more messages when they were older, more educated, and had higher levels of self-reported attractiveness. Women received more messages when they did not describe themselves as "heavy," had higher levels of self-reported attractiveness, and posted a photo on their profiles. The work in hand will explore questions of user popularity using self-reported attractiveness as a measure for attractiveness, while understanding that self-assessment of physical attractiveness may be closer to self-esteem.

Among online daters, sending signals such as a "Superlike" or "Smile," or "favoriting" a user can be a way to let them know a user is interested. In a notable study using a Korean dating/marriage site, researchers found evidence that sending a signal increased the total number of dates. But the study was also able to use various measures to determine who were the most sought after people on the website and who were not as sought after, by ranking participants as high, medium, and low in the distribution of rated attractiveness. And it turns out the most popular people on the website were not very responsive to virtual roses (Lee, S., Niederle, M., Kim, H.-R., & Kim, W.-K. 2011). Because their attitude was "well, of course, that person's interested in me." Instead, the virtual rose was most effective on the middle desirability group which did not have as many great dating options and was almost twice as likely to accept a proposal sent with the costly signal of a rose.

This brings to light issues with signaling optimization: Despite the positive effect of sending roses, a considerable portion of participants did not use their roses and even those who exhausted their supply did not properly use them to maximize their dating success. It seems there are substantial tradeoffs in preference signaling. Reminiscent of the bar scene with John Nash in *A Beautiful Mind*, a user could send their signal to the 'blonde' or the most attractive female on the platform, who would be their number one pick. But if everyone uses this strategy, chances of success are low. Instead, users would be better off using their costly signal on a medium quality mate where chances of reciprocity are higher. By the same token, it seems like success could be almost guaranteed by seeking out the least desirable mate and sending a signal, but this is obviously not optimal. So

there's a trade-off of sorts in choosing who to send a costly signal such as a favorite or message to that goes back to the aforementioned difference in user "quality" or desirability.

**RQ2:** This research will explore the impact of user attractiveness on messaging patterns and whether it has been an accurate predictor of "success" in online dating over time.

In the social sciences, gender is a built-in variable that can account for measurable differences in behavior. (Rakow, 1986). While non-binary users and same-sex dyads are a growing segment of online dating users, the dataset examined in this work consists exclusively of heterosexual dyads. One of the main research areas related to online dating systems is the difference in messaging behavior between men and women on these platforms. But in order to meaningfully investigate computer-mediated communication between genders, it is important to first understand underlying patterns of offline communication between heterosexual dyads that may be reflected, moderated, or exacerbated online.

Examining single women's use of the telephone in heterosexual dating relationships, Sarch found that in line with gender norms at the time of the study, subjects expected men to pursue women (Sarch, 1993). Additionally, on occasions when a woman ever took initiative and started a conversation, she expected her partner to "overcompensate" by reaching out with more frequency. Subjects also reportedly saw the frequency of how often their dates called as an indicator of how well the relationship was going or how often their date was thinking about them. In keeping with these two indicators, subjects did not want to be perceived as the pursuer so they limited the frequency of their own calls by ensuring that each one was "carefully executed so that sufficient time elapsed between multiple phone calls" (Sarch, 1993, p. 141). This phenomenon has not entirely disappeared—Ansari and Klinenberg observe, "the fear of coming off as desperate or overeager through texting" as a common concern in recent focus groups (2015). Despite coming 22 years after Sarch's study, Ansari and Klinenberg's research (2015) shows that initiator status and contact frequency equating to interest has translated from telephone calls to modern online messaging culture.

Besides the stigma against female initiators, another reason initiators tend to be male has to do with the way incentives are structured in online dating. About 60% of the men in Whitty and Carr's study saw online dating as a "numbers game" (2006). Given the seemingly endless number of profiles available, individuals could keep trying until they get a response, meaning they are not fully interested in some of the profiles they send messages to. Instead, they would send a large number of initiations regardless of actual interest and see which women reciprocate, filtering at the response level. The result is staggeringly lop-sided activity levels for men and women. Men are on average twice as active as women in online dating apps—skewing an already imbalanced gender ratio; taking into consideration activity level, the gender ratio of the active user base is more like 80:20 (Harford, 2018). Rudder (2014) confirms this, showing that even the most attractive men receive fewer messages than women on average. In turn, since women are often inundated with date requests, they are less compelled to respond to each request (Tong & Walther, 2011). Fiore confirms this, finding that women responded more selectively than men, answering 16% of the time compared to men's 26% reciprocation rate (2010).

In related research, Zhang and Yasserli found that messages were five times more likely to have been initiated by a man than by a woman even in dating applications that allow users to communicate only after they have mutually signaled their interest (2015), in line with previous work that found men to be the main initiators in heterosexual conversations (Finkel et al., 2012; Whitty, 2012; Tong & Walther, 2011; Whitty, Baker, & Inman, 2007). Fiore also confirms this, finding that rates of initial contact differed sharply by gender. Men initiated a median 1 contact per day compared with 0.875 for women (Fiore, 2010). Given this difference combined with the greater number of men on the site, women tended to be contacted much more often than men, a median 2 times per day, compared to 0.5 for men. In Fiore's work, among users who completed the psychometric questionnaire, men and women who scored higher on general caution contacted others more often, as did those people high in neuroticism, perhaps as a way to control with whom they correspond or as a strategy to evaluate a larger pool of candidates before meeting. Furthermore, men high in general caution were contacted by others less often, though it is unclear what cues they were giving off that might lead to lower levels of contact. Finally, more popular men and women — those who were contacted more often per day — initiated contact with others slightly less often, confirming economic theory that "high quality" users need not pursue others as actively.

**RQ3:** This work will explore whether the previously established phenomenon of gender asymmetry in online dating messaging behavior has remained stable, lessened, or grown over time.

## Data and Methods

To address the aforementioned research questions, this work analyzes a data set obtained through a collaboration with eHarmony UK, a major web-based online dating system. Broadly speaking, web-based online dating systems include the following (Fiore and Donath, 2004):

- Personal profiles for each user, which include demographic and other fixed-choice responses, free-text responses to prompts, and, optionally, one or more photographs.
- Searching and/or matching mechanisms so that users can find potential dates from among the thousands of profiles on a typical system.
- Some means of private communication that permits users to contact potential dates within the closed online dating system without disclosing an email address, phone number, or identifying information. This usually means a private mail system, but it sometimes also includes the ability to send “smiles” or some other token of interest.
- Optionally, other forms of self-description: for example, the results of a personality test, or multimedia uploaded by the user.

eHarmony’s platform follows the typical format of other online dating systems, including personal profiles and messaging channels, but is distinctive in that users can only communicate with matches selected through an algorithm. This matching algorithm is based on responses from a questionnaire each user completes upon registration. This work will utilize stated mate preference and demographic data collected through this questionnaire, as well as the user interactions that occur after the match – namely, messaging communications. Since the aim of online dating systems is to facilitate face-to-face contact (Whitty et al., 2007; Finkel et al., 2012), with communications being a prerequisite to any offline encounters, this research will operationalize communications received, sent, and reciprocated as meaningful measures of interest and popularity.

The sample dataset used in this work was generated from users who registered during a randomly selected month (March) for each year between 2007 to 2018. Data was not sampled from January or February since they are probably not the most “typical” months, due to holidays including New Year’s Day and Valentine’s Day. The data was generated from user profiles and private messaging activity on the dating site over the twelve-year period and consists of 149,440 unique heterosexual users from across the United Kingdom. All demographic information was self-reported upon registration. Gender is selected upon site registration by the user. The dataset did not contain any users identifying as non-binary so the term “gender” in this work will refer to male or female self-identification. Since we sampled for all users registered in the month of March for each year, the registration month for all cases are the same, but the total cases of each year varies as reported in Table 1.

Table 1: Data Summary

YEAR	TOTAL CASES	MALES	FEMALES
2007	50	40%	60%
2008	133	45.11%	54.89%
2009	5,453	37.8%	62.2%
2010	30,942	47.64%	52.36%
2011	16,439	46.23%	53.77%
2012	15,329	51.15%	48.85%
2013	14,344	47.01%	52.99%
2014	13,967	48.16%	51.84%
2015	13,731	46.97%	53.03%
2016	14,059	49.66%	50.34%
2017	14,863	49.03%	50.97%
2018	10,129	50.97%	49.03%

Table 2 summarizes the variables describing users and their behavior. In the following sections, the variables are grouped by type and defined in further detail.

Table 2: Data Parameters

<b>USER-LEVEL DATA</b>
<b>USER CHARACTERISTICS</b> (demographic and profile information)
Age Gender Registration date Religion Smoking level (1-7) Drinking level (1-7) Number of photos
<b>MATE PREFERENCES</b> (Likert scale)
Religion Ethnicity Education Income Distance Age Height Smoking level Drinking level
<b>PSYCHOMETRIC QUESTIONNAIRE</b> (Likert scale)
Attractiveness Neuroticism Athleticism Agreeableness Religiosity Sexual Romantic Cleverness Conflict Resolution Altruism Conscientiousness
<b>COMMUNICATIONS DATA</b>
Communication initiations sent Communication initiations received Communication rate (total communication initiations received/total profile views by other matches)

Mate preferences were collected upon registration through a questionnaire asking about importance of different match criteria based on a Likert-type scale, ranging from Not Important, Somewhat Important, and Very Important. The variable for user attractiveness used in RQ2 was created using the average score of self-reported responses to the following questions: “How stylish do you consider yourself?” “How attractive do you consider yourself?” and “How sexy do you consider yourself?” on a scale from 1-7. The remaining psychometric variables were also created using a similar formula of questionnaire responses, which are detailed in the appendix. Communication-level data was inspected by gender and initiation. Initiation refers to whether the sender of the message is the user to have sent the first message in the conversation. The gender of a given message sender is tied to the initiator of a message, as all messages in the dataset are between heterosexual matches—for example, if the conversation initiator is male, the responder would be female.

When computing messaging statistics, the primary measure was not the sheer number of messages sent or received but the number of distinct people whom a user contacts or is contacted by. This places the focus not on how many messages a pair exchanges, but rather on distinct cases of initiated contact. In particular, one key focus of this study is predicting “popularity” in an online dating system. This study falls in line with Fiore and Donath’s (2010) theory that a person’s popularity on an online dating site is best indexed by the average number of people who initiate contact with him or her. However, this work deviates from their belief that this measure doubly serves as a reasonable proxy for overall attractiveness as well. While Fiore and Donath assumed that more attractive people on average receive more unsolicited attention than less attractive people, this work seeks to tie in later findings from Hannah Fry and Christian Rudder and understand user attractiveness and popularity as two distinct variables. Finally, to control for the fact that the number of matches each user has is an artifact of the algorithm

which has slightly changed over the years, we sought to normalize the number of contacts received by the number of profile views each user received, creating a new “communication rate” variable for each user. This metric is an approximation which accounts for users who might be much more active and get more site exposure than others.

### Ethics

Given that this research used data generated from real users of an online dating platform, privacy was a top ethical concern throughout data collection and analysis. As such, proper precautions were taken to preserve privacy and ensure the anonymity of users. During data collection, the eHarmony team excluded any personally identifiable information such as names, payment information, and address to prevent triangulation. Data was captured, transferred, and stored on a password-protected computer with an encrypted hard-drive. Users are only identified by an anonymous user ID number.

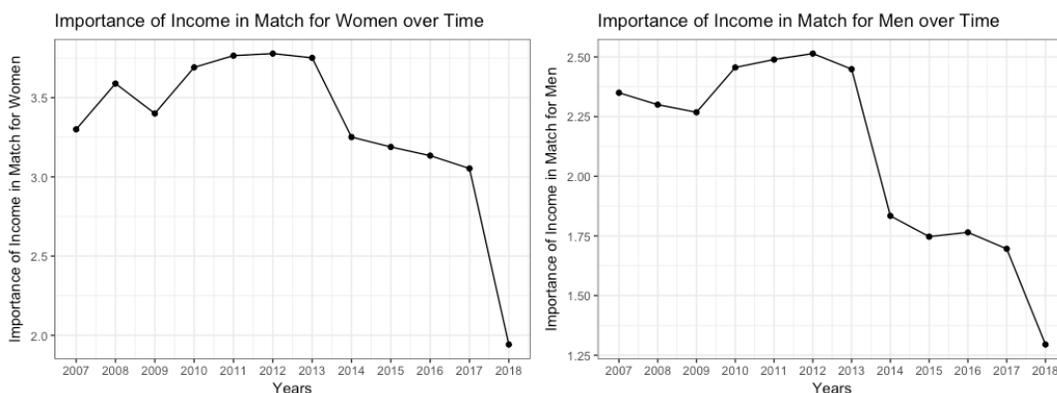
Confidentiality and data transfer agreements were signed both by the company and the University of Oxford to preserve privacy rights for eHarmony users. Users are informed of data collection and analysis efforts at the time of sign up, when presented with Terms & Conditions and Privacy Policy agreements. eHarmony UK operates fully certified under the EU-US and Swiss-US Privacy Shield frameworks. The University of Oxford CUREC (Central University Research Ethics Committee) approved all handling of data and research methods. The CUREC number for this project is SSH OII C1A 18 032.

## Results

### Partner Preferences

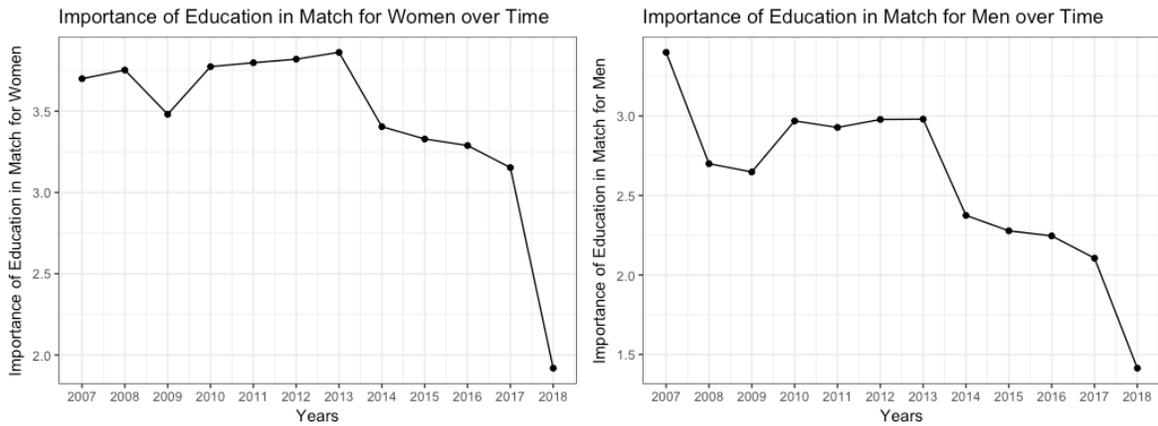
The majority of users in our dataset are from London, followed by Manchester, Birmingham, Glasgow, and Bristol. The minimum age is 18 and the maximum age is 98. The mean age of the users in the sample is 38 while the median age is 37. The gender makeup of the dataset is 52% female and 48% male. Most users are non-religious (53%), followed by Christian (34%), then Other and Muslims. Most users have never been married (67%), 24% are divorcees, and 3% widowed. All users are engaging in heterosexual interactions on the platform.

We inspected the stated level of importance for both men and women in regards to six different mate preference criteria: income, education, age, religion, smoking level, and drinking level.



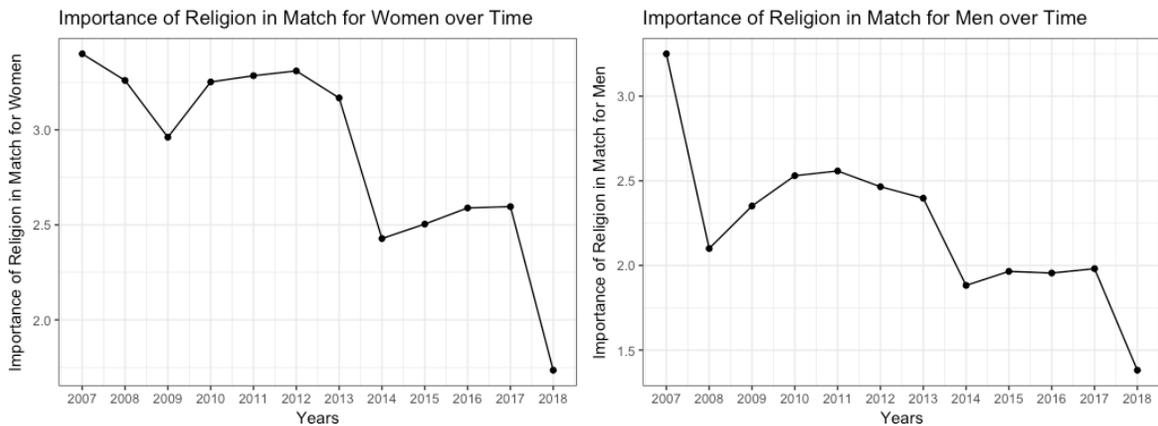
**Figure 1:** Importance of income of the partner (2007-2018).

Regarding the importance of income (Figure 1), women have a consistently higher mean than men, meaning that they consider income of a potential match more important than men do for all years 2007-2018. This difference between female and male preference for income is statistically significant. Nevertheless, for the both genders, after a Post-Financial Crisis increase, we see that the importance of the income of the partner has been decreasing over more recent years.



**Figure 2:** Importance of education level of the partner (2007-2018).

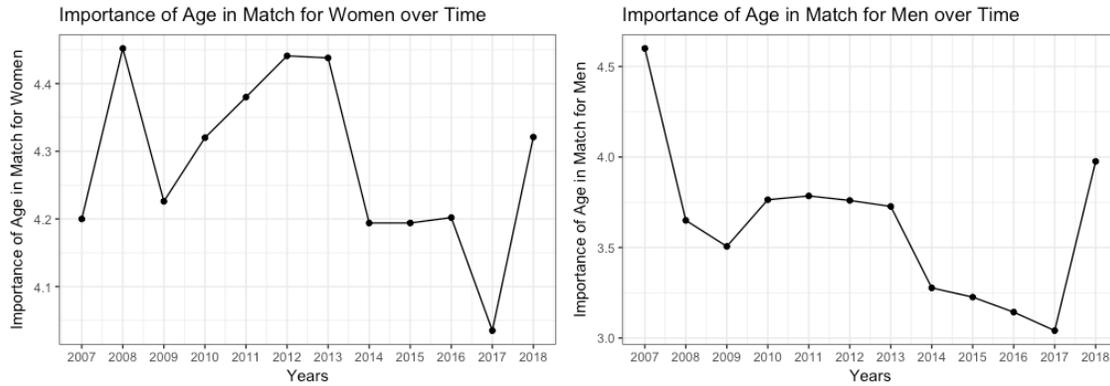
As for education (Figure 2), women have a consistently higher mean than men, meaning they consider education of a potential match more important than men do for all years 2008-2018. The overall trend is very similar to the one for income: an increase around 2010-2013 and then a steady decrease.



**Figure 3:** Importance of religion of the partner (2007-2018).

Considering the importance of religion (Figure 3), women have a consistently higher mean than men, meaning they consider religion of a potential match more important than men do for all years 2008-2018. There is a parallel downward trend for the years 2013 to 2017 and an even sharper decline in 2018. This difference is statistically significant for the years 2007-2018 and does not have a clear pattern.

When it comes to age (Figure 4), women have a higher mean than men for all years 2008-2018, meaning they consider age more important than men do. Change in average score over time is not monotonic for men or women.



**Figure 4:** Importance of age of the partner (2007-2018).

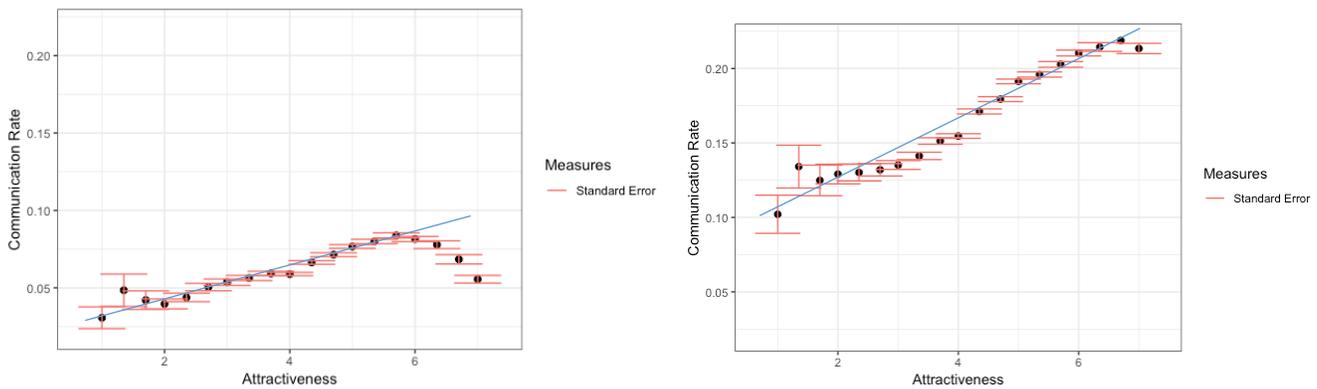
Regarding the importance of smoking and drinking levels, there is no clear pattern in the changes of “average” over time, mostly because users are polarized by prospective partners smoking (58% Not Important, 40% Very Important). Users are less concerned with prospective partners drinking alcohol (77% Not important to Somewhat Not Important) in 2018.

Finally, comparing all online dating mate preferences with each other, women consider these traits most to least important: smoking level, ethnicity, drinking level, education, income, and then religion. For men, the order is: smoking level, ethnicity, drinking level, religion, education, and finally income.

### *Physical Attractiveness*

The second research question we sought to answer was to what extent physical attractiveness determines popularity in online dating. When investigating the relationship between physical attractiveness and *communication rate* (communication initiations received over profile views), we found no significant change from year to year. Thus, here the results will be discussed in context of the overall dataset and not in respect to change over time. Looking at the aggregate dataset, users do tend to have a higher communication rate as attractiveness increases, but the rate of increase appears to first plateau and then decreases.

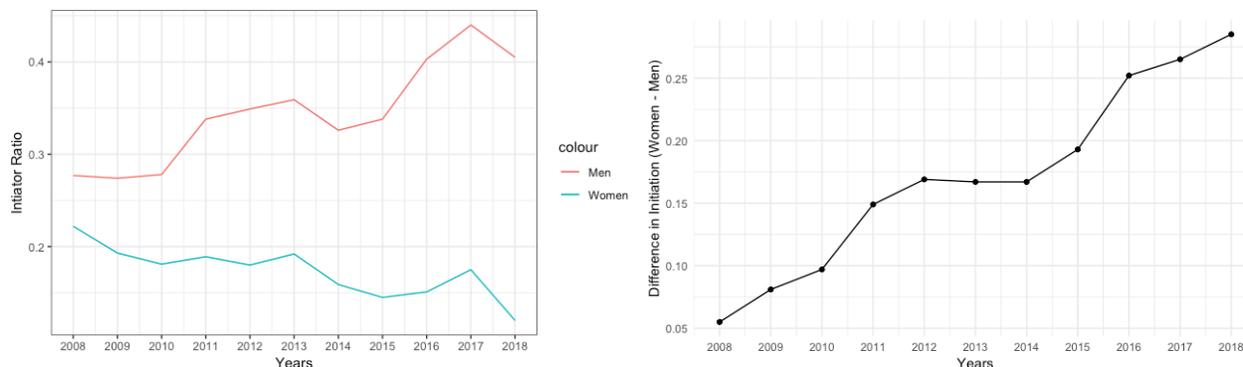
When the data is separated by gender (Figure 5), the pattern holds for both men and women, although the slope for women between 2 and 6 attractiveness (0.023) is significantly larger than for men (0.008).



**Figure 5:** Communication rate vs attractiveness. The slope of the linear fit is 0.008 for male (left) and 0.023 for women (right) profiles.

## Communication pattern

Next, we addressed the third research question regarding the asymmetries in communication initiation between men and women in online dating (Figure 6). The *initiator ratio*, or percentage of sent communication initiations over total communications for the average female user trends downward over time. For men, the initiator ratio shows the opposite trend, increasing from 2008 to 2013, with a small dip in 2014 before climbing again. Initiator ratio drops for both men and women in 2018. It should be noted that percentages for men and women do not add up to 100% for each year because the calculation is not for total communications sent and received between men and women within a single year, but for the lifetime of each user profile sampled from March of each given year. As evidenced, men on average consistently initiate more communications than women. The difference between men and women's average initiator ratios is statistically significant from 2009-2018.



**Figure 6:** Initiation rates for men and women over time (left) and difference in initiation rates between men and women over time (right).

## Personality features

Finally, we built a multivariate regression model to determine which variables could predict “success” in online, as measured by communication rate (communication initiations received over profile views by matches). After transforming skewed variables to normalize distribution and standardizing all coefficients, the results of the multivariate regression against communication rate are reported in Table 3.

**Table 3.** Multivariate linear regression models to determine which variables predict receiving communication initiations. The first model is for men receiving communication initiations from women, and the second is for women receiving communication initiations from men.

Variable	Men		Women	
	Estimate	S.E	Estimate	S.E
(Intercept)	7.917e-04	7.710e-03	0.0007	0.005
User Drinking Level	6.070e-02***	8.003e-03	-0.010	0.006
Age	-5.067e-02***	8.112e-03	-0.329***	0.006
Communications Sent	-2.564e-01***	8.564e-03	-0.174***	0.006
Total Photos	1.626e+02***	8.658e+00	0.151***	0.006
Neuroticism	-2.433e-02**	8.038e-03	0.008	0.006
Athleticism	1.760e-01***	8.604e-03	0.256***	0.006
Agreeableness	2.999e-02**	1.157e-02	-0.018*	0.008
Sexual	-1.165e-01***	8.857e-03	-0.106***	0.006
Romantic	3.700e-02***	1.060e-02	0.093***	0.007
Cleverness	-3.300e-02***	8.465e-03	0.0002	0.006
Conflict Resolution	-6.110e-02***	9.201e-03	-0.038***	0.006
Altruism	6.023e-02***	1.044e-02	0.045***	0.007
Conscientiousness	-1.215e-02	7.998e-03	0.006	0.006
Number of observations	71674		77765	
Multiple R-squared	0.134		0.256	
Adjusted R-squared	0.133		0.256	
Degrees of Freedom	14570		21649	

\*\*\* p < 0.001      \*\* p < 0.01    \* p < 0.05

The results of the individual models for each gender reveal that there are different variables that predict success for men and women. Since the coefficients are standardized, we can compare between variables within each gender. For men, being altruistic and having a higher drinking level were the strongest predictors of receiving messages, while being older and more oriented toward conflict resolution were the most negative predictors of receiving messages. For women, cleverness, neuroticism, and drinking level had no impact on predicting likelihood of receiving messages. Being older was the strongest negative predictor of receiving messages, while being athletic was the strongest positive predictor. Similar to the results for men, sending communications and being sexual or oriented toward conflict resolution had a negative impact on receiving messages. Having photos and being romantic and altruistic helped chances of success for women as well.

## Discussion and Conclusion

Our findings provide a quantitative overview of how heterosexual users seek mates, evaluate physical attractiveness, and communicate with one another in online dating systems. The results span investigations of various online dating phenomena first at the individual level, then between pairs of users, and finally between genders. In addition to its broader findings, this work sheds light on latent gender asymmetries in the user preferences and user behavior of online daters and how these differences have changed over time. The results from the aforementioned areas, and the regression of a number of them against the number of communications received on the platform, show that while there are many variations across mate preferences and communication patterns, there are few pointed variables that could actually act as potential predictors of sending and receiving messages overall.

The development of evolutionary theories of human social behavior (Buss, 1989; Cunningham, 1986; Kenrick, Sadalla, Groth, & Trost, 1990; Symons, 1979; Thiessen & Gregg, 1980; Trivers, 1985) has afforded a strong theoretical framework for sex differences in mate selection criteria. The finding that women have consistently higher means across mate preferences in this work confirms findings of gender differences in mate preferences; namely that women are more selective and restrict their potential mating pool more than men do. (Hirsch et al. 2010) This finding has been found in literature about speed-dating as well (e.g., Fisman et al. 2006; Kurzban and Weeden 2005), and falls in line with theories in evolutionary biology about females being pickier about their potential mates. However, there are notable new findings in the work at hand that contradict previous investigations of mate preference in online daters.

For instance, Hirsch et al. claims that women have a stronger preference than men for income over physical attributes (Hirsch et al., 2010). This work reveals that smoking level, ethnicity, and drinking level were the most important match criteria for both men and women overall, suggesting that ethnicity and lifestyle choices are important across both genders. In fact, income was the second least important criterion to women, religion being the least. Hirsch's claim is partially true, in that women on average do consider income in a potential match more important than men do, but the importance of this trait has decreased significantly over time. This change could theoretically be due to women's increased financial independence, though it would be difficult to attribute cause definitively.

The decline in importance of income, religion, and education for both men and women is a surprising trend that suggests perhaps people are becoming more tolerant and open to dating others outside of their own social strata. This tolerance has notably not translated over to age preferences, where patterns over time are less clear. Somewhat surprisingly, women are still more restrictive overall in their preference for age than men are. This may seem counterintuitive to those who might expect men to only seek mates within child-bearing age. As it turns out, women are pickier across the board, which may also have more to do with male over-representation on online dating sites and therefore increased female choice.

The finding that gender differences in response for the two lifestyle questions (smoking level and drinking level) were not significant from 2015 onward may reveal that social attitudes toward these activities is not gender-dependent. While the importance of drinking level for men rose from 2014-2017, both genders consistently regard drinking level "Somewhat Important," suggesting that social attitudes may have relaxed toward drinking level for both men and women. Meanwhile, preferences for smoking level became almost evenly split between those who consider smoking "Very Important" and "Not Important," suggesting that people in general fall into the two camps

of smokers and non-smokers. Since smoking levels have decreased in Britain over time, this polarization of opinion may be due to changing demographics of the user base as well (UK Office for National Statistics, 2014).

While women are more selective along virtually every mate preference criterion, this gender difference in selectivity crucially depends on group size. Previous literature has found that in smaller sessions (fewer than fifteen partners), selectivity is virtually identical for men and women, with subjects of each gender “saying yes” to about half of their partners. In larger group sizes, however, male selectivity is unchanged, while females become significantly more selective, choosing a little more than a third of their partners (Fisman et. Al, 2016). These results are quite distinct from the average difference in selectivity between men and women, suggesting rather more rapidly diminishing returns for increased dates for females when group size increases. Though Fisman’s research focused on speed-dating, the parallel holds for the significantly increased group size of an online dating platform, where choice is virtually endless. The reasons women may be more selective than men and find less utility in increased choice could be manifold, from social stigma against women who go on many dates to differing motivations for why men and women use online dating in the first place.

The findings relating to the relationship between physical attractiveness and communication rate are notable due to their online context. Other studies attempting to measure the effects of physical attractiveness on popularity have encountered difficulties separating physical attractiveness from confounding characteristics, including social skills (Feingold, 1990; Goldman & Lewis, 1977). However, the online nature of this work is unique in that very little can be socially expressed from an online profile on eHarmony. After being matched through an algorithm, users are left to evaluate a profile based on little more than a picture. The findings that physical attractiveness does not have a linear relationship with communication rate is somewhat surprising, but in line with previous research that produced similar findings (Fry, 2015). One explanation for this phenomenon could be masked strategic behavior on the part of users sending communication initiations. For instance, consider how users of lower attractiveness might approach the decision to initiate communication or not. Let us assume that there is a single dimensional index of attractiveness in the market, and consider the decision by an unattractive man as to whether he should send an introductory e-mail to a very attractive woman. If composing the e-mail is costly, or the psychological cost of being rejected is high, the man may not send an e-mail, thinking that the woman is “beyond his reach,” even though he would ideally like to match with her. Thus, communication rates may not be dictated only by users’ physical attractiveness, but also their expectations of who will respond to them.

The slight but notable differences in the relationship for each gender have several implications. First, the higher rate of change for women scored between 2 and 6 in attractiveness suggests that women’s communication rates are more dependent on their looks than for men. The finding that men value attractiveness more than women is consistent with previous research that found stronger correlations between opposite-sex romantic popularity for women than for men (Cohen, 1977). It is also in line with critical feminist theory as well as evolutionary and sociocultural theories of mate selection preferences that contend that men place greater value on physical attractiveness than do women. However, this is complicated as the rate of change is steeper and more negative for men ranked 6 and above. The same fear of rejection mentioned earlier may be stronger than for women initiating conversations with particularly attractive men.

The findings of growing asymmetry in communication initiation between men and women is rather counterintuitive. While early on, people might have hoped online dating would create a more equal playing field for women to initiate courtship, it has become clear that online dating has not only reflected but exacerbated male-dominated initiation. This is due largely to the lopsided activity levels for men and women on online dating sites, as women learn to expect male initiation and avoid initiation in keeping with learned norms. The introduction and mass popularity of mobile dating applications such as Tinder in 2014 could also explain the accelerated decline of female initiation over the following years, as online dating became more popular and the signaling and psychological costs for men sending messages declined.

As online dating becomes more popular and increasingly sophisticated, a new generation of dating apps are embedding costly signals into their platform design to solve this issue of lopsided communication. By instituting a mechanism whereby each agent has only a limited number of signals, they create opportunity costs associated with sending signals. For instance, Coffee Meets Bagel has a Woo button, where users pay (with the in-app “beans” currency) to send an extra signal to a specific someone. Since users only get beans by performing tasks like inviting friends or purchasing them directly in the app store, Woos successfully signal to recipients that senders are genuinely interested. In a similar vein, Tinder lets users send one Superlike per day. These signals work because they are costly to the sender by virtue of scarcity and the receiver knows this, so they pay attention to the signal in

an otherwise noisy environment. The practical effects would be less messaging initiation from men but hopefully, more two-way communication for initiations that do take place.

One app that has integrated these game theory principles into its design remarkably well is the widely popular mobile dating application Bumble. Founded by female ex-Tinder employees who recognized the market congestion and male-dominated design of Tinder, Bumble quickly rose to popularity as a female-friendly dating app. On Bumble, after a match is made, women only have 24 hours to start chatting or else the match disappears. Any worries that responding too quickly will signal over-enthusiasm are allayed because it is common knowledge that the app leaves no choice. Similarly, women do not have to worry about being perceived as low quality or over-eager for initiating a conversation. By tweaking traditional market design, Bumble strategically restricts behavior to shift users out of a bad equilibrium – low-quality messages and low response rates – into a better one. Bumble also allows men to “extend” one, and only one, match each day, which tells the recipient that she is special to him. Bumble’s unique feature is that only women can make the first move by sending the first message. Of course, this greatly restricts activity for the men, but the restriction breaks the great coordination problem and solves the tragedy of the commons: since women are not being inundated with messages, the men they match with have a real chance of a date.

Regressing individual variables against communication rate results in statistically significant models due to the size of the dataset, but with low predictive power. “Predictive power” does not necessarily mean how likely a variable is to *cause* an outcome. Instead, rates typically refer to how likely an outcome can be predicted based on a variable’s value. R-squared values are low for the most part, 30.07% for the overall model and 13% and 25% for the male and female models respectively. This is most likely due to high variance or extreme values in most parameters—a phenomenon that is unsurprising in big data.

From the models, we learn that being younger and athletic and having more photos increases likelihood of receiving messages in online dating, as does being romantic and altruistic. These results add a more nuanced understanding to previous findings in RQ2 about importance of physical attractiveness. It could be possible that being young and athletic is at least related to identifying as physically attractive, and that these traits increase likelihood of receiving messages. The negative relationship between communication rate and being older could suggest that age is not heterogeneous, but that users prefer younger potential partners. The negative relationship between communication rate and sending communication initiations also confirms that users who receive many communication initiations are less likely to send initiations themselves. It is unclear what signals users with higher levels of neuroticism and conflict resolution skills are sending in their profiles that decrease likelihood of receiving messages.

As for the differences between predicting success for men and women, the findings that drinking and being clever were positive predictors of success for men, but not for women were noteworthy. It findings suggest that physically reflected traits such as age and athleticism were most important factors for determining whether women would receive messages, in line with our earlier results in RQ2 about women being evaluated by their looks more than men.

Finally, one should note that this work was conducted within the context of data generated from one online dating site within the United Kingdom geography. While there was extra caution taken to ensure that findings were as representative as possible, it could always be valuable to confirm validity by testing novel data sets from other dating sites and from different geographies where social norms may differ. Future research could also strive to situate these findings within the offline courtship context. Building on this work, researchers could use a combination of qualitative and quantitative methods to better understand whether users approach mate preference, evaluation of physical attractiveness, and communication initiation differently in offline contexts where search costs or fear of rejection may be higher.

## References

- Azevedo, E. M., & Leshno, J. D. (2016). A Supply and Demand Framework for Two-Sided Matching Markets. Retrieved from <https://www.journals.uchicago.edu/doi/pdfplus/10.1086/687476>
- Bell, A., & Jones, K. (2015). *Age, Period and Cohort Processes in Longitudinal and Life Course Analysis: A Multilevel Perspective. A Life Course Perspective on Health Trajectories and Transitions*. Springer. [https://doi.org/10.1007/978-3-319-20484-0\\_10](https://doi.org/10.1007/978-3-319-20484-0_10)

- Chiappori, P.-A., Oreffice, S., Quintana-Domeque, C., Chiappori, P.-A., & Oreç, S. (2013). BIDIMENSIONAL MATCHING WITH HETEROGENEOUS PREFERENCES: SMOKING IN THE MARRIAGE MARKET. *Royal Economic Society Meetings*. Retrieved from <https://www.economics.ox.ac.uk/materials/papers/13236/paper696.pdf>
- Ellison, N., Heino, R., & Gibbs, J. (2006). Managing Impressions Online: Self-Presentation Processes in the Online Dating Environment. *Journal of Computer-Mediated Communication*, 11(2), 415–441. <https://doi.org/10.1111/j.1083-6101.2006.00020.x>
- Feltovich, N., Harbaugh, R., & To, T. (2002). Too cool for school? Signalling and countersignalling. *RAND Journal of Economics* *Z. Levinson, from A Beautiful Mind*, 33(4), 630–649. Retrieved from <https://kelley.iu.edu/riharbau/cs-randfinal.pdf>
- Joan Ferrante. (2007). *Sociology: A Global Perspective: Edition 7*, Cengage Learning.
- “First evidence that online dating is changing the nature of society.” MIT Technology Review. <https://www.technologyreview.com/s/609091/first-evidence-that-online-dating-is-changing-the-nature-of-society/> (accessed April 22, 2018.)
- Fisman, R., Iyengar, S. S., Kamenica, E., & Simonson, I. (2006). *GENDER DIFFERENCES IN MATE SELECTION: EVIDENCE FROM A SPEED DATING EXPERIMENT\**. Retrieved from <https://academic.oup.com/qje/article-abstract/121/2/673/1884033>
- Fry, Hannah, (2015). *The mathematics of love: patterns, proofs and the search for the ultimate equation*. London: TED Books.
- Hartford, Tim. “Online dating? Swipe left.” *Financial Times*. <https://www.ft.com/content/b1a82ed2-8e34-11e5-8be4-3506bf20cc2b> (Accessed April 22, 2018).
- Hitsch, G. J., Hortaçsu, A., Ariely, D., Hitsch, G. J., Hortaçsu, A., & Ariely, D. (2010). What makes you click?—Mate preferences in online dating. *Quant Mark Econ*, 8, 393–427. <https://doi.org/10.1007/s11129-010-9088-6>
- Igarashi, T., Takai, J., & Yoshida, T. (2005). Gender differences in social network development via mobile phone text messages: A longitudinal study. *Journal of Social and Personal Relationships*, 22 (5), 691–713. doi:10.1177/0265407505056492
- Lee, S., Niederle, M., Kim, H.-R., & Kim, W.-K. (2011). NBER WORKING PAPER SERIES PROPOSE WITH A ROSE? SIGNALING IN INTERNET DATING MARKETS. Retrieved from <http://www.nber.org/papers/w17340>
- Mayer-Schönberger, V., & Cukier, K. (2013). *Big data: A revolution that will transform how we live, work and think*. London: John Murray.
- Mikołaj, H. H., Piskorski, J., Haa, H., & Laj, M. (2013). Competing by Restricting Choice: The Case of Search Platforms. Retrieved from [http://www.hbs.edu/faculty/Publication Files/10-098\\_316490ad-1183-4c71-95bc-2fcab610c0ab.pdf](http://www.hbs.edu/faculty/Publication%20Files/10-098_316490ad-1183-4c71-95bc-2fcab610c0ab.pdf)
- “Modern romance: online dating as a two-sided matching market.” Cornell University. <https://blogs.cornell.edu/info4220/2018/03/09/modern-romance-online-dating-as-a-two-sided-market/> (Accessed on April 22, 2018).
- Ortega, J., & Hergovich, P. (2017). The Strength of Absent Ties: Social Integration via Online Dating. Retrieved from <http://arxiv.org/abs/1709.10478>
- Oyer, Paul Edward, (2014). *Everything I ever needed to know about economics I learned from online dating*. Boston, Massachusetts : Harvard Business Review Press.
- Roth, Alvin E., (2015). *Who gets what - and why: the hidden world of matchmaking and market design*. London : William Collins.
- Sorensen, A. T. (2000). Equilibrium Price Dispersion in Retail Markets for Prescription Drugs. *Journal of Political Economy*, 108(4). Retrieved from [https://www.ssc.wisc.edu/~sorensen/papers/sorensen\\_JPE\\_2000.pdf](https://www.ssc.wisc.edu/~sorensen/papers/sorensen_JPE_2000.pdf)
- Tong, S. T., & Walther, J. B. (2011). “Just say no thanks”: Romantic rejection in computer-mediated communication. *Journal of Social and Personal Relationships*, 28(4), 488–506. doi:10.1177/0265407510384895
- Walther, J. B., & Burgoon, J. K. (1992). Relational Communication in Computer-Mediated Interaction. *Human Communication Research*, 19(1), 50–88. <https://doi.org/10.1111/j.1468-2958.1992.tb00295.x>
- Whitty, M. (2009). Love Letters. In *Oxford Handbook of Internet Psychology*. Retrieved from <http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199561803.001.0001/oxfordhb-9780199561803-e-003>
- Whitty, M. T., & Carr, A. N. (2006). *Cyberspace Romance: The Psychology of Online Relationships*. Palgrave Macmillan.
- Zhang, J., & Yasseri, T. (n.d.). What Happens After You Both Swipe Right: A Statistical Description of Mobile Dating Communications. Retrieved from <https://arxiv.org/pdf/1607.03320.pdf>