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Propose with a rose? Signaling in internet dating markets

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Abstract A growing number of papers theoretically study the effects of introducing a preference signaling mechanism. However, the empirical literature has had difficulty proving a basic tenet, namely that an agent has more success when the agent uses a signal. This paper provides evidence based on a field experiment in an online dating market. Participants are randomly endowed with two or eight "virtual roses" that a participant can use for free to signal special interest when asking for a date. Our results show that, by sending a rose, a person can substantially increase the chance of the offer being accepted, and this positive effect is neither because the rose attracts attention from recipients nor because the rose is associated with unobserved quality. Furthermore, we find evidence that roses increase the total number of dates, instead of crowding out offers without roses attached. Despite the positive effect of sending roses, a substantial fraction of participants do not fully utilize their endowment of roses and even those who exhaust their endowment on average do not properly use their roses to maximize their dating success.

Keywords Field experiment · Matching · Preference signaling · Market design · Online dating

JEL Classification D82 · A11 · J12

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1 Introduction

In many matching markets, candidates vying for positions inundate employers or schools with applications, making it difficult to decide which candidates to offer a limited number of interviews, job offers, or admission slots. For employers or schools, it therefore becomes important to assess not only the quality but also the attainability of an applicant. To help make this assessment, many markets have formal or informal preference signaling mechanisms in place.[1] Although a growing number of papers theoretically study preference signaling,[2] the empirical literature has had difficulty proving that an agent has more success when the agent uses a signal (e.g., Avery et al. 2003, for U.S. college admissions; Coles et al. 2010, for the American Economic Association (AEA) signaling; Roth and Xing 1997, for the U.S. market for clinical psychologists; and Niederle et al. 2006, for the U.S. Gastroenterology Fellowship match).[3] Furthermore, in order to use preference signaling as a market design instrument, it is also critical to understand the behaviors of market participants in terms of how actively they use preference signaling as well as how effectively they use signaling to improve their outcomes. However, existing studies provide little information on how market participants use preference signaling, largely due to data limitations.[4] The goal of this paper is to narrow this gap in two ways. First, we provide clean empirical evidence that sending a preference signal can considerably improve one's chances of success. Second, because we observe all behaviors of market participants in our field experiment setting, we are able to present detailed behavioral patterns regarding the use of preference signaling. These two pieces of information are necessary ingredients for signaling mechanisms to be valuable and to be promoted in market design.

We conduct a field experiment in online dating, where individuals can express a non-binding special interest to a limited number of potential dates. A large online

[1] There are numerous examples of informal preference signaling. In the economics job market, for example, it is through advisors and their connections that graduate students on the market can convey their interest. In the law clerk market, law appellate court judges seem to be able to receive binding commitments from law students (see Avery et al. 2001). In U.S. college admissions, students are advised to show interest by visiting the college. For example, college data, at (http://www.collegedata.com/cs/content/content_getinarticle_tmpl.jhtml?articleId=10045), claims that "demonstrated interest" is a factor of considerable importance to colleges: "Going on a college visit, talking with admission officers, or doing an enthusiastic interview can call attention to how much you really want to attend. Applying for an early decision may also make a good impression."

[2] Examples of recent studies are Avery and Levin (2010) and Coles et al. (2013).

[3] A much-studied version of signaling is costly signaling (see Spence 1973), where agents undertake various actions, in general visible to all participants, whose costs depend on the underlying trait to be signaled. Such costly signaling has, for example, been used as a partial explanation for education (for an early overview, see Weiss 1995), conspicuous consumption (Veblen 1899; Charles et al. 2009) and even in biology for the famous extravagance of the peacock's tail (Zahavi 1975). It is, however, difficult to show that costly signals sway the decisions of other agents (see the debates regarding the signaling value of education: Tyler et al. 2000; Jepsen et al. 2010; Martorell and Clark 2014). Given the difficulty of proving the effect of costly signaling, it is not surprising that the empirical literature on preference signaling that does not even yield direct costs has faced similar difficulties.

[4] For example, the datasets used in existing studies on preference signaling provide only a partial list of the colleges/firms a person applied to when seeking admission/a job.

dating company organizes two dating events with 613 participants, about 50 % of whom are female. All participants are endowed with two "virtual roses" and a randomly chosen 20 % of participants are endowed with eight. A participant can send dating requests to up to ten different people by sending a pre-made electronic note, a *proposal.* Participants can attach at most one virtual rose, a digital image icon, when sending a proposal. The roses are described as a way to show special interest. Hence, roses are signals that everyone can send for free to anyone, and roses are costly only because they are in limited supply. If sending a preference signal increases a person's success in getting a date, then we expect, all else being equal, that attaching a rose to a proposal improves the chance of that proposal being accepted.

Compared to other environments, our set-up offers three major advantages for testing the impact of preference signaling. First, we have the same information about potential dating partners (and often even more) available to a participant. This is one of the distinguishing features of our environment. In general, market participants such as colleges or universities tend to have more detailed information about an applicant (e.g., application essay, high school performance, job market paper) than the researcher does. Second, even though the market is decentralized, we observe not only accepted proposals but all proposals, because the market operates on the dating company's website. This is an unusual amount of information for a decentralized market. Third, we are able to randomly select participants whom we endow with eight roses (versus two).[5] This randomization will allow us to make a clean causal inference of the effect of preference signaling, mitigating the concern over potential endogeneity bias. These three features provide us with cleaner evidence than previous studies to test whether sending a non-binding signal can enhance the signaler's chance of receiving a coveted date, college admission, a job interview, or a job offer. Furthermore, our study of online dating may itself be economically relevant because an important economic variable, marriage, is a result of dating,[6] and because online dating services are rapidly growing throughout the world (see Oyer 2014).

The experiment consists of two special online dating sessions in South Korea for people who are college-educated, never-married, aged between 26 and 38 for men, and 22 and 34 for women. We impose restrictions on participants' characteristics to create a thick market because heterogeneity in observables may potentially segment the dating market. For the first 5 day of the event, a participant can browse profiles and send up to ten proposals. A proposal can be sent with at most one rose attached. Participants have two roses they can attach to proposals, with a randomly selected

[5] Such an intervention may be ethically more problematic in the labor or education markets. The main difference between the dating and employment environments is that the dating market is more continuous. As such, any dating website is portioning off a fraction of the "natural" dating market and manipulating it. It is much more problematic to influence a national or even international market such as the economics junior market that operates once a year and whose initial outcome may have a large impact on careers (Oyer 2006).

[6] Marriage has received some attention following the seminal work by Becker (1973). Examples of empirical studies on marriage include Abramitzky et al. (2011), Choo and Siow (2006), Fisman et al. (2006, 2008), Hitsch et al. (2010), and Lee (2009).

20 % of participants having eight roses. Once this period ends, each participant receives his or her proposals and observes whether they come with a rose. For the next 4 day, participants decide whether to accept each proposal; they can accept at most ten proposals. After the acceptance phase, an accepted proposal results in the company sending a text message to provide the involved pair with each other's contact information.

Motivated by the discussions in the preference signaling literature, we hypothesize that preference signaling will increase the acceptance rate; the positive effect will be large, particularly if a person sends a signal to an agent whom may think the person is "too good"; and signaling will increase the total number of matches, instead of crowding out other offers. We test these hypotheses using our data and find supporting evidence.

To test our hypotheses, we need to define the extent to which a person is desirable as a spouse/dating partner. Then, we can measure the effect of roses, for example, by comparing a dating offer accompanied by a rose with another offer without a rose, when those two offers were sent by two equally desirable persons. In our environment we have a clear desirability measure of participants. This measure is provided by the online dating site and has been validated by Lee (2009) using a much more comprehensive dataset than the one used in this study. We use this desirability measure to classify experimental participants into one of three groups—bottom (the least desirable group), middle, or top (the most desirable group). We also use alternative measures of desirability, and our findings below are robust.

We find that, all else being equal, sending a proposal with a rose attached increases the probability that a recipient will accept the proposal by 3.3 % points, which corresponds to a 20 % increase in the acceptance rate. This effect is similar in magnitude to the increase in the acceptance rate when the dating offer comes from a sender in the middle, rather than bottom, category. Furthermore, we confirm the positive of effect of roses by showing that participants endowed with eight roses instead of only two are more successful in that they initiate more dates. Next, we show that every recipient group responds positively to roses when the proposals are made by senders from a higher desirability group. That is, when a sender from the top desirability group makes an offer to a middle or bottom group recipient, this offer is significantly more likely to be accepted when a rose is attached. The same is true for offers from middle senders to bottom recipients. The effect of a rose in all those instances is more than a 50 % increase in the acceptance rate, which corresponds to twice the increase in the acceptance rate when moving the sender from the bottom to middle desirability group. We also show that these positive effects of roses are neither because the roses attract attention from recipients nor because they are associated with unobserved quality. We therefore provide evidence that roses can serve as a way to signal special interest and increase the chance of an offer being accepted. Finally, we find that individuals who received at least one rose accepted more dating offers than their counterparts who did not receive a rose, suggesting that roses may increase the total number of matches, rather than crowding out other offers.

Despite the positive effects of roses on acceptance rates, participants in our experiment did not use roses strategically. Thirty-two percent of male participants

and 69 % of female participants did not exhaust their rose endowments: they sent some dating requests without a rose, although they had roses left. Furthermore, approximately 30 % of roses were sent in vain to top group recipients who did not positively respond to them. Given our earlier finding that roses do not crowd out other offers, there exists a potentially large gain from educating dating market participants on how to strategically use preference signaling.

Our experiment on Internet dating provides clear evidence that by sending a preference signal, a proposer can increase the chance of being accepted when everyone can send signals for free but signals are limited in number. It appears that senders are able to convey information to recipients using preference signals, and recipients react to these signals. These are the necessary ingredients for a signaling mechanism to affect a market. Given the present evidence, as well as the multitude of suggestive evidence that we review in the discussion section, it seems that preference signaling has a place in the toolkit of market designers.

2 Preference signaling in practice

This section briefly overviews the role of preference signaling in two settings that are most closely related to our experiment: early application in admission to U.S. colleges and the AEA signaling mechanism for the economics job market.

In the U.S., over two-thirds of top colleges have one of two types of early admissions programs: early action programs where students are accepted well before the standard March announcement date but are not committed to enroll, and early decision programs where students commit to enroll if accepted (Avery and Levin 2010). Avery et al. (2003) and Avery and Levin (2010) argue that colleges use an early admission program as a signaling device through which they can assess an applicant's likelihood of accepting an offer if one is made. If colleges care about student preferences, then a college will be more likely to accept an early applicant than someone who submits a regular application. Avery et al. (2003) find that by using early application, average applicants to the 14 selective colleges can double their chances of getting an offer. They also show that the benefit of using early application is not large for applicants with high SAT scores (e.g., 1,600 s in SAT-1) because their chances of receiving an offer are high even in regular admission, whereas the benefit is large for applicants whose expected acceptance rate is around or slightly less than 50 % in regular admission. It is worth noting that the evidence regarding early applications is suggestive because Avery et al. (2003) received access to only a subset of information about applicants that schools declared to be relevant to admissions decisions. Furthermore, channels other than preference signaling are discussed to explain the seemingly beneficial effect of early applications.[7]

As for the AEA signaling, each job applicant is asked to select two employers (universities) and then the AEA informs each employer of the list of candidates who selected the employer with signaling, so that they can use the information to

[7] Kim (2010) focuses on early admission as a screening device for students who do or do not require financial aid.

determine interviewees. The AEA introduced this system in 2006 to address the problem that most economics departments receive applications from more suitable candidates than they can interview and therefore they may decide not to interview many promising candidates for fear of filling interview slots with applicants that have only weak interest in the position. AEA conjectures that signaling will increase a candidate's chance of getting an interview, particularly if the candidate sends a signal to a university that considers the candidate "too good" to accept its offer.[8] Coles et al. (2013) theoretically examine this conjecture by building a two-sided matching model and they present an environment where the agents positively respond to signals and where the introduction of preference signaling increases the total number of matches in the market. However, the empirical evidence supporting the AEA conjecture is not conclusive but suggestive. Coles et al. (2010) report a positive effect of signaling on an applicant's chance of getting interviewed, but their data is based not on a representative sample of candidates but on a small number of candidates who chose to participate in their survey. Moreover, data limitations prohibited them from controlling for important characteristics such as the list of schools a candidate applied to and the candidates' detailed quality, which could result in a spurious positive correlation between signaling and the chance of getting an interview due to omitted variable bias. Note that Coles et al. (2010) do not examine what types of applicants benefit most from signaling.

3 Experimental design

3.1 Background information

We conduct a field experiment at a major online dating company in South Korea that also operates in China, Singapore, and the United States. Since 1991, the company has been helping clients find spouses from among clients of the opposite sex. The company provides two types of membership: regular and event. The main differences between the two are the cost, the length of service, the degree of the company's involvement in a client's search process, and the depth of supporting documents for legal verification of a client's information. A regular membership lasts for one year and costs about $900, whereas an event membership is for a one-time dating event that occurs, for example, on Valentine's Day, during the summer vacation season, or at Christmas time.

For regular members, the company suggests "suitable" dating partners based on its matching algorithm. To match members, the company creates an index (herein, *desirability index*), which is a sex-specific weighted sum of a person's

[8] The AEA offers advice includes: "The two signals should not be thought of as indicating your top two choices. Instead, you should think about which two departments that you are interested in would be likely to interview you if they receive your signal, but not otherwise (see advice to departments, above). You might therefore want to send a signal to a department that you like but that might otherwise doubt whether they are likely to be able to hire you." (see http://www.aeaweb.org/joe/signal/signaling.pdf).

characteristics, many of which have to be legally verified.[9] The desirability index is intended to predict how attractive a person would be to the opposite sex as a spouse. It ranges from 0 (least desirable) to 100 (most desirable). The desirability index is not visible to members of the dating site. Using a dataset from the company (separate from the experiment) collected by Lee (2009), we find that the desirability index is a good predictor of whether a client is attractive as a dating partner (see Sect. 1 of the supplementary document). Event members are asked the same set of questions as regular members but are not required to answer them all; they can also fail to submit some of the legal documents. The company constructs a verification score ranging from 0 (no legal verification) to 100 (full legal verification)[10] and posts it on the member's online profile.

3.2 Experimental design

3.2.1 Procedure

In summer 2008, the company advertised two sessions of the field experiment in Korea as one of its special dating events, one in July and the other in August. The company's advertisement noted that the dating sessions were designed only for people who were Korean, college educated, never married, and aged from 26 to 38 for men and 22 to 34 for women. These restrictions are imposed to reduce heterogeneity among participants and thus to create a thick market. While the market thickness may make it easier for participants to find a good match, it may also imply that participants may not have sufficient time to date all desirable candidates. Finally, the company charged a fee of approximately $50 for each dating session and this fee is comparable to that of the company's other special dating events.

Each session of the experiment consists of two stages: the first is a proposal stage, which lasts 5 days; then there is a response stage of 4 days. In the proposal stage, each participant can browse profiles of other participants that contain their submitted information, including a head-to-shoulder photo and their verification score. Each participant can send a pre-made electronic note (herein *proposal*) asking for a date to up to ten participants of the opposite sex. Furthermore, each participant can attach up to one virtual rose per proposal. The virtual roses are a preference signaling mechanism specifically introduced for this dating event. In the response stage, participants receive proposals and see whether a rose is attached. Participants can accept up to ten proposals but do not receive any information regarding whether any of the proposals they made are accepted. No new proposals can be made in the response stage. An accepted proposal (a date) results in the company sending a text

[9] A person's desirability index is calculated based on earnings, assets, job security (full time job or not), height, weight, a company-generated score based on the profile picture, a score based on the college attended and the chosen major, both of which are highly correlated with the score on the national college entry exam, birth order, and family characteristics (parents' wealth and marital status, and siblings' educational attainment).

[10] To receive 100 percent verification, a participant needs to submit a copy of the national household registration form (for age, birth order, marital history and parents' marital status), diploma (for education) and proof of employment (for type of employment and industry).

message to the two involved participants including each other's phone numbers right after the response stage. Given the experimental design, each participant can have at most 20 first dates.

Because the proposal stage is separated from the response stage, participants cannot observe the proposals of others when deciding to whom to send a proposal. Similarly, during the response stage, participants do not know whether any proposals are accepted or rejected. This simplifies the empirical analysis by preventing a participant from making his or her decisions based on the other participants' decisions (apart from responding to the proposals he or she received).

3.2.2 Treatments

The innovation in the dating event is to endow participants with virtual roses. The main analysis in this study is to assess whether attaching a rose increases the chance of a proposal being accepted. The first treatment variable is to change the number of roses participants are endowed with. Eighty percent of participants receive two roses, while 20 % receive eight roses. Note that the company did not advertise that there were two levels of rose endowment. See details, in Sect. 3.2.3. We use the rose treatment to examine the effect of signaling in two ways. If signaling has any impact, then we will observe a difference between the 2-rose and 8-rose groups. Furthermore, we will use the treatment status as an instrumental variable to address endogeneity problems when assessing whether roses increase the chance of a proposal being accepted.

The experiment also includes a second, more psychological treatment. The motivation is that many researchers have documented that women are more passive in dating and seem mostly to react to offers (Hitsch et al. 2010; Fisman et al. 2006, 2008; Kurzban and Weeden 2005). If women and men differ in their preferences regarding spousal traits, then who marries whom may depend on who initiates matches. Furthermore, when marital surplus is not fully transferable, passivity in the mate search process may make women worse off.[11] The aim of the second treatment is to affect the behavior of women and men to reduce the gender inequality in the mate search process. In the *female empowerment* treatment, we randomly select 50 % of female participants. During the proposal stage, we show them a banner that is built into the main webpage and visible whenever a treated participant is on the website. The aim was to encourage women to initiate a proposal.[12] Finally, we have an equivalent treatment for men, called *male empowerment*. We randomly select 50 % of male participants and, during the response stage, we show treated male participants a banner to encourage them to accept offers by women whenever they

[11] There may be several core outcomes of who is married to whom, in which case men's preferred outcome is different from the women's preferred outcome (see Roth and Sotomayor 1990, for an overview). A dating market in which men make offers may be closer to achieving the male optimal stable matching, the most preferred outcome by men. Lee (2009) provides evidence that matches would be quite different if women were to make offers.

[12] The banner read, in translation: "Will you wait until Prince Charming asks you out? Or will you take the lead to meet him? Dear client, did you find someone you want to date? Please do not let this opportunity pass you by. Contact him first and give him the opportunity to meet you."

are on the website.[13] We find that these encouragements have no impact. Thus, we control for them in our analyses, but we will not discuss them further.

3.2.3 Information

The dating company advertised that participants could use electronic roses in the dating session, but it did not inform participants about how many roses they would get until the dating session started, and it did not advertise the design that some participants would be endowed with eight roses and the rest with two roses. This feature was due to the concern that some participants might not comply with their treatment status (e.g., a person endowed with two roses may demand eight roses), which would invalidate the randomization of our experiment. A participant's online profile, which other participants can access, contains his or her socioeconomic and demographic information. However, the profile does not include the following information: a person's membership status (e.g., whether the person held a regular membership and if so since when), desirability index, treatment status and activities during the dating sessions (e.g., the number of proposals the person made, the number of roses the person sent).

3.2.4 Data

The dataset consists, for each participant, of his or her characteristics, desirability index, verification score, the list of people to whom the participant sends a proposal and whether a rose is attached, the list of people from whom the participant receives a proposal and whether a rose is attached, and, for all those proposals, whether they are accepted, declined, or ignored.

3.3 Participants

There are 212 participants in the first and 401 in the second session. Roughly half of each session's participants are female. Thirty-three men and 25 women participate in both sessions. All participants meet the participation criteria, apart from four high-school graduates. Twenty percent of participants of each sex receive eight roses, and Table 1 compares the average characteristics of the participants endowed with two roses and the rest (columns (1) and (2) respectively). Column (3) reports the p values of testing the null that the difference is zero. For female participants, the two groups are comparable in all variables except for a small difference in age. For male participants, the two groups are different in terms of membership status, which accounts for the differences in age, residence, and verification score. This difference in observables for men arose because the company's randomization algorithm may create imbalanced subgroups in membership status when the number of participants is small. It turned out that, for women, the algorithm generated the two groups balanced in terms of the share of regular members, while for men, the

[13] The banner read, in translation, "Congratulations! You have received a dating request. Please give an opportunity to the one who has fallen in love with your charms!".

Table 1 Participants' characteristics by treatment status

	Treatment		Diff.: 2 roses–8 roses		
	2 Roses (1)	8 Roses (2)	All members (3)	Regular members (4)	Event members (5)
Male participants No obs.	243	61	304	183	121
Age	32.1	33.1	[0.016]	[0.616]	[0.142]
Greater Seoul (%)	88.9	82.0	[0.145]	[0.127]	[0.854]
Desirability index by the company	75.0	76.8	[0.130]	[0.745]	[0.070]
Event members (%)	45.3	18.0	[0.000]	–	–
Verification—fully-verified (%)	66.7	86.9	[0.002]	[0.208]	[0.905]
Verification—not-verified (%)	2.5	0	[0.217]	–	[0.431]
Female participants No obs.	248	61	309	228	79
Age	29.5	30.1	[0.063]	[0.086]	[0.575]
Greater Seoul (%)	87.5	82.0	[0.260]	[0.551]	[0.150]
Desirability index by the company	79.0	80.0	[0.322]	[0.669]	[0.281]
Event members (%)	27.0	23.0	[0.519]	–	–
Verification—fully-verified (%)	67.7	75.4	[0.246]	[0.161]	[0.710]
Verification—not-verified (%)	4.0	1.6	[0.368]	[0.676]	[0.355]

In columns (3) to (5), brackets contain p values of t-testing the difference is zero

algorithm happened to assign a larger share of regular members to the 8-rose group compared to event members. However, conditional on gender and membership status, the 2-rose and 8-rose groups are comparable to each other. To show this, we compare the two groups among regular membership holders (column (4)) and among event membership holders (columns (5)) and report the p values of the two-sided tests. The two columns show that at a 5 % level, we conclude that the treatment status is not correlated with any observable conditional on gender and membership status. Although a person's treatment status is correlated with his or her observables, we can still draw a causal inference because the treatment status still does not depend on a person's unobservables, and we can control for the observable characteristics in our empirical analyses.

4 The effect of roses

We begin this section by presenting several hypotheses regarding preference signaling in our setting. We then test each hypothesis.

4.1 Hypotheses

As discussed in Sect. 2, various studies have conjectured about the effects of preference signaling and have provided suggestive evidence supporting those conjectures. As our experimental setting shares some features with the AEA job

market and U.S. college early-admission programs, we formulate some hypotheses in line with the literature.

Hypothesis 1 All else being equal, participants accept a dating request with a rose attached more often than a request without a rose.

Hypothesis 2 All else being equal, participants endowed with eight roses have more dates than their counterparts with 2 roses.

If dating is costly, then our participants will carefully scrutinize dating offers and accept only those that have a reasonable chance of developing into a long-term relationship. That chance will be large if the person requesting a date is enthusiastic about the recipient, which can be expressed by sending a rose. Our participants are close to the peak age of first marriage in Korea and are busy young people who are likely to be careful about how they spend their limited spare time. Therefore, we expect roses to have a positive effect on acceptance rate. Participants in our dating sessions accepted only a small number of dating requests. Of the 1,921 proposals, 295 were accepted. The average number of acceptances among participants who received an offer is 0.8 for men and 0.7 for women.[14] This low acceptance rate suggests that the opportunity cost of dating is high among our experiment participants.

Hypothesis 3 Participants who are in high demand by the opposite sex do not respond as positively to roses as their low-demand counterparts do.

The conjectures in the AEA signaling study imply that if a university is the first choice of all job seekers, then the university will not respond to signals because it knows that a person will accept its offer if the offer is made. The analogue in our setting is that a person considered to be a very desirable dating partner will not respond to roses, because they already know potential partners want to match with them; that is, the rose is not conveying valuable information.

Hypothesis 4 Participants respond more strongly to a dating request with a rose attached if the request comes from a person who is considered more attractive than they are.

This hypothesis is based on the conjectures in the AEA signaling study. If roses transmit valuable information and participants reject offers they deem insufficiently likely to result in a long-term relationship, we would expect that the responsiveness towards offers with a rose to be particularly present when offers are made by proposers who are considered more desirable than the recipient.

Hypothesis 5 A participant who received a rose accepts more dating requests than his/her counterpart who did not receive a rose.

By theoretically analyzing a two-sided market, Coles et al. (2013) show that the introduction of preference signaling increases the total number of matches compared to the case without preference signaling. In our setting, we can indirectly

[14] While the average number of accepted offers is similar between women and men, women are significantly less likely to accept an offer than men (16 versus 29 percent, $p < 0.01$). This is because women on average receive 5.9 offers, while men receive only 3.9.

examine this finding by comparing participants who received roses with their counterparts who did not receive roses. If roses help increase the total number of dates, then recipients who receive roses will accept *more* dating offers than their counterparts. Alternatively, if roses shift the recipient's acceptance away from an offer without a rose towards an offer with a rose, then we will not find any difference in the number of accepted offers between the two types of recipients.

4.2 Participant's type

To empirically test our hypotheses, it is crucial for us to ex-ante determine who would be considered desirable as dating partners/spouses among our participants. For this purpose, we define a participant's type based on his or her desirability index, age, residential location, and legal verification level. Although we have a large number of characteristics per participant, we opt to use the desirability index as a summary statistic for how desirable participants are to the opposite sex as dating partners. In a different and much larger sample of regular members that fulfill the requirements of our experiment, we find that the variables we use to define a participant's type explain almost all the variations in a person's desirability as a dating partner compared to when we use all available characteristics (see Sect. 1 of the supplementary document). In our analysis, we partition participants according to their desirability index into three categories within each sex: the bottom 30 %, the top 30 %, and the remaining 40 % (referred to as bottom, top, and middle, respectively). We further partition individuals based on the extent to which their information is verified: fully, partially, or not at all legally verified. Therefore, we define the type of a participant in the experiment based on four characteristics: his or her desirability index (bottom, middle and top), age, residential location, and legal verification level. Note that we use a middle group heavy partitioning to ensure sufficient differences in desirability across the bottom, middle, and top groups because desirability indexes are heavily concentrated around the mean. However, as shown in Sect. 3 of the supplementary document, our results remain qualitative the same when we use alternative definitions of a participant's "desirability."

Given this definition of a person's type, we can test Hypotheses 1 and 2 by comparing the acceptance rates of offers with and without roses, conditional on sender's and recipient's types as well as by comparing participants with two and eight roses; Hypothesis 3 by comparing participants in the top desirability group with the rest; Hypothesis 4 by examining participants' responses to roses depending on who sent the roses; and Hypothesis 5 by comparing participants who received a rose and those who did not in terms of the number of dating offers they accepted.

4.3 Empirical tests

Hypothesis 1 To test Hypothesis 1, we need to find, for each proposal with a rose, its counterpart that is exactly the same except that it does not have an accompanying rose. To do so, we design regression models. Before we explain our models, here are some summary statistics regarding acceptance rates. Among the proposals sent to men, 19.7 % of the proposals without roses were accepted, whereas 23.6 % of the

proposals with roses were accepted. Among the proposals sent to women, 12.3 % of the proposals without roses were accepted and 12.9 % of the proposals with roses were accepted. Although these differences in acceptance rate are rather small and insignificant, the effect of roses becomes significant once we properly control for observables, as we will show below.

We construct a dependent variable that is one if a proposal is accepted and zero otherwise.[15] As a baseline analysis, we regress the acceptance of a proposal on whether a rose is attached, recipient fixed effects, the sender's age and legal verification level, a dummy indicating whether the sender lives in greater Seoul, the squared age difference between the sender and the recipient, and a dummy indicating whether the sender and recipient live in the same location (Greater Seoul, Gangwon, Chungcheong, Jeolla/Jeju, and Gyeungsang). Recipient fixed effects allow for recipient specific reservation values when accepting a proposal. We include dummies for the desirability group of the sender of the proposal (S_Middle and S_Top).

If Hypothesis 1 is correct, then the estimated coefficient of "whether a rose is attached" will be positive, and indeed that is what we find. Column 1 of Model A in Table 2 reports a positive coefficient of "rose," suggesting that attaching a rose significantly increases the probability of being accepted by 3.3 % points. This corresponds to a 20 % increase compared to the overall acceptance rate. Furthermore, this positive effect of sending a rose is economically significant: compared to a proposal from a sender in the bottom desirability group, recipients are more likely to accept an offer from a sender in the top desirability group (by approximately 18 % points) or from a sender in the middle group (by 5 % points). The estimated benefit of sending a rose is comparable to (and about three-quarters of) the benefit of being in the middle desirability group relative to being in the bottom group.

While we have an unusual amount of information about candidates and observe all communications compared to existing empirical studies (Avery et al. 2003 and Coles et al. 2010), it may, in principle, still be the case that endogeneity may account for the positive coefficients of "roses" in the regressions described so far. For example, it may be that participants observe information not present in our data that inform them whether a match would have a particularly high value and hence whether an offer is likely to be accepted. If participants attach roses to offers that yield higher match qualities due to unobservable characteristics, estimating the effect of a rose based on the difference in the acceptance rate between offers with and without roses would bias the results in our favor. To address this endogeneity issue, we take an alternative approach based on instrumental variable estimation. We use the treatment status of the sender, whether the sender is endowed with eight roses, as an instrumental variable with which we instrument the dummy variable indicating whether a proposal has a rose attached. Recall that participants are randomly assigned to be endowed with two or eight roses; furthermore, other participants do not know whether a sender had two or eight roses. Therefore,

[15] This means we treat "no response" as an explicit rejection. In Sect. 7 of the supplementary document, we present evidence that our approach is justified.

Table 2 Effect of roses

Model	FE-R	FE-R-IV	FE-R	OLS	FE Logit	FE-R
	(1)	(2)	(3)	(4)	(5)	(6)
Recipients	All	All	Active	All	All	2 roses
Model A						
Rose	0.033**	0.041	0.054**	0.030*	0.443**	0.034*
	(0.016)	(0.029)	(0.025)	(0.018)	(0.201)	(0.018)
S_Middle	0.048**	0.047***	0.079**	0.074***	0.811***	0.052**
	(0.019)	(0.017)	(0.031)	(0.020)	(0.298)	(0.022)
S_Top	0.178***	0.177***	0.293***	0.191***	2.284***	0.181***
	(0.020)	(0.018)	(0.033)	(0.021)	(0.312)	(0.023)
R-sq (log Lik.)	0.50	0.50	0.46	0.13	−242.37	0.49
No. of proposals	1,902	1,902	1,153	1,902	796	1,516
No. of recipients	393	393	226	393	103	310

Columns labeled FE-R report OLS estimates with recipient fixed effects. FE-R-IV of Model A follows the same specification as Model A of column (1) but instruments Rose with whether the sender is endowed with eight roses and reports second stage regressors. The F-statistic of the excluded instrument is 442.45. FE Logit reports logit model estimates with recipient fixed effects. The dependent variable is one if a recipient accepted a given proposal and zero otherwise. "S_" and "R_" denote sender and recipient characteristics, respectively. All regression models control for sender's verification level (none, medium, full), age, living in greater Seoul, the squared difference of age between a sender and a recipient and a dummy indicating whether the two are in the same location. Location has five categories: Greater Seoul, Gangwon, Chungcheong, Jeolla/Jeju, and Gyeungsang. Column 4 includes in addition control variables for recipient characteristics: number of proposals made, number of roses sent, number of proposals received, a dummy for whether at least one rose was received, the number of roses received, and the recipient's characteristics corresponding to those of senders (verification level, age, living in greater Seoul, R_Middle and R_Top)

Standard errors are in parentheses

*, **, and *** indicate that the p value of testing the coeffcient is zero is significant (two-sided test) at 10, 5, and 1 %, respectively

whether the sender has eight or two roses should not be correlated with the recipient's decision whether to accept an offer conditional on observables. However, having eight roses is significantly correlated with a proposal being accompanied by a rose (F-stat 442.45).[16]

Column 2 of Table 2 reports the estimates from the second stage with standard errors that take the first stage estimation errors into account. We find that sending a rose increases the chance of acceptance by 4.1 % points, larger than but not statistically different from the baseline effect (3.3 % points). The finding from the IV regression suggests that possible endogeneity bias may not fully account for the estimated effect of roses on acceptance rates. The overall effect of roses estimated by the IV regression is not statistically significant at a conventional level. However, as we will show in the next model, Model B, the IV estimate when considered for

[16] See Sect. 6 of the supplementary document for details, including identification assumptions and a formal description of the IV model.

specific recipients not only yields an effect of similar magnitude as the standard estimate, but it also remains significant.

The results regarding the effect of a rose are robust across various specifications and sub-samples.[17] In column 3, we restrict our attention to recipients who actively responded to at least one proposal.[18] In column 4, we use a linear regression model instead of a recipient fixed effects model and control for recipient characteristics such as the number of offers and roses both sent and received. In both cases, the recipient's response to a rose is qualitatively the same as in the baseline analysis in column 1. Likewise, a logit regression with recipient fixed effects where we report the coefficients of the latent index (column 5) yields similar results.[19] In column 6, we restrict our attention to recipients who had only two roses as a way to assess whether participants endowed with two roses react to roses differently than those endowed with eight roses. We find that the results remain virtually unchanged.[20] This is not very surprising since the effect of a rose is the difference in the acceptance rate of an offer with a rose attached compared to an offer without a rose.[21] Finally, when we separately estimate the effect of roses for men and for women, we find that the estimated magnitudes are comparable.

[17] In addition to the approaches explained in this paper, we perform the following two exercises (for details, see Sect. 2 of the supplementary document). First, instead of our baseline cutoffs (30th percentile and 70th percentile), we use the 20th and 80th percentile to classify participants into three desirability groups. We re-estimate Model A and find that a rose increases the chance of a proposal being accepted by 3.2 percentage points, almost identical to the baseline result. Second, we use the number of proposals a participant received as a proxy for the participant's desirability. We re-estimate Model A but include dummy variables of the number of proposals a sender received instead of the desirability index group dummies. We find that a recipient accepts a proposal by 3.4 percentage points more if the proposal is accompanied by a rose, an effect virtually identical to the baseline result.

[18] We have 56 individuals who participated in both sessions, and 39 of them received at least one proposal in the second session. We examine whether recipients respond to a rose differently in their second session. To do so, we re-estimate Model A but include the interaction between a rose and a dummy variable that indicates the second session and two-time participants. Note that 215 out of 1,921 proposals are sent to two-time participants. We find that there is no statistical difference in terms of recipients' response to a rose in their second participation.

[19] We also run a regression where, in addition to fixed effects for recipients, we use fixed effects for senders instead of their desirability group. The estimated coefficient of a rose is 0.031, qualitatively the same as in the baseline regression (column 1), though just barely not significant (the s.e. is 0.019, $p = 0.104$).

[20] We also formally test whether the effect of roses on the acceptance rate depends on a recipient's treatment group. We re-estimate Model A while including an interaction term between receiving a rose and whether a recipient had eight or two roses. The coefficient on the interaction term is not significant, indicating that the difference in the acceptance rate due to a rose is similar between recipients who themselves had two or eight roses (see Sect. 7 of the supplementary document).

[21] Participants who have two roses may view an offer with a rose as "special," while offers without a rose show perhaps "normal" interest. On the other hand, participants who have eight roses may not feel equally flattered when receiving a rose. However, for them, not receiving a rose may be a sign of not really being special, since, in their view, only two out of ten offers are precluded from having a rose attached. Note that these two cases are in a way symmetric: either two out of ten offers are more special compared to other offers—for recipients endowed with two roses—or two out of ten offers are less special compared to other offers—for recipients endowed with eight. Due to this symmetry, it may not be surprising that the change in the acceptance rate in reaction to a rose may be similar for recipients endowed with two or eight roses.

Table 3 Treatment effects

	2 Roses	8 Roses	Increase
Panel A. Men (Seoul, full verification) No obs.	*144*	*42*	
Have at least one initiated date	0.313	0.452	45 %**
No of initiated dates	0.556	0.833	48 %*
Quality adj. no of initiated dates	0.535	0.806	51 %*
Panel B. Men (regular members) No obs.	*133*	*50*	
Have at least one initiated date	0.308	0.420	36 %*
No of initiated dates	0.556	0.800	44 %*
Quality adj. no of initiated dates	0.540	0.767	42 %*
Panel C. Women No obs.	*248*	*61*	
Have at least one initiated date	0.218	0.328	50 %**
No of initiated dates	0.379	0.705	86 %**
Quality adj. no of initiated dates	0.369	0.688	86 %**

To quality-adjust proposals, we compute the weight of a proposal as the desirability index of the recipient divided by the average desirability index of participants who received at least one proposal

*, **, and *** indicate that the p value of testing the increase from the value in column 1 to the value in column 2 is significant (one-sided test) at 10, 5, and 1 %, respectively

Hypothesis 2 If roses increase the chance of an offer being accepted, and the proposal behavior of participants endowed with two and eight roses is comparable, we would expect participants with eight roses to have more of their offers accepted than those who have only two roses. Indeed, we find that the two groups exhibit comparable behavior in terms of to whom they make offers and to which offers they attach a rose. See detailed analyses in the supplementary document. In the following we refer to an offer the proposer made that was accepted as an initiated offer, and all our tests on dating success will be one-sided, since we assess whether roses help participants get their proposed dates accepted. To make the 2-rose and 8-rose groups comparable in their observables, we examine two subsets of male participants: men who live in greater Seoul and have full verification (panel A of Table 3), and men who have regular memberships (panel B of Table 3). We use all female observations since there are no observable differences among women in various treatment groups (panel C of Table 3).

Men have approximately 40 % increase in their chance of having at least one offer accepted (initiated date), and also have at least 40 % more initiated dates; both effects are not only economically but also statistically significant. The effect of having eight roses on dating success is even larger for women. While having more initiated dates is clearly a sign of success, one concern may be that those "additional" dates of participants with eight roses are not comparable in "quality" to the initiated dates of participants with two roses. Put differently, participants may care not only about the total number of dates but may prefer dates with more desirable partners. We therefore quality-adjust each proposal. For each proposer, we compute the weight of a proposal as the desirability index of the recipient divided by the average desirability index of participants who received at least one proposal.

Table 4 Effect of roses (Model B)

Model	FE-R	FE-R-IV	FE-R	OLS	FE Logit	FE-R
	(1)	(2)	(3)	(4)	(5)	(6)
Recipients	All	All	Active	All	All	2 roses
Model B						
R_Bottom Rose	0.054	0.035	0.087	0.003	0.935	0.071
	(0.047)	(0.054)	(0.071)	(0.047)	(0.598)	(0.052)
R_Middle Rose	0.078***	0.064**	0.097**	0.082***	0.677**	0.068**
	(0.027)	(0.031)	(0.040)	(0.029)	(0.317)	(0.031)
R_Top Rose	−0.001	−0.002	0.013	0.003	0.131	0.006
	(0.021)	(0.025)	(0.035)	(0.024)	(0.292)	(0.024)
S_Middle	0.047**	0.047**	0.079**	0.072***	0.815***	0.051**
	(0.019)	(0.019)	(0.031)	(0.020)	(0.299)	(0.022)
S_Top	0.176***	0.177***	0.290***	0.189***	2.283***	0.180***
	(0.020)	(0.020)	(0.033)	(0.021)	(0.314)	(0.023)
R-sq (log Lik.)	0.50	0.50	0.46	0.13	−241.18	0.49
No. of proposals	1,902	1,902	1,153	1,902	796	1,516
No. of recipients	393	393	226	393	103	310

FE-R-IV of Model B follows the same specification as Model B of column (1) but instruments R_Bottom Rose, R_Middle Rose and R_Top Rose with the predicted probability of attaching a rose interacted with the recipient's desirability group (for details see Sect. 6 of the supplementary document). The Cragg-Donald's F-statistic of the three excluded instruments is 1,141.30. See notes of Table 2 for the control variables and explanation of each column

Standard errors are in parentheses

*, **, and *** indicate that the p value of testing the coeffcient is zero is significant (two-sided test) at 10, 5, and 1 %, respectively

For both women and men, the increase in the number of such "quality-adjusted" dates is comparable to the total increase in the number of dates. This suggests that the additional dates participants with eight roses achieve are not of inferior quality.

Hypothesis 3 We now test whether a recipient's behavior toward roses differs depending on the recipient's desirability by including interaction terms between receiving a rose and the desirability group of the recipient in the model we used to test Hypothesis 1. For instance, "R_Top Rose" is one if a proposal is accompanied by a rose and sent to a top group recipient. If Conjecture 3 is correct, then we will find that the coefficient of "R_ Top Rose" will be smaller than that of "R_ Middle Rose" or "R_Bottom Rose," which is the case. Table 4 reports the results. Recipients in the top desirability group have an overall acceptance rate of 12.03 % and are the most selective group. They do not appear to postively respond to roses, as "R_Top Rose" has a coefficient close to zero. While in some specifications the point estimate is even slightly negative, it is never close to being significant at conventional levels.

Different from top group recipients, middle and bottom group recipients positively respond to a rose, although the effect of roses for the bottom group is not statistically significant. Column 1 of Model B shows that middle group recipients

are 7.8 % points more likely to accept an offer with a rose than one without a rose. The overall acceptance rate for middle group recipients is 18.42 %, so a rose results in a roughly 40 % increase in the acceptance rate. Furthermore, under all specifications, the effect of attaching a rose is similar and generally larger than the effect of moving a sender from the bottom to the middle desirability group (which is 4.7 % points in "S_Middle," column 1). Recipients in the bottom desirability group overall have a positive response to a rose of 5.4 % points, but the effect is not significant. Since the overall acceptance rate for bottom participants is 19.21 %, a 5 % point increase corresponds to about a 25 % increase in the acceptance rate. However, participants in the bottom group receive only a small fraction of all offers (12.04 %), which may account for the large standard errors. Note that in almost all specifications, the effect of a rose is quantitatively similar to the increase in the acceptance rate when the sender is from the middle rather than bottom desirability group.

These findings are robust across various alternative specifications reported in columns 2–6 in Table 4. We also repeat our IV analysis for Model B, where we now have three potentially endogenous variables. Following Wooldridge (2010, Chap. 21), we use three instruments excluded from the second stage regression, which are the three dummies for the desirability group of the sender interacted with the predicted probability of attaching a rose (for details see Sect. 6 of the supplementary document). The three instruments significantly predict whether a proposal will come with a rose (Cragg-Donald's F-stat 1,141.30). Column 2 of Table 2 reports the second stage results. The results are qualitatively the same as baseline estimates. An F-test suggests that these three estimates are not statistically different from the baseline estimates ($p = 0.937$). This strongly suggests that the effect of a rose on the acceptance rate is not due to endogeneity, but indeed is causal.

Hypothesis 4 To test Hypothesis 4, we design a regression model (Model C) that allows for the possibility that the effect of roses depends on both the recipient's and the sender's desirability groups. Consistent with our hypothesis, we find that for all recipients, the effect of a rose is positive and significant when the sender belongs to a more desirable group than that of the responder, see column 1 of Table 5. That is, bottom recipients react significantly (both economically and statistically) to roses when they are attached to offers from medium and top desirability participants. For middle desirability recipients, the effect of a rose on the acceptance rate of an offer is positive and significant when the offer is made by a participant from the top desirability group. The effect is always more than twice the increase in acceptance when moving, as a sender, from the bottom to the middle desirability group. The effect of a rose is always more than a 50 % increase in acceptance rate for either the bottom or middle recipients. The only surprising result in Table 5 is that offers from bottom desirability senders to middle desirability recipients have a higher chance of being accepted when a rose is attached; all other coefficients are as expected.

These findings are robust across alternative specifications reported in columns 2–6. In column 2, we employ the IV approach to address the nine endogenous variables. We use nine instruments excluded from the second stage equation, which

Table 5 Effect of roses (Model C)

Model	FE-R	FE-R-IV	FE-R	OLS	FE Logit	FE-R
	(1)	(2)	(3)	(4)	(5)	(6)
Recipients	All	All	Active	All	All	2 roses
R_Bottom						
S_Bottom Rose	−0.052	−0.026	−0.076	−0.024	−1.522	−0.041
	(0.064)	(0.074)	(0.096)	(0.063)	(1.401)	(0.074)
S_Middle Rose	0.125*	0.073	0.189*	−0.001	1.883*	0.122
	(0.070)	(0.078)	(0.107)	(0.068)	(0.962)	(0.076)
S_Top Rose	0.160*	0.073	0.275**	0.072	2.889**	0.170*
	(0.084)	(0.092)	(0.137)	(0.087)	(1.463)	(0.086)
R_Middle						
S_Bottom Rose	0.106**	0.097*	0.150*	0.076	1.246*	0.083
	(0.049)	(0.056)	(0.078)	(0.050)	(0.669)	(0.058)
S_Middle Rose	0.019	0.014	0.018	0.065	0.247	0.011
	(0.039)	(0.043)	(0.059)	(0.041)	(0.464)	(0.045)
S_Top Rose	0.124***	0.105**	0.151**	0.108**	0.892*	0.116**
	(0.040)	(0.045)	(0.060)	(0.045)	(0.464)	(0.045)
R_Top						
S_Bottom Rose	−0.003	0.007	−0.001	0.01	−0.654	0.018
	(0.044)	(0.053)	(0.070)	(0.046)	(0.919)	(0.051)
S_Middle Rose	0.034	0.034	0.060	0.026	0.57	0.033
	(0.032)	(0.037)	(0.051)	(0.035)	(0.425)	(0.036)
S_Top Rose	−0.033	−0.037	−0.031	−0.025	−0.069	−0.022
	(0.032)	(0.035)	(0.053)	(0.035)	(0.394)	(0.035)
S_Middle	0.041*	0.046*	0.071*	0.069***	0.677*	0.047*
	(0.023)	(0.025)	(0.037)	(0.024)	(0.368)	(0.026)
S_Top	0.171***	0.180***	0.281***	0.188***	2.182***	0.174***
	(0.024)	(0.026)	(0.039)	(0.026)	(0.370)	(0.027)
R-sq (log Lik)	0.50	0.50	0.47	0.13	−234.80	0.49
No. of proposals	1,902	1,902	1,153	1,902	796	1,516
No. of recipients	394	394	227	393	104	310

Columns labeled FE-R report OLS estimates with recipient fixed effects. FE-R-IV follows the same specification as column (1) but instruments the nine rose variables with nine dummy variables indicating the sender's and recipient's desirability group times the predicted probability of attaching a rose (see Sect. 6 of the supplementary document). The Cragg-Donald's F-statistic of the nine excluded instruments is 296.38. See notes of Table 2 for the control variables and explanation of each column

Standard errors are in parentheses

*, **, and *** indicate that the p value of testing the coeffcient is zero is significant (two-sided test) at 10, 5, and 1 %, respectively

are the nine dummies indicating the sender's and the recipient's desirability group times the predicted probability of attaching a rose (for details see Sect. 6 of the supplementary document). These nine instruments significantly predict whether a proposal will come with a rose (Cragg-Donald F-stat: 296.38). Column 2 of Table 5 reports the second stage results. The results are qualitatively the same as baseline

Table 6 Acceptance and receiving a rose

	All (1)	Men (2)	Women (3)
Receive at least one rose	0.259*	0.484**	0.087
	(0.139)	(0.237)	(0.156)
Female	−0.335**		
	(0.133)		
Constant	0.488***	0.432***	0.231**
	(0.097)	(0.117)	(0.106)
No. obs	97	49	48
R-sq	0.080	0.081	0.007

OLS estimates. The dependent variable is the number of proposals that a recipient accepted

Standard errors are in parentheses

*, **, and *** indicate that the p value of testing the coeffcient is zero is significant (two-sided test) at 10, 5, and 1 %, respectively

estimates. An F-test shows that the nine estimates of the IV regression are not statistically different from the baseline estimates ($p = 0.989$).

Hypothesis 5 We conduct the following thought experiment to assess whether roses change the total number of acceptances. Take two identical recipients who have the same number of offers, with, however, one recipient having received at least one rose while the other received none. If Hypothesis 5 is correct, then the former will accept more offers. To perform this analysis, we need to restrict ourselves to a sample where participants, while receiving the same number of offers, are about equally likely to have at least one rose or no rose. This is the case for middle desirability recipients who have received up to three offers. This corresponds to 60.25 % of all middle recipients who received an offer. In Table 6 we use a linear regression on how many offers participants accepted depending on whether they received at least one rose. Overall, participants who receive at least one rose accept 0.259 more offers than those who receive no rose. For that group, each responder accepts on average 0.412 proposals; this corresponds to a 37 % increase. Note that this effect is almost entirely driven by men.

5 Discussions

5.1 How to use roses

Given our findings regarding the positive impact of roses, it is useful to assess the extent to which participants used their roses strategically to maximize the chances of their offers being accepted. Surprisingly, participants in our sample, particularly females, did not actively use roses. Among those who made at least one dating request, men were more likely than women to use at least one rose (90.30 compared to 64.91 %, $p = 0.00$). Conditional on sending a rose, men were also more likely to

exhaust their roses, that is, to use up all their roses or to use as many roses as proposals (75.17 % versus 47.30 %, $p = 0.00$). As our experimental design intended, participants endowed with 8 roses sent a larger number of roses than those endowed with two roses (5.5 roses versus 1.3 roses, $p = 0.00$). However, we did not find a systematic relationship between a sender's desirability and whether or not the sender used roses actively (see the supplementary document).

Next we examine to whom participants sent their roses. If they wanted to maximize the chance of their proposals to be accepted, then they should have avoided sending roses to the top group. Table 7 reports the fraction of proposals with a rose attached depending the sender's and recipient's desirability groups. Overall, over 30 % of the proposals to the top group participants were accompanied by roses, and this share does not vary much if we consider the sender's gender and desirability groups. For example, the first row in Panel A shows that 37.5 % of proposals sent by men to the women in the top group had a rose attached, whereas the shares for the bottom and middle group female recipients were 42.1 and 39.2 %, respectively. Similarly, as shown by the first row in Panel B, over 30 % of proposals made by women to the top group men had roses attached. This finding that a significant fraction of proposals sent to the top group recipients were accompanied by roses remains the same across senders' desirability groups, although the bottom group senders less frequently sent roses to the top group recipients. These results, together with the finding that roses do not crowd out (testing Hypothesis 5), suggest that, with the proper use of roses, a participant could substantially increase his or her number of dates by reallocating roses to middle or bottom group recipients.

This non-strategic use of roses in our sample may be reasonable to expect, considering that participants were new to preference signaling and thus did not know how the roses would affect their outcomes. To a certain degree, non-strategic use of preference signaling is also found in the AEA signaling setting. Coles et al. (2010) surveyed job market candidates in 2008 and found that only 66 % of respondents reported using the AEA signaling. Furthermore, they found that, against

Table 7 Share of proposals with roses (%)

	Recipient's desirability		
	R_Bottom	R_Middle	R_Top
Panel A. Male senders			
All proposals	42.19	39.16	37.48
by S_Bottom	43.18	34.00	33.83
by S_Middle	45.76	41.58	37.81
by S_Top	35.56	41.14	39.37
Panel B. Female senders			
All proposals	29.73	18.82	31.34
by S_Bottom	16.67	9.33	27.62
by S_Middle	40.00	24.24	33.15
by S_Top	50.00	26.67	31.79

the AEA's advice, a non-negligible fraction of candidates sent their signals to the universities that were very likely to ignore their signals. For example, among the signals sent by the candidates trained at the top 151st to 480th universities, 4 % went to the best universities (top 1–10) and 21 % to the second best universities (top 11–50) (see Table 2 in Coles et al. 2010).

5.2 Do roses merely attract attention?

We have shown that attaching a rose affects the chance of an offer being accepted and we have explained the positive effect of roses by the hypothesis that they convey special interest, which is correctly interpreted by the recipient. Using IV analyses, we found that the positive effects of roses are not driven by endogeneity, that is, participants attaching roses to offers that are more likely to be accepted anyway. In this section, we discuss an additional mechanism through which sending a rose may be effective.

Roses may direct attention to proposals when recipients have a large number of proposals to consider. That is, roses may function as attention-getting devices rather than preference signaling devices. However, we offer two pieces of evidence suggesting that roses are not merely such devices. If roses are attention-getting devices, we would expect them to be especially beneficial when sent to participants who receive a lot of offers. In our data, participants who received the most offers were in the top desirability group (followed by middle and bottom desirability participants), while the fraction of offers with a rose is similar to that of participants in the middle and bottom desirability groups. However, we have seen in Sect. 4.2 that top group recipients made no response to receiving a rose, while the middle and bottom groups do. Next, if roses were only attention-getting devices, we would expect two individuals receiving a comparable number of dating requests and roses to respond to a rose in a similar way, independent of their desirability. We test this hypothesis by estimating Model B of Sect. 4.2 with a restricted sample in which top and middle group recipients are comparable to each other in terms of number of proposals they received, as well as fraction of proposals that came with a rose. Specifically, we examine participants who received between 2 and 10 offers. With this restriction, the top group received 4.7 offers on average, compared to 4.3 for middle group recipients ($p = 0.23$). A Kolmogorov–Smirnov equality-of-distributions test shows that the distribution of number of proposals received by the top group is not statistically different from that received by the middle group ($p = 0.654$). Furthermore, the top and middle groups in the restricted sample have on average the same number of roses (1.4 and 1.6, for middle and top group recipients, respectively, $p = 0.224$) and the same fraction of offers with a rose (0.30 and 0.32, respectively, $p = 0.757$, using two-sided t tests in both cases). Estimating Model B from Sect. 4.2 on this sample shows that middle group participants are 7.5 % points more likely to accept a proposal if the proposal comes with a rose ($p = 0.059$), an effect very comparable to all middle group participants, see Table 6 Model B. In contrast, top group recipients are 4.9 % points *less* likely to accept the proposal, although this negative effect is not significant ($p = 0.148$). These results suggest that roses are not merely attention grabbers; rather, recipients react to roses because they seem to transmit valuable information.

6 Conclusion

This paper presents a field experiment in Internet dating that shows that sending a preference signal can affect outcomes. In our dating experiment, the participants are full-time employed, never married, college-educated Koreans. This group seems to have high opportunity costs, which is reflected in the relatively low number of dates they accepted. In the experiment, we show that adding a preference signal, a rose, to an offer significantly increases the chance that the offer will be accepted. Overall, the effect corresponds to a 20 % increase in the acceptance rate, which is similar to the increase in the acceptance rate when the offer is made by a candidate from the middle rather than the bottom desirability group. A more detailed analysis shows that roses alter acceptance behavior whenever a recipient considers an offer from a sender who is more desirable than the recipient is. Using participants who were randomly selected to receive more signals than others, we can show that the estimated benefits of using a signal are not due to potential endogeneity problems. We also provide evidence that suggests that a preference signal seems to convey information rather than simply being a device that attracts attention to specific offers. Finally, we find evidence that signaling may not crowd out dating requests without an accompanying rose; rather, it may increase the total number of dating requests accepted in the dating market. Interestingly, despite the positive effect of signaling, participants in our experiment often do not exhaust the roses they are endowed with and they often waste their roses by sending them to top-group recipients, who ignore the roses. These results suggest that there exists a potentially large gain from introducing preference signaling, particularly when market participants receive proper education on how to strategically use signaling.

The setting of our experiment shares various similarities with the AEA signaling setting and our findings confirm the conjectures on which the AEA bases its advice to job applicants regarding how to use the AEA mechanisms. Universities can grant a much smaller number of interviews and offers compared to the number of applications they receive (see details in Coles et al. 2010). When interviews or offers are costly, some universities may not contact a candidate whom they consider out of reach. In this case, if a candidate uses an AEA signal, it may persuade a university to interview him or her by informing them of the candidate's likelihood of accepting an offer. Based on these conjectures, the AEA advises job applicants to use signaling to indicate their special interest to those universities who may view them as out of reach. However, data limitations prevent empirical work testing those conjectures and the only empirical report available so far is Coles et al. (2010), which presents some suggestive evidence that AEA signaling increases a person's interview chances. Our finding that sending a rose increases the likelihood of a positive response from another participant, particularly if the dating request is sent from a desirable person to a less desirable person, is consistent with the AEA's conjectures.

Like any other empirical signaling paper on signaling, we cannot assess whether the signaling mechanism improves welfare. While one can show in theory that preference signals can improve welfare (see Avery and Levin 2010; Coles et al. 2013), this is hard to demonstrate empirically for many reasons. The foremost is that

the welfare criterion is not obvious. How should various dates be traded off? Would all participants having one date be better than only a few having multiple dates? Even counting the total number of dates may not be a good measure, as clearly some dates are more desirable than others. Despite this limitation, this paper provides clean empirical evidence that, in a real market, people indeed respond to preference signals and that using a signaling mechanism can have a sizable impact on a person's outcomes. This evidence has important implications for researchers and practitioners who work on improving the efficiency of a market. They have so far mostly focused on turning decentralized markets into centralized ones, such as the market for medical residents and fellows (see Roth 1984; Roth and Peranson 1999; Roth 2008).[22] However, centralizing a decentralized market is a challenging task. This paper suggests that, without requiring a rather drastic intervention, namely centralization, market design may be ready to help decentralized markets operate differently and that preference signaling can be used as a policy instrument.

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[22] Note that in the market for medical residents, the welfare implications of a centralized clearinghouse are also hard to assess. It seems, however, that centralized clearinghouses affect who is matched with whom (Niederle and Roth 2003) and the timing of the match (Roth 1984; Niederle et al. 2006).

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