Truncation Strategies in Two-Sided Matching Markets:
Theory and Experiment

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Abstract

We investigate strategic behavior in a centralized matching clearinghouse based on the Gale-Shapley deferred acceptance algorithm. To do so, we conduct a laboratory experiment to test whether agents strategically misrepresent their preferences by submitting a "truncation" of their true preferences. Our experimental design uses a restricted environment in which subjects always have a best-response in truncation strategies. We find that subjects do not truncate their preferences more often when truncation is profitable. They do, however, truncate less often when truncation is dangerous - that is, when there is a risk of "over-truncating" and remaining unmatched. Our findings suggest that eliminating profitable opportunities for strategic behavior may not be sufficient to induce participants to report their true preferences.

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1 Introduction

Two-sided matching theory has informed the design of institutions in areas as diverse as kidney exchange (Roth, Sönmez, and Ünver, 2004), entry-level labor markets (Roth and Peranson, 1999), and school choice (Abdulkadiroğlu and Sönmez, 2003). These institutions often operate as centralized clearinghouses, in which participants submit rank-order lists of their preferences and then a particular algorithm selects the final outcome (i.e., who is paired with whom). In this context, a widely-used matching algorithm is the Gale-Shapley deferred acceptance algorithm.[1,2] In the DA algorithm, the market is divided into "proposers" and "receivers." This algorithm has an important property: if all agents submit their true preferences, then the resulting outcome is stable and is also the most preferred stable outcome for the proposing side of the market.[3] In the DA algorithm, it is well-known that the proposers have a dominant strategy of truth-telling (Dubins and Freedman, 1981). The receivers, on the other hand, might have incentives to misrepresent their preferences to produce a more favorable outcome for themselves (Gale and Sotomayor, 1985).

We investigate whether - and under what conditions - receivers behave strategically in the preference-revelation game induced by the DA algorithm. We focus attention on a particular class of strategic behavior: truncation strategies (i.e., submitting a shortened preference list that otherwise maintains the order of the true preferences). This emphasis arises for two reasons. First, truncation strategies are intuitively appealing and simple for agents to implement. Second, when evaluating an agent's profitable misrepresentation opportunities in the DA algorithm, it suffices to restrict attention to truncation strategies. In other words, misrepresenting one's true preferences in a manner other than truncation can do no better than what can be achieved via truncation (Roth and Peranson, 1999).

To make progress on this question, we first characterize the conditions under which a receiver *acting on her own* can secure a match that is no worse than her most preferred achievable partner.[4] Our proposition is a straightforward extension of a classic result: in markets with more than one stable matching, there will be an incentive for some receiver to truncate her preferences whenever all other agents report their preferences truthfully (Gale and Sotomayor, 1985). Although an agent's optimal truncation is a function of the profile of other agents' reported preferences, we show that no direct knowledge of the strategies of other agents is required. Rather, it merely suffices for other receivers to be constrained to truncation strategies to be able to calculate the best response. In general, the optimal truncation strategy will change if other receivers are allowed to play more general misrepresentation strategies since these strategies can substantially alter the set

[1] The algorithm was first introduced by Gale and Shapley (1962).

[2] Henceforth, DA algorithm.

[3] A matching is said to be stable if no agent prefers remaining unmatched to her current allocation and no pair of agents mutually prefer each other to their current allocations.

[4] Two individuals are said to be achievable for each other if they are paired at some stable matching.

of stable matchings. In those situations, it is possible to be optimally truncating with respect to the true preferences but sub-optimally truncating with respect to the reported preferences. While not breaking new ground, this result is methodologically important for our experimental design. It allows us to construct environments that maintain the key interactive features of matching markets while essentially reducing optimal truncation to a decision-theoretic problem.

Even after removing this aspect of strategic uncertainty, there are two practical difficulties that present themselves with respect to optimal truncation. First, an agent might be unable to identify the existence of a profitable opportunity to misrepresent her preferences. Second, an agent might over-truncate her preferences and remain unmatched (her worst possible outcome).[5] In a laboratory experiment, we investigate whether truncation depends on the magnitude of the potential monetary gains from truncation as well as the rank of the most preferred achievable partner in an agent's preferences. The first measure is important since it is only when a profitable opportunity exists that an agent has an incentive to truncate her preferences. The second measure is important since the rank of the most preferred achievable partner determines the likelihood of remaining unmatched by mistakenly over-truncating.

To mirror the theoretical conditions, the experiment is conducted in an environment with complete information about other agents' preferences. The proposing side of the market is automated to play its dominant strategy of truthful preference revelation. The experimental subjects play in the role of the receivers and they are restricted to either truth-telling or truncation strategies. Importantly, since we have removed the element of strategic uncertainty over other players' actions, the *only* risk associated with truncation in our environment comes from over-truncating. Our experiment tests whether agents truncate their preferences in situations that are the most conducive to truncation behavior.[6] Ideally, the simplicity of our environment would provide insight into the reasons why market participants choose to either behave straightforwardly or strategically.

We find truth-telling to be the most common strategy in our experimental markets: 56% (511/920) of submitted rank-order lists are identical to subjects' true preferences. We also find that truncation is not sensitive to considerations of profitability, but is sensitive to the rank of the most preferred achievable partner. This result is robust to alternative specifications. We consider this to be remarkable given the difficulty in identifying achievable match partners even in small markets.

Regarding aggregate outcomes, 88% (203/230) of our experimental markets culminate in stable outcomes. This is not only due to the fact that truth-telling is common, but also because

[5] Over-truncation refers to the situation where an agent truncates "too much" and leaves her most preferred achievable partner off her submitted rank-order list.

[6] Another factor that makes truncation more attractive in our experiment is the linearity in subject payoffs. In most applications, it is reasonable to expect a discontinuity in utility between matching with one's least preferred partner and remaining unmatched. If the risk of remaining unmatched is important in our environment, then it is likely to be even more important in field settings where remaining unmatched is very costly.

over-truncation is rare.[7] We also find that final outcomes are closer to the receiver-optimal stable matching than to the proposer-optimal stable matching. However, this result is not entirely surprising. Since strategic behavior has positive spillover effects in our environment, the receiver-optimal stable outcome can be attained when only a subset of agents truncates its preferences optimally.

A useful benchmark to measure the success of centralized matching clearinghouses is their ability to produce stable outcomes.[8] The hallmark of a stable matching mechanism is that, for any profile of reported preferences, it produces an outcome that is stable with respect to the reported preferences. However, understanding *which* stable outcome arises in markets with multiple stable outcomes is no less important than the question of *whether* a stable outcome arises. The issue of equilibrium selection has important welfare consequences since the interests of the two sides of the market are diametrically opposed on the question of which stable matching to implement.[9] This is a relevant consideration for policymakers, who may have reasons to favor the welfare of one side of the market over another when designing matching markets. In May 1997, for instance, the National Resident Matching Program (NRMP) switched from the hospital-proposing version of the DA algorithm to the student-proposing version over concerns that the original design unduly favored hospitals at the expense of students.

Empirically, it is also important to determine whether the DA mechanism approaches strategy-proofness in practice. By providing a level playing field for all participants, regardless of their institutional knowledge or strategic reasoning abilities, strategy-proof mechanisms can help assuage the concerns of market participants and promote market "thickness". If receivers generally play truth-telling strategies even in situations where there are gains from preference misrepresentation, then this fact could partially explain the success and persistence of the DA mechanism in the field.

Finally, our work highlights the complementarity between controlled laboratory experimentation and market design. In the field, data on submitted rank-order lists is often available but participants' underlying preferences are not observed. This makes the extent of strategic behavior difficult to estimate. By allowing us to directly control for subjects' preferences and other market features, the laboratory setting is ideally suited for answering questions related to both strategic behavior and equilibrium selection. Our results show that subjects respond to market features, but not necessarily in the ways suggested by theory. In particular, the finding that subjects respond to the riskiness of strategic behavior suggests that behavioral insights can play an important role in the field of market design.

There is a growing body of experimental work studying the performance of centralized matching

[7] Due to the constrained nature of our strategy space, over-truncation is the only way to observe instability in final outcomes.

[8] Mechanisms that produce unstable outcomes necessarily give some participants an incentive to seek out alternative match partners after the market closes. In fact, centralized clearinghouses based on unstable matching mechanisms often perform no better than the decentralized markets that they replace (Roth, 1991).

[9] This result is a consequence of the fact that the set of stable matchings is a lattice.

mechanisms in the lab. However, much of this experimental literature focuses on the DA algorithm as it relates to the school choice problem (e.g. Chen and Sönmez, 2006; Ding and Schotter; Featherstone and Niederle, 2014; Pais and Pintér, 2008). In these studies, strategic agents exist only on the proposing side of the market. There has been relatively little experimental work done on the strategies pursued by the *receiving* side of the market.[10] This is an important gap to fill: only the receivers in the DA algorithm face substantive strategic questions. In addition, their ability to behave strategically - either in isolation or as a group - can have large effects on market outcomes and participants' welfare.[11]

Our work is most closely related to Featherstone and Mayefsky (2014), which to the best of our knowledge is the only laboratory experiment studying the DA algorithm to automate the proposing side of the market in order to focus exclusively on the strategies pursued by the receiving side. They interpret "out-of-equilibrium truth-telling" as a reason for the success and persistence of the DA mechanism despite being manipulable in theory. However, our paper departs from their design in that we introduce a novel experimental framework with which to study truncation strategies. The advantage of our approach lies in the fact that, by studying a restricted version of the same problem, we have created an environment in which some form of truncation is always a best response. Although our work addresses the optimal truncation problem in a complete information environment, it can also be viewed in the same spirit as Roth and Rothblum (1999), which addresses the question of what practical advice can be given to market participants in the context of a centralized matching clearinghouse based on the DA algorithm. They show that any non-truncation strategy is stochastically dominated by a truncation strategy in symmetric, incomplete information environments.[12]

A critical question that remains is whether truncation behavior has theoretical or empirical relevance. While the literature on "core convergence" suggests that there is little scope for strategic misrepresentation in large markets (Immorlica and Mahdian, 2005; Kojima and Pathak, 2009; Lee, 2014), there are important qualifications to these results. Coles and Shorrer (2014), for instance, show that while the utility gain from optimal truncation may be small, the optimal degree of truncation can still remain quite large. In fact, when an agent has uniform beliefs regarding the reported preferences of others, the optimal truncation approaches 100% of her list as the size of the market grows.[13]

The paper is organized as follows. Section 2 provides theoretical background, Section 3 describes

[10] Existing studies, however, report high rates of truth-telling by receivers (Echenique, Wilson, and Yariv, 2014; Featherstone and Mayefsky, 2014; Harrison and McCabe, 1989).

[11] However, it should be noted that "core convergence" results for large matching markets imply that there is limited scope for strategic behavior in this context. We will return to this issue when discussing the implications of our main findings.

[12] Ehlers (2008) generalizes this result from deferred acceptance mechanisms to a much larger class of mechanisms.

[13] "Uniform beliefs" refers to the case where an agent believes that the reported preferences of others are chosen uniformly and randomly from the set of all possible full-length reported preference lists.

our experimental design, Section 4 presents results, and Section 5 discusses broader implications and concludes.

2 Theory

In this section, we introduce the theoretical framework that informs our experimental design. We first review some basic results from two-sided matching theory that are necessary for this purpose. For a more detailed survey, see Roth and Sotomayor (1992).[14] Consider two finite, disjoint sets M and W, where M is the set of men and W is the set of women. Each agent has complete and transitive preferences over the agents on the other side of the market (as well as remaining single). The preferences of man m will be represented by an ordered list of preferences $P(m)$ on the set $W \cup \{m\}$. Similarly, the preferences of woman w will be represented by an ordered list of preferences $P(w)$ on the set $M \cup \{w\}$. We write $w \succ_m w'$ to denote that m prefers w to w', and $w \succeq_m w'$ to denote that m likes w at least as much as w'. Similarly, we can write $m \succ_w m'$ and $m \succeq_w m'$. Woman w is said to be ***acceptable*** to man m if he likes her at least as much as remaining single (i.e., $w \succeq_m m$). Similarly, m is acceptable to w if $m \succeq_w w$.

Let $\mathbf{P}$ denote the set of all preferences, one for each man and one for each woman. A marriage market is denoted by the triplet $(M, W, \mathbf{P})$. A matching is a function $\mu : M \cup W \longrightarrow M \cup W$ such that

1. for any $m \in M$, $\mu(m) \in W \cup \{m\}$
2. for any $w \in W$, $\mu(w) \in M \cup \{w\}$
3. for any $m \in M$, $w \in W$, $\mu(m) = w$ if and only if $\mu(w) = m$

Throughout the analysis, we also distinguish between market-wide matchings (represented by μ) and a given individual's match partner. For woman w at the matching μ, her match partner is represented by $\mu(w)$. For each individual, their preference over two alternative matchings corresponds exactly to their preference over their match partners at the two matchings.

A matching μ is ***individually rational*** if every individual is matched to an acceptable partner. A pair of agents (m, w) is said to ***block*** a matching μ if they are not matched to one another at μ but they prefer each other to their assignments at μ (i.e., $w \succ_m \mu(m)$ and $m \succ_w \mu(w)$). A matching μ is ***stable*** if it is individually rational and not blocked by any pair of agents. A stable matching is called an ***M-optimal stable matching*** (denoted μ_M) if every man likes it at least as well as any other stable matching. A ***W-optimal stable matching*** can be defined analogously (denoted μ_W). The M-optimal stable matching is thus the "best" stable matching for the men and the W-optimal

[14] Proofs of most of the cited results can be found there.

stable matching is the "best" stable matching for the women. A man m and a woman w are said to be ***achievable*** for each other in a marriage market $(M, W, \mathbf{P})$ if they are matched to each other at some stable matching. For woman w, $\mu_W(w)$ is her most preferred achievable partner.

Gale and Shapley (1962) proved the following result:

Theorem 1: *A stable matching exists for every marriage market.*

In their constructive proof of the existence of stable matchings, Gale and Shapley (1962) developed a "deferred acceptance" procedure that produces one of the two extremal stable matchings for any preference profile. In their algorithm, the market is divided into two groups: "men" (proposers) and "women" (receivers). Initially, all the men and women are unmatched. The algorithm then goes through several stages where men and women take turns in making decisions. In a generic stage, each unmatched man makes an offer to his most preferred woman among the set of women that he has not previously made an offer to. Each woman then views all the offers she has received in that stage and tentatively accepts her most preferred offer among the new offers and any tentatively accepted offer that she is still holding from a previous stage. The algorithm ends when there are no men left to make offers. This can happen because (1) all men are matched or because (2) the only unmatched men have already been rejected by all of the women. The tentative matches that are in place when the algorithm ends become the final matches. This leads directly to the following result:

Theorem 2: *When all men and women have strict preferences, there always exist an M-optimal stable matching and a W-optimal stable matching. The matching produced by the deferred acceptance algorithm with men proposing is the M-optimal stable matching. The W-optimal stable matching is the matching produced by the algorithm when the women propose.*

A related result, often referred to as the "lone wolf" theorem, will prove useful later in our analysis:

Theorem 3: *In a market $(M, W, \boldsymbol{P})$ with strict preferences, the set of people who are single is the same for all stable matchings.*

To examine the strategic issues involved in two-sided matching markets, we analyze the preference-revelation game in which each man m with preferences $P(m)$ is faced with the strategy choice of what preference ordering $Q(m)$ to state, and likewise for the women. Denote the set of stated preference lists, one for each man and one for each woman, by $\mathbf{Q}$. The mechanism then computes a matching $\mu = h(\mathbf{Q})$, where h is the function that maps any set $\mathbf{Q}$ of stated preferences into a matching. A mechanism h that for any stated preferences $\mathbf{Q}$ produces a matching $h(\mathbf{Q})$ that is stable with respect to the stated preferences is called a stable mechanism. If $h(\mathbf{Q})$ produces the M-optimal stable matching with respect to $\mathbf{Q}$, then h is called the M-optimal stable mechanism. The next theorem highlights an important negative result:

Theorem 4: *No stable matching mechanism exists for which stating the true preferences is a dominant strategy for every agent.*

However, it is possible to arrange the market in such a way that only one side faces strategic questions. This is summarized by the following theorem:

Theorem 5: *The M-optimal stable mechanism makes it a dominant strategy for each man to state his true preferences.*

Combining these results suggests that, under the M-optimal stable mechanism, it is the women who will sometimes have a profitable deviation by misrepresenting their true preferences. This is formalized below:

Corollary 1: *When preferences are strict and the M-optimal stable mechanism is employed, there will be an incentive for some woman to misrepresent her preferences whenever more than one stable matching exists.*

Consider a marriage market characterized by $(M, W, \mathbf{P})$ in which preferences are strict and there is more than one stable matching. Let μ_M denote the M-optimal stable matching and μ_W denote the W-optimal stable matching under the true preferences $\mathbf{P}$. With slight abuse of notation, we denote the last man on the preference list $P(w)$ of woman w by $\underline{P}(w)$. Furthermore, we confine attention to markets in which each agent prefers being married to remaining single (all men are acceptable to all women and vice versa) and $|M| = |W|$. Without loss of generality, the theoretical results below are framed in terms of the incentives facing the women in the revelation game induced by the man-proposing deferred acceptance algorithm. A symmetric argument holds for men when the woman-proposing deferred acceptance algorithm is used.

We will find it useful to define two classes of strategies for the women in this market:

Definition 1: *A **truncation** of a preference list $P(w)$ containing k acceptable men is a list $P'(w)$ containing $k' \leq k$ acceptable men such that the k' elements of $P'(w)$ are the first k' elements of $P(w)$, in the same order.*

Definition 2: *A **manipulation** of a preference list $P(w)$ is any list that is not a truncation of $P(w)$.*

A truncation strategy involves misrepresenting your preferences by shortening the list of acceptable matches without changing their order. For convenience, we allow for truth-telling to trivially satisfy the definition of a truncation strategy. A manipulation strategy involves misrepresenting preferences by changing the order of preference between at least two men (regardless of the length of the list). We now define three particular types of truncation strategies that are central to our analysis:

Definition 3: *An **over-truncation** of a preference list $P(w)$ is a truncation of $P(w)$ that does not contain $\mu_W(w)$, the most preferred achievable partner of woman w.*

Definition 4: ***Optimal truncation*** *of a preference list $P(w)$ is a truncation of $P(w)$ that contains $\mu_W(w)$ but does not contain any men who are ranked below $\mu_W(w)$.*[15]

Definition 5: *An **under-truncation** of a preference list $P(w)$ is a truncation of $P(w)$ that contains $\mu_W(w)$ but also contains at least one man who is ranked below $\mu_W(w)$.*

By submitting a truncated preference list, an agent is effectively telling the mechanism to play a threshold strategy on her behalf (i.e., to reject all offers below a certain cutoff). With truncation, agents face a balance of risks: the likelihood of remaining unmatched increases, while conditional on matching the likelihood of being matched to a more favorable partner increases. The risks associated with truncation can arise from two sources: over-truncation and uncertainty regarding other agents' actions. This is a subtle point that deserves clarification. Optimal truncation requires an agent to possess a great deal of information on the preferences of other agents and the ability to calculate or otherwise identify her most preferred achievable partner. A mistake in this calculation could result in over-truncation. If an agent over-truncates, then this opens up the possibility of remaining unmatched.[16]

However, even if an agent is able to correctly identify her most preferred achievable partner and then truncate optimally, it is still possible for her to remain unmatched depending on the actions of other agents. If other agents distort their preferences in a manner that changes the set of stable

[15] To be clear, it is still possible for an agent to achieve the optimal equilibrium result (being matched to her most preferred achievable partner) without optimal truncation. However, it is convenient to define optimal truncation in this manner.

[16] An agent who over-truncates is hurting herself but is also helping the other agents on her side of the market. Thus, even with over-truncation, it is possible for an agent to be matched if at least one other agent over-truncates.

outcomes, then it is possible for a particular woman to be optimally truncating with respect to the *true* preferences but over-truncating with respect to the *stated* preferences. This naturally leads to the question of what restrictions need to be placed on other agents' strategies to prevent this from happening.

In the context of the man-proposing deferred acceptance algorithm, we can now state and prove the following results:

Proposition 1. *Consider a marriage market in which preferences are strict and there is more than one stable matching. Suppose that $|M| = |W|$ and all men are acceptable to all women (and vice versa). Let $\boldsymbol{Q}$ be a profile of stated preferences in which each man states his true preferences, and each woman w states a list $Q(w)$ that constitutes a truncation of $P(w)$ but not an over-truncation. Then the following statements are true:*

1. *No woman w will remain single.*

   Proof. See Appendix A. □

2. *The set of stable matchings under $\boldsymbol{Q}$ is a subset of the set of stable matchings under $\boldsymbol{P}$.*

   Proof. See Appendix A. □

3. *Each woman w can truncate in such a way as to be matched to $\mu_W(w)$, her most preferred achievable partner under the true preferences $\boldsymbol{P}$.*

   Proof. See Appendix A. □

If we do not restrict attention to Nash equilibrium strategy profiles (and hence permit outcomes that are unstable with respect to the agents' true preferences), we can make an even stronger statement regarding the conditions under which it is advisable for an individual agent to play a truncation strategy. This is formalized in the following proposition:

Proposition 2. *Consider a marriage market in which preferences are strict and there is more than one stable matching. Suppose that $|M| = |W|$ and all men are acceptable to all women (and vice versa). Let $\boldsymbol{Q}$ be a set of preferences in which each man states his true preferences, and each woman in $W \setminus \{w\}$ states a list that is not a manipulation of her true preferences. Then woman w can truncate her preference list in such a way as to be matched to a man she likes at least as much as $\mu_W(w)$, her most preferred achievable partner under the true preferences $\boldsymbol{P}$.*[17]

Proof. See Appendix A. □

[17] This proposition is a straightforward extension of a result from Gale and Sotomayor (1985).

An alternative characterization of Proposition 2 is as a dominant-strategy result for a modified matching game with a pruned strategy space. Suppose a woman found herself playing the preference-revelation game induced by the man-proposing DA algorithm. Suppose further that the woman knew the identity of her most preferred achievable partner. Would it be advisable for this woman to truncate her preferences by leaving off all men ranked below her most preferred achievable partner? In general, the answer to this question would depend on the woman's risk attitudes and beliefs about other agents' actions. However, Proposition 2 provides the conditions on other players' strategies such that the answer to this question is unambiguously yes.

Proposition 2 is at the heart of our experimental design. Our environment contains automated, truthful proposers and also constrains the set of strategies that are available to receivers. This approximation of a decision-theoretic setting allows us to conveniently test for truncation behavior without worrying about the need to coordinate behavior with other agents and the heterogeneity of beliefs over other agents' actions. As detailed in the next section, our experimental design systematically manipulates the profitability of truncation (i.e., the magnitude of the monetary gain from truncation) and the riskiness of truncation (i.e., the likelihood of over-truncation).

There are two points worth emphasizing. First, we should only expect *behavioral* agents to be responsive to the magnitude of the monetary gain from truncation and the likelihood of over-truncation. Sophisticated agents who have the ability to calculate the set of stable outcomes should only be responsive to the *existence* of a profitable strategic opportunity: they should (optimally) truncate their preferences only if they have more than one achievable partner. Second, these features that we identify are only relevant under the conditions imposed in our experiment. If an agent faces strategic uncertainty about the actions of other agents, then these notions lose much of their value. For instance, it could be the case that an agent is optimally truncating with respect to the true preferences but over-truncating with respect to the stated preferences.

In the context of our experiment, we can now cast the following hypotheses:

Hypothesis 1: *Truncation behavior will be increasing in the profitability of truncation.*

Hypothesis 2: *Truncation behavior will be decreasing in the riskiness of truncation.*

3 Experimental Design

In the experiment, the two sides of the market are labeled "firms" (proposers) and "workers" (receivers). Each experimental market consists of four subjects. Each experimental session contains either one or two parallel experimental markets (thus each session consists of either four or eight subjects). The roles of the firms are automated: they are programmed to play their dominant strategy of truth-telling. Fixing the behavior of firms in this fashion is necessary in order to test our main proposition. Each subject is randomly assigned to the role of one of the four workers. Their assigned role remains the same throughout the experiment.

Upon arriving at the lab, subjects read and sign an informed consent document. The experimenter then reads aloud the experimental instructions.[18] Before the experiment begins, each subject is required to work through a demonstration of the DA algorithm and answer relevant questions. We use a hypothetical set of reported preferences that includes examples of both truth-telling and truncation. To secure comprehension, we do not proceed with the actual experiment until all the subjects complete the demonstration and answer the questions correctly. The relevant screen shots from the demonstration are included in Appendix B.

Subjects play 10 rounds of the preference-revelation game induced by the firm-proposing DA algorithm. In each round, subjects observe the payments that they (and the other subjects) will receive from matching with the different firms. They also observe the order in which the firms will be making offers to match with the workers in the DA algorithm. The action that subjects take in each round is to choose which message (i.e., ranking of the firms) to submit to the computer to be used in the matching process.[19] Subjects are required to spend a minimum of three minutes on this task in each round: if all subjects are done sooner than that, they still have to wait until the full three minutes have elapsed. A representative screen that subjects face during the experiment is shown in Figure 1.

At the end of each round, subjects are informed of the identity of their match partner and their payoff for that round. While each subject's role remains the same throughout the 10 rounds, each round corresponds to a different matching market (i.e., the agents are endowed with a different set of preferences). The particular preference profiles used in the experiment are included in Appendix C. At the end of the experiment, 1 of the 10 rounds is randomly selected and subjects are paid based on their match partners in that round (in addition to a fixed \$5 show-up payment).[20] Matched subjects earn anywhere from \$5 to \$20 in increments of \$5 (depending on whether they matched with their most preferred, second most preferred, third most preferred, or least preferred firm). Unmatched subjects earn \$0 for that round.

Proposition 2 establishes the optimality of truncation when other workers refrain from manipulating their preferences (i.e., they do not switch their order of preference between firms). In that sense, strategic behavior in the context of the DA algorithm can be viewed as a coordination

[18] The full set of instructions is included after the appendices.

[19] Importantly, the terminology of "preferences" is never used in the experimental instructions or the experimental interface. Subjects' true preferences are referred to as payments and subjects' reported preferences are referred to as submitted messages or rankings. This caution was taken to reduce experimenter demand effects.

[20] The choice of payment procedure is still an open question in the field of experimental economics. Advantages and disadvantages of competing approaches, and the theoretical conditions under which they can be justified, are discussed in Azrieli, Chambers, and Healy (2014).

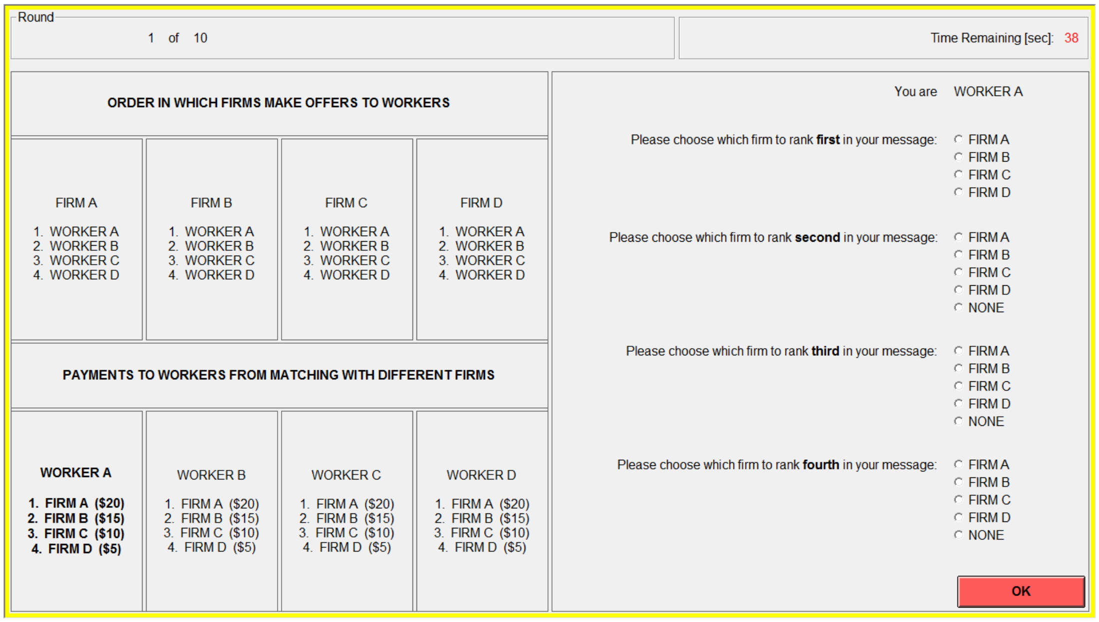

Figure 1: An example of our experimental interface. This is the screen that WORKER A observes in Round 1 of the experiment.

problem: a worker can best-respond by truncating her preferences only if other workers are also truncating (or truth-telling). In our experiment, we solve this coordination problem by restricting subjects to either truth-telling or truncation. Thus, in our 4x4 experimental markets, each subject has four pure strategies. Their decision problem consists of choosing the length of their submitted rank-order list.[21] Subjects who attempted to submit a manipulation of their preferences or who left an empty position in the middle of their rank-order list received appropriate error messages on their screens.

However, even controlling for the behavior of other agents, optimal truncation is still a practical challenge. For an agent to optimally truncate, it requires (1) the ability to identify the existence of a profitable strategic opportunity and (2) the ability to identify her most preferred achievable partner. Having controlled for other agents' behavior, the *only* risk associated with truncation in our experiment is the possibility of over-truncation (which could result in remaining unmatched). We use a within-subject experimental design to investigate whether truncation behavior is correlated with the profitability and riskiness of truncation.

By **profitability**, we refer to the ordinal distance between a worker's most preferred and least preferred achievable firms in her preference list (i.e., the span of the core).[22] If a worker has a unique

[21]The same number of mouse clicks was required to submit a rank-order list, regardless of length. This was done to ensure that subjects do not perceive truncation to be (marginally) more convenient or easier than truth-telling.

[22]This measure is distinct from the number of achievable partners that an agent has. Rather, it can be thought of as a measure of the potential monetary gain from optimal truncation compared to truth-telling.

	risky	not risky
not profitable	$P(w) = f_2, f_4, f_1, f_3{}^*$	$P(w) = f_2{}^*, f_4, f_1, f_3$
profitable	$P(w) = f_2, f_4{}^*, f_1{}^*, f_3$	$P(w) = f_2{}^*, f_4{}^*, f_1{}^*, f_3{}^*$

Table 1: Our within-subject experimental design varies the strategic incentives that subjects face in terms of the profitability and riskiness of truncation.

achievable firm, then truncation can do no better - and in fact can do worse - than truth-telling. If a worker has multiple achievable firms, then her optimal strategy is to submit a truncation of her true preferences by leaving off all firms that are ranked below her most preferred achievable firm.[23]

By **riskiness**, we refer to the ranking of a worker's most preferred achievable firm in her preference list. If a worker's most preferred achievable firm coincides with her most preferred firm overall, then there is no possibility of mistakenly over-truncating. On the other hand, if a worker's most preferred achievable firm coincides with her least preferred firm overall, then *any* truncation is an over-truncation and carries with it the possibility of remaining unmatched.

Table 1 illustrates how our within-subject experimental design systematically varies the profitability and riskiness of truncation. Note that the worker's achievable firms are denoted by asterisks (*) in her preference list. In the top left box of Table 1, it is both unprofitable and risky for worker w to submit a truncation of her true preferences. There is a unique achievable firm (so there is no benefit to misrepresenting preferences) and furthermore *any* truncation will be an over-truncation. In the bottom right box of Table 1, it is both profitable and risk-less for worker w to truncate her preferences. By truth-telling, worker w will be matched to firm f_3, but by optimally truncating her preferences worker w will be matched to firm f_2.[24] Since her most preferred achievable firm is also her most preferred firm overall, there is no chance of mistakenly over-truncating and remaining unmatched.

For convenience, we define indices for profitability and riskiness that we refer to throughout the remaining analysis. We measure the profitability of truncation on an integer scale from 0-3, representing the ordinal distance between an agent's most preferred and least preferred achievable partners in her preference list. For a worker with a unique achievable firm, the profitability of truncation is thus coded as a "0". Similarly, we measure the riskiness of truncation on an integer scale from 1-4, representing the ranking of an agent's most preferred achievable partner in her preference list. For a worker whose most preferred achievable firm coincides with her most preferred firm overall, there is no possibility of over-truncation and the riskiness of truncation is coded as a "1".

[23] In fact, any truncation that does not include a worker's second most preferred achievable firm will yield the same result. Thus, there is no unique optimal truncation strategy in certain markets.

[24] These statements assume that all other workers submit their true preferences. If other workers are truncating, this can sometimes result in worker w being matched to a more favorable partner than f_3 even if she behaves truthfully. In other words, truncation behavior in this environment has positive externalities.

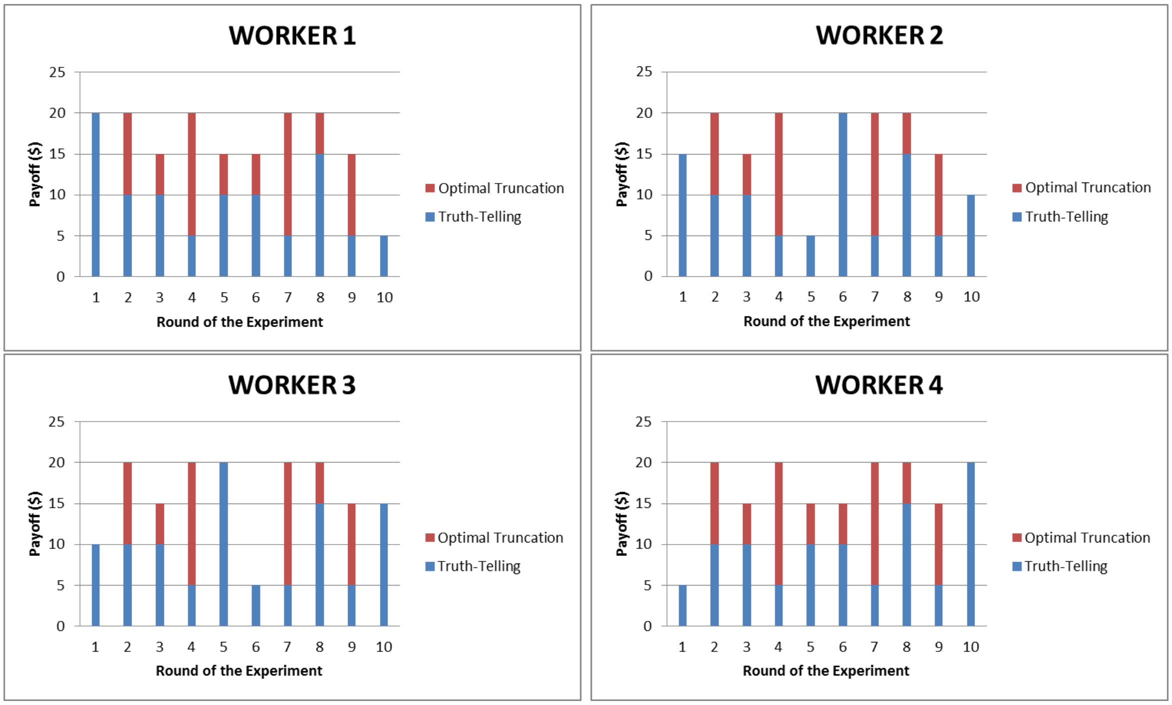

Figure 2: The payoff difference between truth-telling and optimal truncation across rounds of the experiment.

Another characterization of profitability is given in Figure 2, which presents the payoff difference between truth-telling and optimal truncation across all experimental rounds. This difference is calculated under the assumption of truthful reporting by all other subjects. However, calculating the optimal truncation strategy is a difficult problem. It is natural to ask how profitability is perceived by a naive agent who chooses a truncation level (corresponding to a "cut point" in her preferences) and plays it consistently throughout all experimental rounds. Appendix D shows the expected payoffs in the experiment for this hypothetical subject in different roles.[25] Even for a subject who does not optimally best-respond, the strategic tension is apparent: on average, truncation will increase a subject's payoff up until the most extreme truncation strategy. Thus, our experimental design allows for significant amounts of truncation to be profitable and for the gains from truncation to be realized by naive agents.

Clearly, the measures that we use for profitability and riskiness are correlated. In fact, approximately 31% of the variability in the profitability index is shared with the riskiness index in our experimental markets. When discussing the results, we will use regression analysis to tease out the effects of the variables in isolation. However, a strength of our experimental design lies in the fact that profitable and risk-less opportunities for truncation are not clustered near the beginning nor

[25] As before, the expected payoff is calculated under the assumption of truthful reporting by all other subjects.

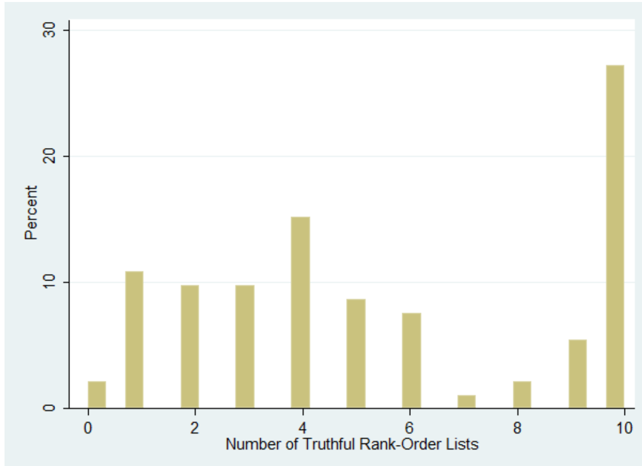

Figure 3: Distribution of the number of truthful reports.

end of the experiment, but rather are spread uniformly throughout. Appendix D lists key features of the markets in the order that they are presented to subjects.

Experiment Implementation

The experimental sessions were conducted from June-October 2014 at the ICES Experimental Economics Laboratory of George Mason University. A total of 92 subjects participated in the experiment. Experimental subjects were recruited via email from a pool of George Mason University undergraduates who had all previously registered to receive invitations for experiments. Each experimental session lasted approximately 90 minutes. Subject payments ranged from \$5 to \$25 (including a \$5 show-up payment). The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007).

4 Experimental Results

The rest of this section proceeds as follows. We begin by analyzing individual behavior, and then move on to market-level outcomes.

Individual Behavior

We first analyze the basic decision of whether to report preferences truthfully or to behave strategically (i.e., truncate preferences). We find that truth-telling is common in our experimental markets: 56% (511/920) of submitted rank-order lists coincide with agents' true preferences. Since subjects have four pure strategies, uniformly random behavior would imply a truth-telling rate of 25%. We find that truth-telling occurs significantly more often than random chance would predict ($\chi^2(1) =$

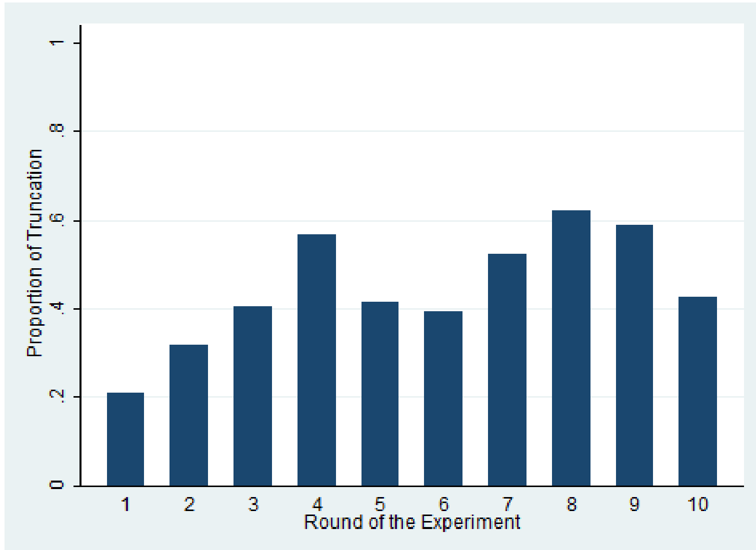

Figure 4: Truncation rates across the rounds of the experiment.

457.740, p-value < 0.001). Each individual subject submits a total of 10 rank-order lists throughout the experiment (one for each experimental round). Figure 3 shows the distribution of the number of truthful rank-order lists in our experimental data. Twenty-seven percent (25/92) of subjects consistently reported their true preferences; the remaining subjects truncated their preferences in at least one round.

A natural question that emerges from this analysis is whether subjects become more strategic with market experience. Figure 4 shows truncation rates across the rounds of the experiment. We use an extension of the Wilcoxon rank-sum test to non-parametrically test for any trend in truncation rates across experimental rounds. We find that truncation rates systematically increase across the rounds of the experiment ($z = 5.090$, p-value < 0.001).[26]

Tables 2 and 3 show a more detailed breakdown of the strategies found in our experimental data. Table 2 shows the breakdown according to the length of the submitted rank-order list (i.e., how many firms were included in the ranking), while Table 3 shows the breakdown according to the degree of truncation (i.e., over-truncation, optimal truncation, and under-truncation). For this latter purpose, it is convenient to classify *all* strategies as either over-truncation, optimal truncation, or under-truncation.[27] In both tables, we include the distribution of strategies derived from random behavior (i.e., if subjects were to randomize uniformly among their four pure strategies) alongside the distribution from our experimental data. When comparing the empirical distribution with the

[26] It should be noted that the incentive to truncate does not exist in all experimental rounds. However, this result is unchanged when we confine attention to cases where the span of the core is non-zero ($z = 4.270$, p-value < 0.001).

[27] If an agent's unique achievable partner is ranked last in her preferences, then truth-telling qualifies as optimal truncation. In all other cases, truth-telling constitutes under-truncation.

	Frequency	Percent	Random Percent
1 Firm	99	10.76	25.00
2 Firms	165	17.93	25.00
3 Firms	145	15.76	25.00
4 Firms	511	55.54	25.00
Total	920	100	100

Table 2: Distribution of subjects' strategies (based on the length of the submitted rank-order list). The distributions from both the experimental data and derived from uniformly random behavior are included.

	Frequency	Percent	Random Percent
Over-Truncation	30	3.26	18.75
Optimal Truncation	247	26.85	25.00
Under-Truncation	643	69.89	56.25
Total	920	100	100

Table 3: Distribution of subjects' strategies (based on the degree of truncation). The distributions from both the experimental data and derived from uniformly random behavior are included.

random distribution, we find a significant difference for both cases (Table 2: $\chi^2(3) = 467.7$, p-value < 0.001; Table 3: $\chi^2(2) = 149.410$, p-value < 0.001). The entire difference comes from experimental subjects behaving more conservatively: the rate of the most extreme truncation strategy (only one ranked firm) is 57% less than random behavior would dictate and the rate of over-truncation is 83% less than random behavior would dictate.

We now examine whether strategic behavior is sensitive to considerations of profitability and riskiness. For the remainder of our analysis, we differentiate truncation from truth-telling. In other words, a truncation is observed whenever an agent's submitted rank-order list contains strictly less than four firms. Figure 5 shows the proportions of truncation in varying environments of profitability and riskiness.[28] We find that there is a statistically significant relationship between truncation and both measures (profitability: $\chi^2(3) = 23.025$, p-value < 0.001; riskiness: $\chi^2(3) = 45.876$, p-value < 0.001). Furthermore, non-parametric trend tests show that truncation is increasing in profitability and decreasing in riskiness (profitability: p-value < 0.001; safety: p-value < 0.001).

We estimate an OLS regression model of a dummy variable for truncation on relevant market features: the index for profitability (0-3), the index for riskiness (1-4), and the round of the experiment (1-10).[29] We find that the riskiness of truncation and market experience are the only significant predictors of truncation. In particular, moving the most preferred achievable firm down

[28]Since profitability and riskiness are correlated, a more illuminating 3-D graph of the sensitivity of truncation to strategic incentives is shown in Appendix D. The "holes" in the graph to the right of the main diagonal correspond to profitability-riskiness ordered pairs that are impossible to construct in 4x4 matching markets.

[29]The OLS regression results are shown in Table 4. By using individual-specific fixed effects, our estimation rules out the effects of "naive" truncators who are playing identical strategies in each round.

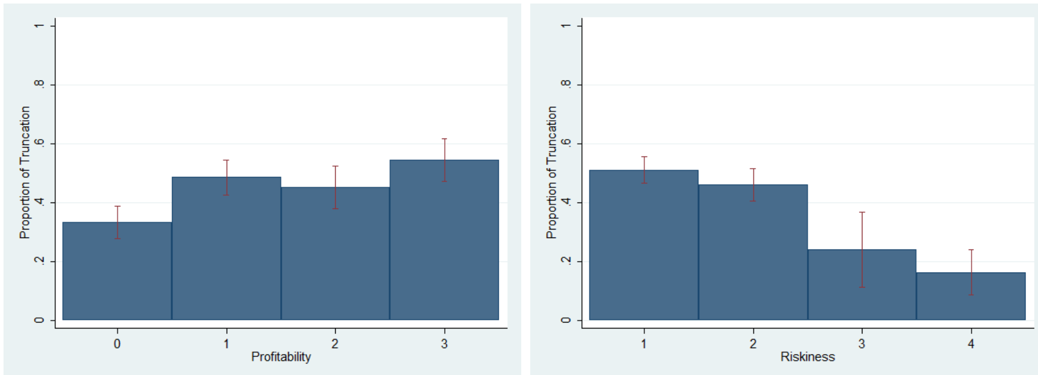

Figure 5: Proportion of truncation according to the profitability and riskiness of truncation.

one rank in preference decreases the probability of truncation by 0.11 and an additional round of market experience increases the probability of truncation by 0.3. We also estimate probit and conditional logit regression models of the dummy variable for truncation on the same set of regressors.[30] The main results remain unchanged. The coefficient estimates for both the riskiness of truncation and the round of the experiment are still significant in the directions predicted by theory.

We conduct several checks for the robustness of our results. First, we replace our index for profitability with a dummy variable for situations where truncation is profitable (i.e., whenever an agent has more than one achievable partner). Even if agents are not responsive to the magnitude of the monetary gains from truncation, it is possible that they are responsive to the *existence* of a profitable strategic opportunity. We find that profitability measured in this manner is also not significant at conventional levels.

Second, we add an "average rank" variable to the regressions. For a particular worker in a given market, average rank is defined as the average of the ordinal position of that worker in the firms' preference lists. Thus, average rank would be "1" for a worker who is ranked first by all of the firms and "4" for a worker who is ranked last by all of the firms. Since determining the riskiness of truncation according to our measure requires that a worker have knowledge of the identity of her most preferred achievable firm, average rank has appeal as a plausible heuristic that agents might instead use in this setting. We find that the coefficient estimate on average rank is only significant for the OLS regression specification. However, the significance of riskiness as a predictor of truncation behavior still remains.

We also explore the possibility of an alternative heuristic. If a worker is ranked first by a particular firm, then the worker can secure that match as a lower bound by including the firm in her reported preference list. This implies that if a worker is ranked first by one of her top

[30]The probit and conditional logit regression results are included in Appendix D.

VARIABLES	(1) Truncation	(2) Truncation	(3) Truncation	(4) Truncation
Profitability	0.00728		0.0251	0.00370
	(0.0125)		(0.0158)	(0.0165)
More than one achievable partner		0.0362		
		(0.0334)		
Riskiness	-0.110***	-0.105***	-0.0722***	-0.115***
	(0.0155)	(0.0157)	(0.0225)	(0.0222)
Average rank in firms' preferences			-0.0485*	
			(0.0274)	
Ranked first by top three				-0.0121
				(0.0369)
Round of the experiment	0.0304***	0.0303***	0.0299***	0.0299***
	(0.00576)	(0.00578)	(0.00571)	(0.00546)
Constant	0.460***	0.437***	0.495***	0.481***
	(0.0435)	(0.0464)	(0.0484)	(0.0686)
Observations	920	920	920	920
Number of individuals	92	92	92	92

Robust standard errors are shown in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: The table reports results from OLS regressions with individual-specific fixed effects.

three firms, then it is safe to exclude her least preferred firm from her reported preference list. To test whether this line of reasoning is predictive of truncation in our experimental data, we add a dummy variable for whether a worker is ranked first by one of her top three firms. For all regression specifications, the coefficient estimate on this dummy variable is not significant while the significance of our riskiness measure remains.

Finally, we investigate whether the degree of truncation is responsive to the strategic incentives that we identify. For this purpose, we estimate an ordered logit regression model of the number of firms included in an agent's submitted rank-order list on the same set of regressors.[31] We find that the round of the experiment and the rank of the most preferred achievable firm matter once again. Surprisingly, we now also have that increasing the monetary gains from truncation makes subjects slightly more likely to lengthen their submitted rank-order lists. This finding is the opposite of what theory predicts. However, the significance of profitability disappears both when average rank is included in the regression and when our index for profitability is replaced with a dummy variable. The other findings remain unchanged in these alternative specifications.

[31] Results from the ordered logit regression are shown in Table 5. We exclude the dummy variable for whether a worker is ranked first by one of her top three choices since that line of reasoning would not capture any truncation beyond the fourth choice.

Dependent Variable: Number of Firms in Submitted List VARIABLES	(1)	(2)	(3)
Profitability	0.130**		0.0870
	(0.0543)		(0.0682)
More than one achievable partner		0.117	
		(0.164)	
Riskiness	0.736***	0.671***	0.647***
	(0.0965)	(0.0918)	(0.124)
Average rank in firms' preferences			0.126
			(0.139)
Round of the experiment	-0.160***	-0.159***	-0.159***
	(0.0252)	(0.0250)	(0.0251)
Observations	920	920	920

Standard errors are shown in parentheses and are clustered at the individual level.
*** p<0.01, ** p<0.05, * p<0.1

Table 5: The table reports results from ordered logit regressions.

Aggregate Outcomes

Stability is the norm in our experimental markets: 88% (203/230) of final outcomes are stable. Assuming uniformly random behavior by subjects, only 51% of final outcomes are expected to be stable. The high incidence of stability in our data is due to the fact that over-truncation is the only way to observe instability. As shown earlier, over-truncation is rare in our experiment. Three percent (30/920) of submitted preference lists constitute over-truncation and this occurs in 27 of the 230 markets. Table 6 shows a more detailed distribution of the stability of final outcomes. The worker-optimal stable matching arose in 24% (56/230) of markets, suggesting a limited ability on the part of our experimental subjects to play the "right" kind of truncation strategy.

To make welfare statements about the two sides of the market, we need a meaningful way to measure the "distance" from an observed outcome in our experimental data to a particular stable outcome. To that end, we first define a metric for the space of all matchings. Let $\mathcal{M}$ denote the set of all matchings and let W denote the set of all workers. Consider an arbitrary matching $\mu \in \mathcal{M}$ and an arbitrary worker $w \in W$. Define $F(\mu(w))$ as the position of $\mu(w)$ in the ordinal preference list of worker w. If w is matched to her most preferred firm at μ, then $F(\mu(w)) = 1$. If w is matched to her least preferred firm at μ, then $F(\mu(w)) = 4$. For simplicity, if w is unmatched we let $F(\mu(w)) = F(w) = 5$. Thus, $|F(\mu(w)) - F(\mu'(w))|$ is the absolute distance in ranking between $\mu(w)$ and $\mu'(w)$ according to the preferences of worker w. We can then define the distance from μ to μ' as the sum of this measure for all the workers in the market. More formally, the distance $d : \mathcal{M} \times \mathcal{M} \longrightarrow \Re_+$ between two matchings μ and μ' is defined

	Frequency	Percent
Firm-Optimal Stable	48	20.87
Worker-Optimal Stable	56	24.35
Intermediate Stable	60	26.09
Unique Stable	39	16.96
Unstable	27	11.74
Total	230	100

Table 6: Distribution of final outcomes.

as $d(\mu, \mu') = \sum_{w \in W} |F(\mu(w)) - F(\mu'(w))|$. Intuitively, we are defining the distance between two outcomes as the sum of the absolute distance between each worker's match partners at those outcomes (according to the worker's ordinal preferences).

Figure 6 shows the distances to the worker-optimal and firm-optimal stable matchings across all experimental markets. According to our metric, the average distance to the worker-optimal stable matching is 2.16 and the average distance to the firm-optimal stable matching is 3.42. We find that final outcomes are significantly closer to the worker-optimal stable matching than to the firm-optimal stable matching (one-sided t-test, p-value < 0.001). However, this result should be interpreted with caution: it is *not* due to the fact that a majority of agents optimally truncates its preferences. In this context, truncation behavior has positive externalities: non-strategic agents can benefit from other agents' truncation behavior. Thus, the worker-optimal stable matching can be observed if even a small subset of agents optimally truncates its preferences.

5 Discussion and Conclusion

The paper investigates the ability of agents to strategically misrepresent their preferences in two-sided matching markets. We use a controlled laboratory experiment that allows us to construct environments that are conducive to truncation behavior. We find that subjects do not truncate their preferences more often when it is profitable to do so. They do, however, truncate less often when it is dangerous (i.e., when there is a risk of "over-truncating" and remaining unmatched).

Our results suggest that agents in matching markets may respond to strategic incentives, but not necessarily in the ways that are predicted by theory. In particular, this implies that eliminating profitable opportunities for strategic behavior might not be sufficient to induce participants to reveal their true preferences. In other words, just as agents can fail to recognize profitable strategic opportunities, they can also fail to recognize the *lack* of profitable strategic opportunities.[32] Our work also highlights the importance of understanding behavioral biases and heuristics when designing matching markets. In fact, for the proposing side of the market, it has been shown that

[32] Relatedly, there is evidence that proposers also misunderstand the incentives in the DA algorithm and engage in suboptimal behavior (Echenique et al., 2014; Rees-Jones, 2014).

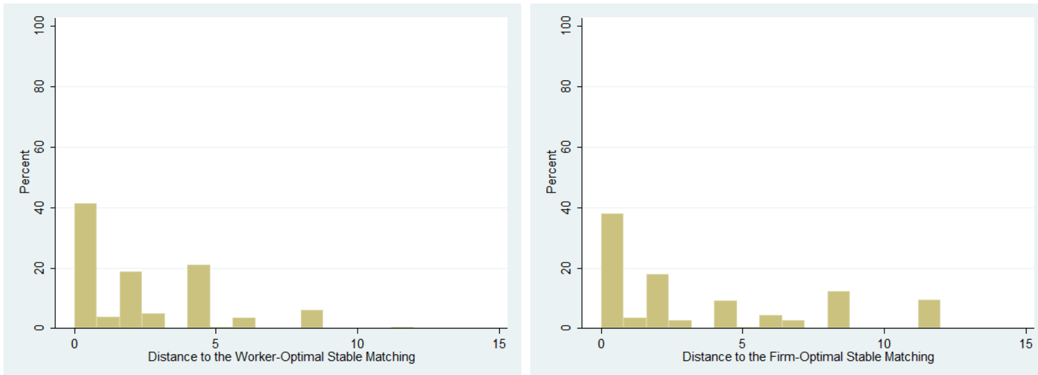

Figure 6: Distributions of the distances to the worker-optimal and firm-optimal stable matchings.

the DA algorithm already possesses protective features that bound the losses of agents who behave sub-optimally (Rees-Jones, 2014). However, more work needs to be done to understand the extent to which this tolerance of behavioral faults applies to the receivers in the DA algorithm.

An open question remains as to the efficacy of strategic behavior in this context. We argue that the ability of agents to engage in strategic behavior is important because it affects equilibrium selection - and hence welfare - in these environments. However, there is both computational and theoretical evidence suggesting otherwise. In May 1997, the NRMP transitioned from the hospital-proposing version of the DA algorithm to the student-proposing version. When analyzing the data from the NRMP transition, it has been shown that very few participants would have received different matches from the two algorithms. This has been cited as evidence of the fact that the set of stable matchings is small (Roth and Peranson, 1999).[33] As a consequence, it is argued that there is little room for strategic misrepresentation of preferences in this environment.

However, the comparison of match outcomes in the NRMP transition is based on agents' submitted rank-order lists and not on their underlying preferences. If the students were optimally truncating their preferences in the original NRMP, then reversing the roles in the DA algorithm (with the same set of reported preferences) would still produce the student-optimal stable outcome. Moreover, there is evidence suggesting that the submitted rank-order lists differ substantially from the underlying preferences. Echenique et al. (2014) note the high incidence of matches between residents and their top-ranked hospitals. This suggests that either preferences have a strong negative correlation in this market, or more likely that the stated preferences are different from the true preferences. Thus, the span of the core might be small for the stated preferences but not for

[33] In a field setting such as the NRMP, the set of stable matchings can plausibly be small for several reasons. First, there might be a high degree of positive correlation in agents' preferences. In the extreme case of perfect correlation, there is a unique stable matching. Second, there are practical limits on the number of interviews that can be conducted between hospitals and medical students. This restriction is at the heart of many of the "core convergence" results.

the true preferences.

Even if the theoretical incentives to behave strategically vanish in larger markets (Immorlica and Mahdian, 2005; Kojima and Pathak, 2009; Lee, 2014), survey data from the field suggests that strategic behavior still persists. In March 2014, the NRMP surveyed the directors of all programs participating in the residency match.[34] Across all specialties, the average number of applicants interviewed was 96 and the average number of applicants ranked was 77. It should be noted that this is merely suggestive of truncation and not definitive evidence. It is quite plausible that in many of these instances, the residency programs would genuinely prefer to leave a positon vacant rather than hire a low-quality applicant. The 2013 NRMP Applicant Survey is more conclusive. When asked about different strategies used in creating their rank-order lists, 29% of US senior applicants and 53% of independent applicants answered no to the claim "I ranked all programs that I was willing to attend."[35] This is particularly surprising since the students have a dominant strategy of truth-telling in this environment.

The evidence from the field has natural analogues to our experimental data. The fact that a non-trivial proportion of medical students admit to strategic considerations speaks again to the idea that agents might be misrepresenting their preferences even in environments in which it is unprofitable to do so. Similarly, our finding that subjects take into account the riskiness of truncation suggests that submitted NRMP lists should be shorter on average for top-ranked residency programs.

Our results also suggest natural directions for future work. We have shown that truncation behavior has the flavor of a coordination game: optimal truncation can essentially be reduced to a decision-theoretic problem only if other agents are also truncating. In our experiment, we overcome the need for coordination by exogenously imposing a constraint on the strategy space and making the constraint common knowledge. It would be worthwhile to investigate whether agents can endogenously coordinate on truncation strategies in an unconstrained environment and also whether their truncation behavior depends on the size of the market. In addition to the benefit of increased ecological validity, this environment also allows for a more direct test of the empirical content of truncation strategies.

[34]The results of the 2014 NRMP Program Director Survey can be found here: http://www.nrmp.org/wp-content/uploads/2014/09/PD-Survey-Report-2014.pdf

[35]The results of the 2013 NRMP Applicant Survey can be found here: http://www.nrmp.org/wp-content/uploads/2013/08/applicantresultsbyspecialty2013.pdf

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Appendix A: Proofs

Proof of Proposition 1(a): Consider μ_W, the W-optimal stable matching with respect to the true preferences $\mathbf{P}$. At μ_W, woman w is matched to $\mu_W(w) \in M$.[36] Clearly the matching μ_W is still individually rational under $\mathbf{Q}$.[37] Also, the matching μ_W still admits no blocking pairs under $\mathbf{Q}$ since there are now fewer possible blocking pairs. Thus, μ_W is stable with respect to the stated preferences $\mathbf{Q}$. We can conclude from Theorem 3 that w must be matched at all stable matchings with respect to the stated preferences $\mathbf{Q}$. Since the man-proposing deferred acceptance algorithm produces the M-optimal stable matching with respect to $\mathbf{Q}$, w is matched by the algorithm.

Proof of Proposition 1(b): Suppose that μ is a stable matching with respect to the stated preferences $\mathbf{Q}$. Then μ is individually rational and not blocked by any pair of agents under $\mathbf{Q}$. Clearly, the construction of the preference profile $\mathbf{P}$ does not create any new blocking opportunities. To see this, note that for each man m added to $Q(w)$ in order to construct $P(w)$, we have that $\mu(w) \succ_w m$.[38] Thus, μ is also a stable matching with respect to the true preferences $\mathbf{P}$.

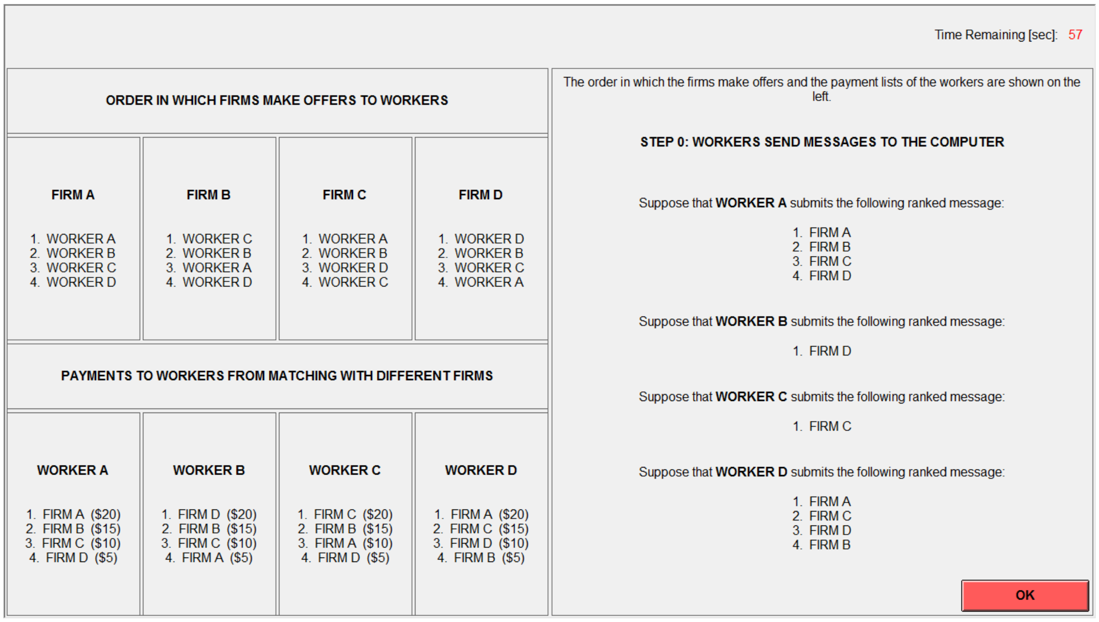
Proof of Proposition 1(c): Let $\underline{Q}(w) = \mu_W(w)$. Denote by μ'_M the M-optimal stable matching with respect to the submitted preferences $\mathbf{Q}$. By Proposition 1(a), we know that woman w will not be single at μ'_M. Thus, w has to be matched to a man she likes at least as much as $\mu_W(w)$. Suppose that w is matched to a man she strictly prefers to $\mu_W(w)$. Denote this man by m. By Proposition 1(b), we know that μ'_M is also stable with respect to the true preferences $\mathbf{P}$. Thus, m is achievable for w and $m \succ_w \mu_W(w)$. We have now arrived at a contradiction since $\mu_W(w)$ is the most preferred achievable mate of w. Therefore, w must be matched to $\mu_W(w)$.

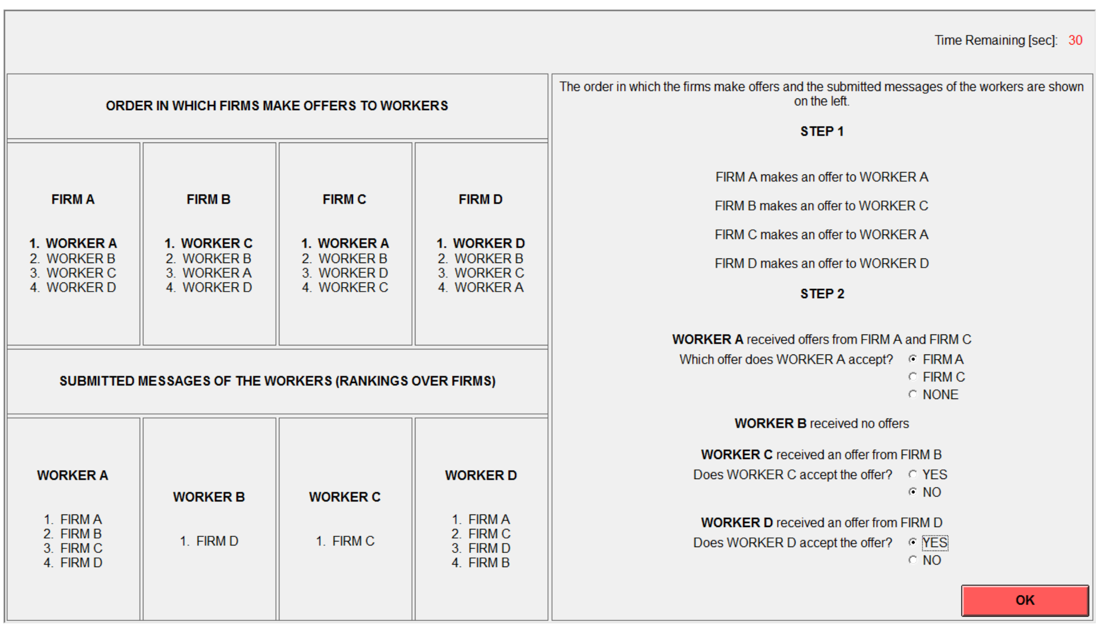
Proof of Proposition 2: Suppose that woman w submits a preference list $Q(w)$ that is a truncation of $P(w)$ such that $\underline{Q}(w) = \mu_W(w)$. If none of the other women over-truncates, then woman w will be matched to $\mu_W(w)$ by Proposition 1(c). So the remaining case to be considered involves at least one of the other women over-truncating. Without loss of generality, suppose that some non-empty subset $T \subseteq W \setminus \{w\}$ over-truncates. Let $M' = \{\mu_W(w') : w' \in T\}$. Each man $m' \in M'$ is now available to make offers to other women in the deferred acceptance algorithm. Clearly woman w can only benefit from the availability of these men. If man m' now makes an offer to match with woman w, the algorithm would only accept the offer on the woman's behalf if it were the case that $m' \succ_w \mu_W(w)$.

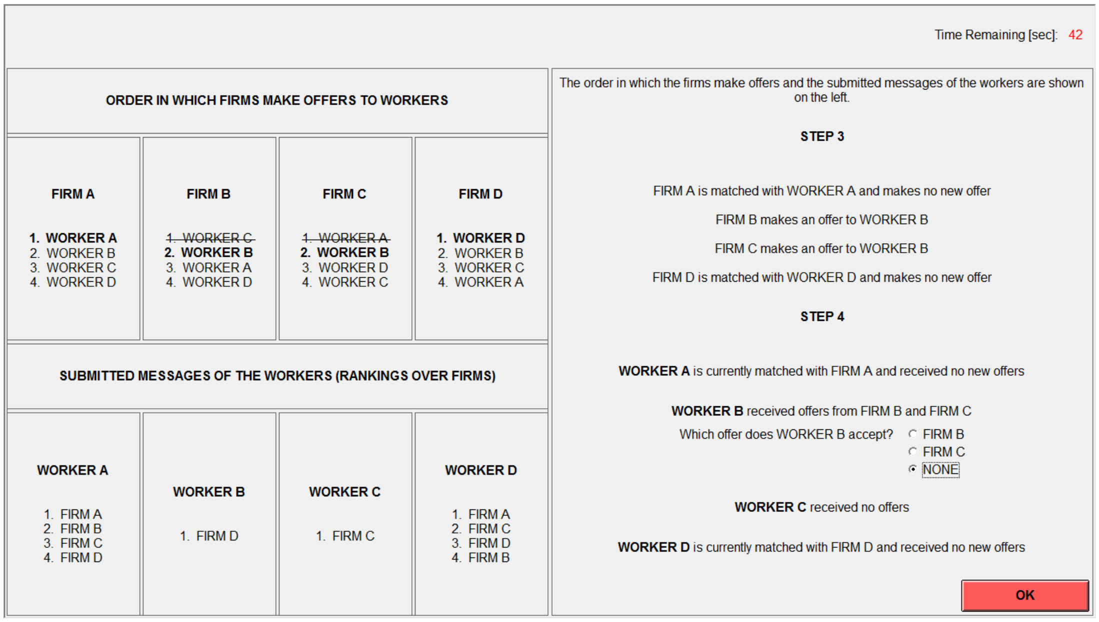
[36]Woman w is not single at μ_W since $|M| = |W|$ and all men are acceptable to all women (and vice versa).
[37]Since no woman is over-truncating, note that $\mu_W(w)$ is included on the list $Q(w)$ for each w.
[38]Recall that w is not single at μ by Proposition 1(a).

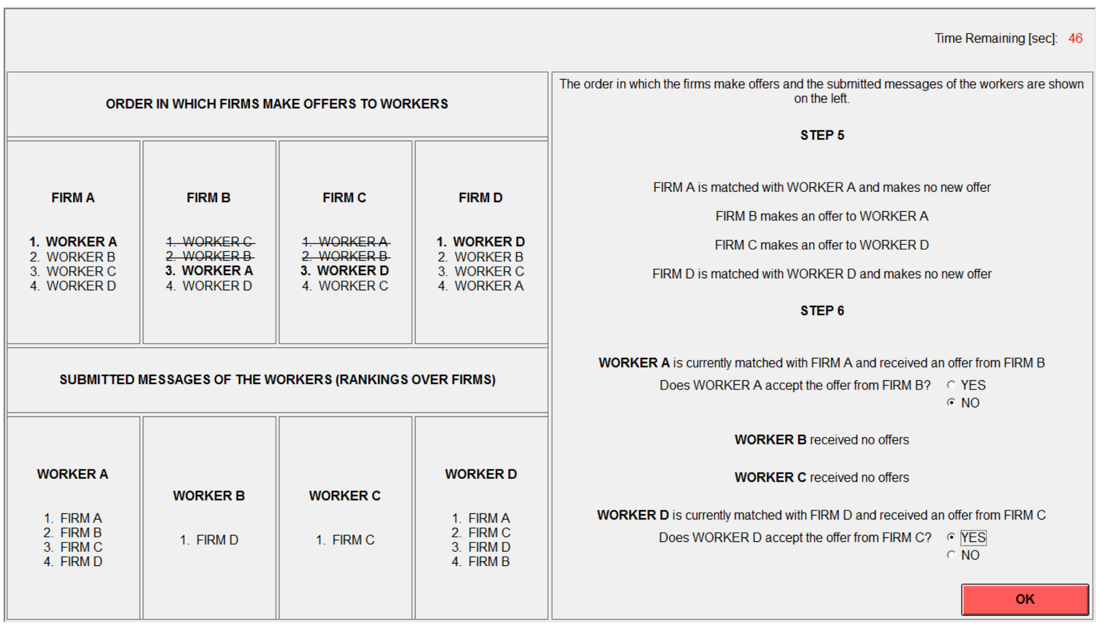
Appendix B: Demonstration of the DA Algorithm

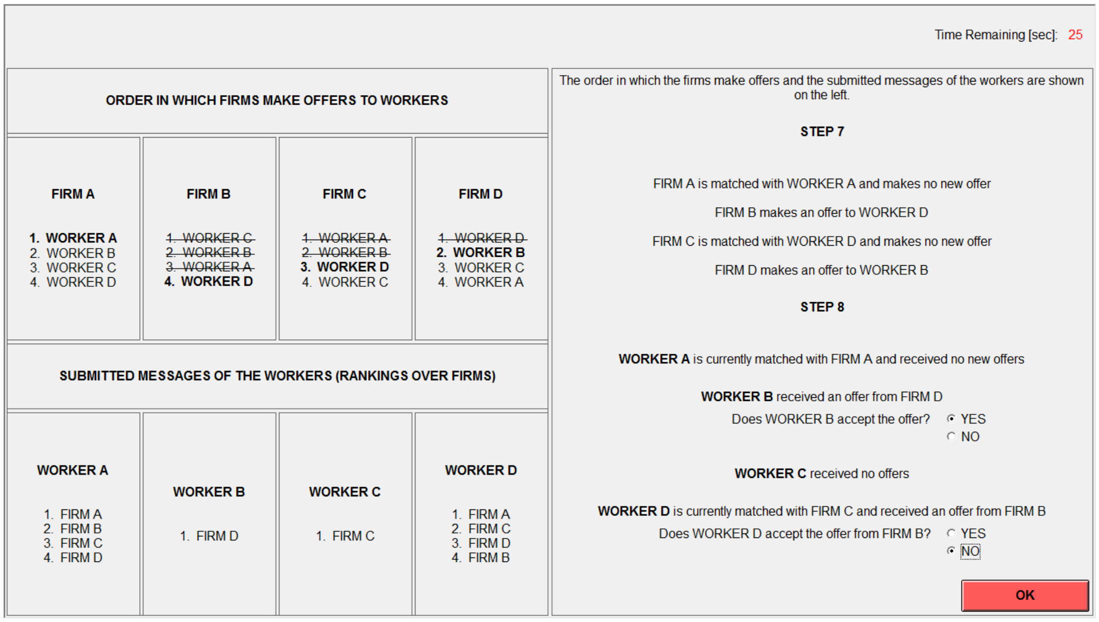
Before the experiment begins, all subjects are required to work through a demonstration of the DA algorithm and correctly answer a series of questions. The relevant screen shots are shown below (with the correct answers already selected).

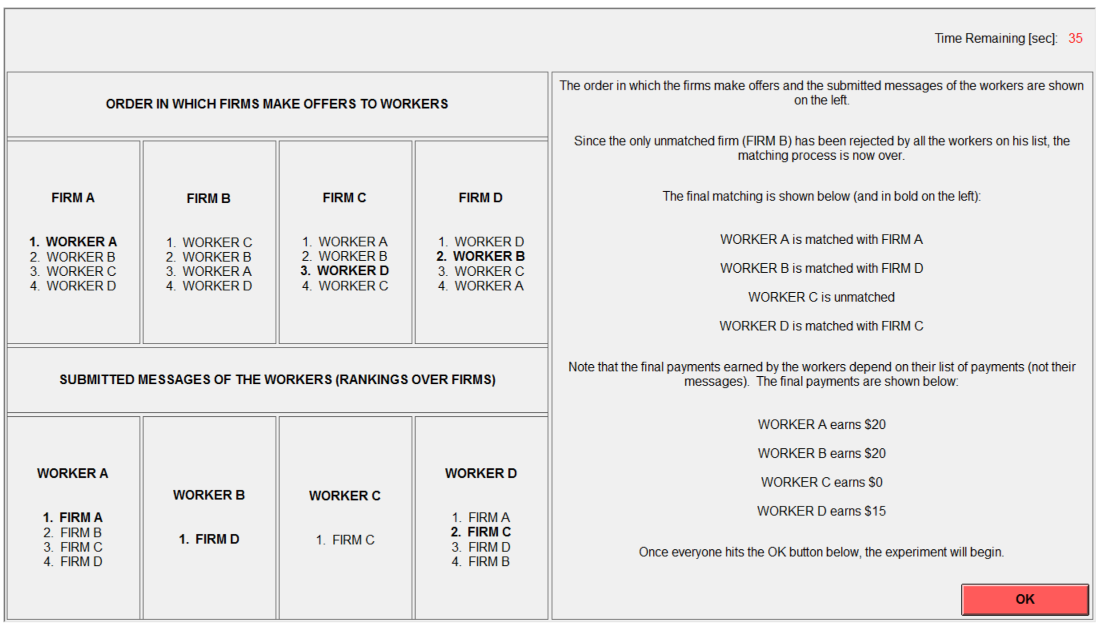





Time Remaining [sec]: 42
ORDER IN WHICH FIRMS MAKE OFFERS TO WORKERS
FIRM A
1. WORKER A
2. WORKER B
3. WORKER C
4. WORKER D
FIRM B
~~1. WORKER C~~
2. WORKER B
3. WORKER A
4. WORKER D
FIRM C
~~1. WORKER A~~
2. WORKER B
3. WORKER D
4. WORKER C
FIRM D
1. WORKER D
2. WORKER B
3. WORKER C
4. WORKER A
SUBMITTED MESSAGES OF THE WORKERS (RANKINGS OVER FIRMS)
WORKER A
1. FIRM A
2. FIRM B
3. FIRM C
4. FIRM D
WORKER B
1. FIRM D
WORKER C
1. FIRM C
WORKER D
1. FIRM A
2. FIRM C
3. FIRM D
4. FIRM B
The order in which the firms make offers and the submitted messages of the workers are shown on the left.
STEP 3
FIRM A is matched with WORKER A and makes no new offer
FIRM B makes an offer to WORKER B
FIRM C makes an offer to WORKER B
FIRM D is matched with WORKER D and makes no new offer
STEP 4
WORKER A is currently matched with FIRM A and received no new offers
WORKER B received offers from FIRM B and FIRM C
Which offer does WORKER B accept?
FIRM B
FIRM C
NONE
WORKER C received no offers
WORKER D is currently matched with FIRM D and received no new offers
OK


Time Remaining [sec]: 46
ORDER IN WHICH FIRMS MAKE OFFERS TO WORKERS
FIRM A
1. WORKER A
2. WORKER B
3. WORKER C
4. WORKER D
FIRM B
~~1. WORKER C~~
~~2. WORKER B~~
3. WORKER A
4. WORKER D
FIRM C
~~1. WORKER A~~
~~2. WORKER B~~
3. WORKER D
4. WORKER C
FIRM D
1. WORKER D
2. WORKER B
3. WORKER C
4. WORKER A
SUBMITTED MESSAGES OF THE WORKERS (RANKINGS OVER FIRMS)
WORKER A
1. FIRM A
2. FIRM B
3. FIRM C
4. FIRM D
WORKER B
1. FIRM D
WORKER C
1. FIRM C
WORKER D
1. FIRM A
2. FIRM C
3. FIRM D
4. FIRM B
The order in which the firms make offers and the submitted messages of the workers are shown on the left.
STEP 5
FIRM A is matched with WORKER A and makes no new offer
FIRM B makes an offer to WORKER A
FIRM C makes an offer to WORKER D
FIRM D is matched with WORKER D and makes no new offer
STEP 6
WORKER A is currently matched with FIRM A and received an offer from FIRM B
Does WORKER A accept the offer from FIRM B?
YES
NO
WORKER B received no offers
WORKER C received no offers
WORKER D is currently matched with FIRM D and received an offer from FIRM C
Does WORKER D accept the offer from FIRM C?
YES
NO
OK


Time Remaining [sec]: 25
ORDER IN WHICH FIRMS MAKE OFFERS TO WORKERS
FIRM A
1. WORKER A
2. WORKER B
3. WORKER C
4. WORKER D
FIRM B
~~1. WORKER C~~
~~2. WORKER B~~
~~3. WORKER A~~
4. WORKER D
FIRM C
~~1. WORKER A~~
~~2. WORKER B~~
3. WORKER D
4. WORKER C
FIRM D
~~1. WORKER D~~
2. WORKER B
3. WORKER C
4. WORKER A
SUBMITTED MESSAGES OF THE WORKERS (RANKINGS OVER FIRMS)
WORKER A
1. FIRM A
2. FIRM B
3. FIRM C
4. FIRM D
WORKER B
1. FIRM D
WORKER C
1. FIRM C
WORKER D
1. FIRM A
2. FIRM C
3. FIRM D
4. FIRM B
The order in which the firms make offers and the submitted messages of the workers are shown on the left.
STEP 7
FIRM A is matched with WORKER A and makes no new offer
FIRM B makes an offer to WORKER D
FIRM C is matched with WORKER D and makes no new offer
FIRM D makes an offer to WORKER B
STEP 8
WORKER A is currently matched with FIRM A and received no new offers
WORKER B received an offer from FIRM D
Does WORKER B accept the offer? YES NO
WORKER C received no offers
WORKER D is currently matched with FIRM C and received an offer from FIRM B
Does WORKER D accept the offer from FIRM B? YES NO
OK


Time Remaining [sec]: 35
ORDER IN WHICH FIRMS MAKE OFFERS TO WORKERS
FIRM A
1. WORKER A
2. WORKER B
3. WORKER C
4. WORKER D
FIRM B
1. WORKER C
2. WORKER B
3. WORKER A
4. WORKER D
FIRM C
1. WORKER A
2. WORKER B
3. WORKER D
4. WORKER C
FIRM D
1. WORKER D
2. WORKER B
3. WORKER C
4. WORKER A
SUBMITTED MESSAGES OF THE WORKERS (RANKINGS OVER FIRMS)
WORKER A
1. FIRM A
2. FIRM B
3. FIRM C
4. FIRM D
WORKER B
1. FIRM D
WORKER C
1. FIRM C
WORKER D
1. FIRM A
2. FIRM C
3. FIRM D
4. FIRM B
The order in which the firms make offers and the submitted messages of the workers are shown on the left.
Since the only unmatched firm (FIRM B) has been rejected by all the workers on his list, the matching process is now over.
The final matching is shown below (and in bold on the left):
WORKER A is matched with FIRM A
WORKER B is matched with FIRM D
WORKER C is unmatched
WORKER D is matched with FIRM C
Note that the final payments earned by the workers depend on their list of payments (not their messages). The final payments are shown below:
WORKER A earns $20
WORKER B earns $20
WORKER C earns $0
WORKER D earns $15
Once everyone hits the OK button below, the experiment will begin.
OK

Appendix C: Ordinal Preference Profiles

An agent's achievable match partners are denoted by asterisks ($*$) in her preference list.

Round 1

$P(f_1) = w_1^*, w_2, w_3, w_4$
$P(f_2) = w_1, w_2^*, w_3, w_4$
$P(f_3) = w_1, w_2, w_3^*, w_4$
$P(f_4) = w_1, w_2, w_3, w_4^*$

$P(w_1) = f_1^*, f_2, f_3, f_4$
$P(w_2) = f_1, f_2^*, f_3, f_4$
$P(w_3) = f_1, f_2, f_3^*, f_4$
$P(w_4) = f_1, f_2, f_3, f_4^*$

Round 2

$P(f_1) = w_1^*, w_2^*, w_3, w_4$
$P(f_2) = w_2^*, w_1^*, w_3, w_4$
$P(f_3) = w_3^*, w_4^*, w_1, w_2$
$P(f_4) = w_4^*, w_3^*, w_1, w_2$

$P(w_1) = f_2^*, f_3, f_1^*, f_4$
$P(w_2) = f_1^*, f_3, f_2^*, f_4$
$P(w_3) = f_4^*, f_1, f_3^*, f_2$
$P(w_4) = f_3^*, f_1, f_4^*, f_2$

Round 3

$P(f_1) = w_4^*, w_2^*, w_3, w_1$
$P(f_2) = w_3^*, w_1^*, w_4, w_2$
$P(f_3) = w_2^*, w_4^*, w_1, w_3$
$P(f_4) = w_1^*, w_3^*, w_2, w_4$

$P(w_1) = f_3, f_2^*, f_4^*, f_1$
$P(w_2) = f_4, f_1^*, f_3^*, f_2$
$P(w_3) = f_3, f_4^*, f_2^*, f_1$
$P(w_4) = f_4, f_3^*, f_1^*, f_2$

Round 4

$P(f_1) = w_1^*, w_2^*, w_3, w_4$
$P(f_2) = w_2^*, w_1^*, w_3, w_4$
$P(f_3) = w_3^*, w_4^*, w_1, w_2$
$P(f_4) = w_4^*, w_3^*, w_1, w_2$

$P(w_1) = f_2^*, f_3, f_4, f_1^*$
$P(w_2) = f_1^*, f_3, f_4, f_2^*$
$P(w_3) = f_4^*, f_1, f_2, f_3^*$
$P(w_4) = f_3^*, f_1, f_2, f_4^*$

Round 5

$P(f_1) = w_3^*, w_1, w_4, w_2$
$P(f_2) = w_3, w_4^*, w_1^*, w_2$
$P(f_3) = w_3, w_1^*, w_4^*, w_2$
$P(f_4) = w_3, w_4, w_1, w_2^*$

$P(w_1) = f_1, f_2^*, f_3^*, f_4$
$P(w_2) = f_1, f_3, f_2, f_4^*$
$P(w_3) = f_1^*, f_2, f_3, f_4$
$P(w_4) = f_1, f_3^*, f_2^*, f_4$

Round 6

$P(f_1) = w_2^*, w_4, w_1, w_3$
$P(f_2) = w_2, w_1^*, w_4^*, w_3$
$P(f_3) = w_2, w_4^*, w_1^*, w_3$
$P(f_4) = w_2, w_1, w_4, w_3^*$

$P(w_1) = f_1, f_3^*, f_2^*, f_4$
$P(w_2) = f_1^*, f_2, f_3, f_4$
$P(w_3) = f_1, f_3, f_2, f_4^*$
$P(w_4) = f_1, f_2^*, f_3^*, f_4$

Round 7

$P(f_1) = w_1^*, w_2^*, w_3^*, w_4^*$
$P(f_2) = w_2^*, w_3^*, w_4^*, w_1^*$
$P(f_3) = w_3^*, w_4^*, w_1^*, w_2^*$
$P(f_4) = w_4^*, w_1^*, w_2^*, w_3^*$

$P(w_1) = f_2^*, f_3^*, f_4^*, f_1^*$
$P(w_2) = f_3^*, f_4^*, f_1^*, f_2^*$
$P(w_3) = f_4^*, f_1^*, f_2^*, f_3^*$
$P(w_4) = f_1^*, f_2^*, f_3^*, f_4^*$

Round 8

$P(f_1) = w_1^*, w_2^*, w_3, w_4$
$P(f_2) = w_2^*, w_1^*, w_3, w_4$
$P(f_3) = w_3^*, w_4^*, w_1, w_2$
$P(f_4) = w_4^*, w_3^*, w_1, w_2$

$P(w_1) = f_2^*, f_1^*, f_3, f_4$
$P(w_2) = f_1^*, f_2^*, f_3, f_4$
$P(w_3) = f_4^*, f_3^*, f_1, f_2$
$P(w_4) = f_3^*, f_4^*, f_1, f_2$

Round 9

$P(f_1) = w_4^*, w_2^*, w_3, w_1$
$P(f_2) = w_3^*, w_1^*, w_4, w_2$
$P(f_3) = w_2^*, w_4^*, w_1, w_3$
$P(f_4) = w_1^*, w_3^*, w_2, w_4$

$P(w_1) = f_3, f_2^*, f_1, f_4^*$
$P(w_2) = f_4, f_1^*, f_2, f_3^*$
$P(w_3) = f_3, f_4^*, f_1, f_2^*$
$P(w_4) = f_4, f_3^*, f_2, f_1^*$

Round 10

$P(f_1) = w_4^*, w_3, w_2, w_1$

$P(f_2) = w_4, w_3^*, w_2, w_1$

$P(f_3) = w_4, w_3, w_2^*, w_1$

$P(f_4) = w_4, w_3, w_2, w_1^*$

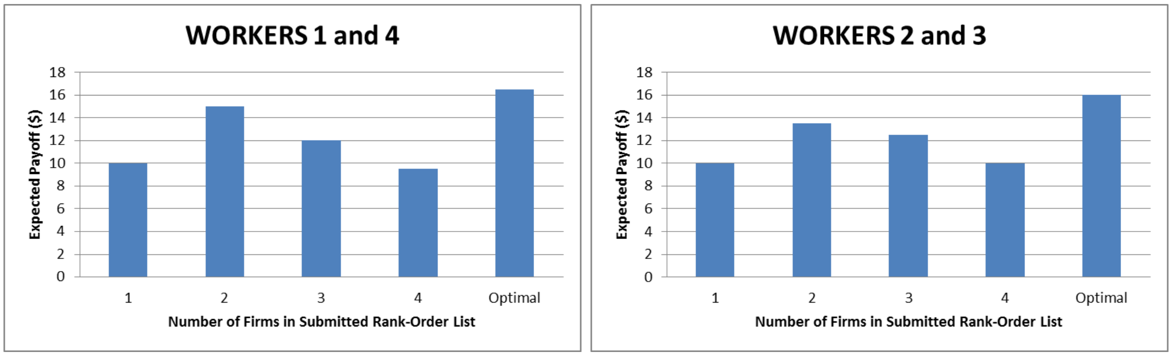
$P(w_1) = f_1, f_2, f_3, f_4^*$

$P(w_2) = f_1, f_2, f_3^*, f_4$

$P(w_3) = f_1, f_2^*, f_3, f_4$

$P(w_4) = f_1^*, f_2, f_3, f_4$

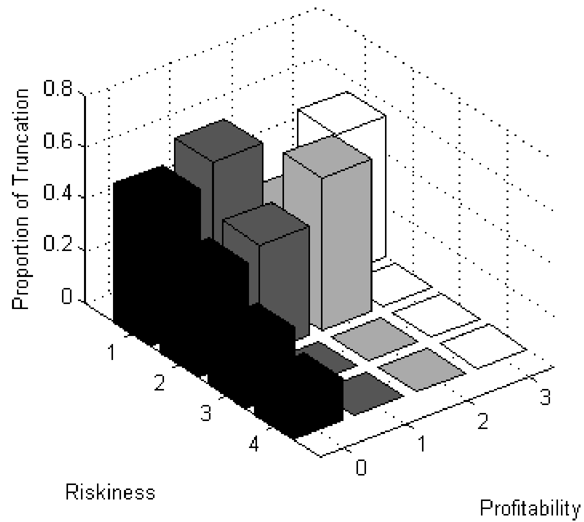
Appendix D: Additional Figures and Tables



The expected payoff of different truncation levels.

Round	Worker	Number of Achievable Partners	Profitability	Riskiness
1	A	1	0	1
1	B	1	0	2
1	C	1	0	3
1	D	1	0	4
2	A,B,C,D	2	2	1
3	A,B,C,D	2	1	2
4	A,B,C,D	2	3	1
5	A	2	1	2
5	B	1	0	4
5	C	1	0	1
5	D	2	1	2
6	A	2	1	2
6	B	1	0	1
6	C	1	0	4
6	D	2	1	2
7	A,B,C,D	4	3	1
8	A,B,C,D	2	1	1
9	A,B,C,D	2	2	2
10	A	1	0	4
10	B	1	0	3
10	C	1	0	2
10	D	1	0	1

The strategic incentives faced by workers in different rounds of the experiment.



Proportion of truncation across varying strategic incentives.

Probit Regression of Truncation by Market Features

VARIABLES	(1) Truncation	(2) Truncation	(3) Truncation	(4) Truncation
Profitability	0.00908		0.0210	0.00713
	(0.0129)		(0.0180)	(0.0177)
More than one achievable partner		0.0562		
		(0.0394)		
Riskiness	-0.123***	-0.115***	-0.0980***	-0.125***
	(0.0193)	(0.0194)	(0.0289)	(0.0258)
Average rank in firms' preferences			-0.0328	
			(0.0346)	
Ranked first by top three				-0.00645
				(0.0391)
Round of the experiment	0.0325***	0.0325***	0.0322***	0.0322***
	(0.00654)	(0.00660)	(0.00650)	(0.00630)
Observations	920	920	920	920

The table reports marginal effects from probit regressions.

Standard errors are shown in parentheses and are clustered at the individual level.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Conditional Logit Regression of Truncation by Market Features

VARIABLES	(1) Truncation	(2) Truncation	(3) Truncation	(4) Truncation
Profitability	0.0355		0.182	0.0208
	(0.110)		(0.155)	(0.134)
More than one achievable partner		0.254		
		(0.254)		
Riskiness	-0.851***	-0.814***	-0.551**	-0.872***
	(0.135)	(0.128)	(0.260)	(0.173)
Average rank in firms' preferences			-0.384	
			(0.289)	
Ranked first by top three				-0.0531
				(0.279)
Round of the experiment	0.238***	0.238***	0.235***	0.236***
	(0.0357)	(0.0356)	(0.0358)	(0.0377)
Observations	650	650	650	650
Number of individuals	65	65	65	65

The table reports results from conditional logit regressions with individual-specific fixed effects. Standard errors are shown in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

WELCOME!

Please turn off all electronic devices and place them in your bag or under your desk.

Throughout the experiment, please do not talk to anybody else and please remain silent at all times. If you have any questions, raise your hand and the experimenter will come to personally assist you.

Thank you for participating in this experiment. By showing up on time, you have automatically earned a $5 payment. If you follow the instructions carefully and make good decisions, you can earn a considerable amount of money in addition to the $5. The amount of money that you ultimately earn in this experiment depends on your decisions, the decisions of others, and random chance. At the end of the session, you will be paid privately in cash.

The experiment will be run entirely on the computer and all interactions between yourself and others will take place via the computer terminal. There are a total of 10 rounds in this experiment. At the end of the experiment, one of the 10 rounds will be randomly selected and your monetary payment will be determined based on the outcome of that round. Thus, it is in your best interest to take each round seriously. Each round is self-contained: your decisions in one round will not affect your opportunities or earnings in another round.

Today's experiment is on matching. There are two groups in the experiment: firms and workers. There are 4 firms and 4 workers. The firms are labeled FIRM A, FIRM B, FIRM C, and FIRM D. The workers are labeled WORKER A, WORKER B, WORKER C, and WORKER D. The roles of the firms are computerized. They are programmed to behave in a certain way (this will be discussed later). Each of you has been assigned to the role of one of the four workers. Your role will remain the same in each round of the experiment. Your goal in each round is to match with one of the four firms. You will earn different payments from different matches. The payments corresponding to all possible matches will be made available in each round.

During each round of the experiment, you will see 8 lists on your screen (one for each firm and one for each worker). Each firm's list contains four workers and it shows the order in which the firm will be making offers to match with the different workers. Each worker's list contains four firms and it shows how much money the worker would earn if matched with the different firms.

As a worker, if you are matched with the firm in the first position of your list in a given round, you will earn a payment of $20 for that round. Similarly, matching with the firm in the second position of your list results in a payment of $15, matching with the firm in the third position of your list results in a payment of $10, and matching with the firm in the fourth position of your list results in a payment of $5. Remaining unmatched will result in a payment of $0 for that round.

To determine which firm you are matched with, you will send a message in each round. The message is sent to the computer. It is very important that you understand what a message is since the messages sent by all four workers determine who gets matched with whom. A message is a ranking of firms. This ranking is used to determine which firm to match you with if such an opportunity arises. The message may or may not include all the firms. Thus, although there are four firms you could potentially be matched with, your message can contain either one, two, three, or four firms.

In each round you will have at least 3 minutes (180 seconds) to submit your message. If you submit your message early you will still have to wait until the end of the 3 minutes. If you have not submitted your message by the end of the 3 minutes, there will be a reminder on your screen telling you to make a decision. The experiment will not proceed until everyone has submitted a message and the 3 minutes have elapsed. The top right-hand corner of the screen will display the time remaining (in seconds).

The way the computer uses the messages to determine who is matched with whom will be explained below. The computer will go through these steps on its own and you will not see this process in each round. Instead, what you will see is how much you earn in a round and who is paired with whom. However, we will go through these steps so you understand how earnings and matches are determined.

Before we go through the procedure in detail, we will summarize the main ideas. Essentially, the computer uses the message you submit to decide which offers to accept and reject on your behalf. There are two rules that describe this process. First, the computer never matches you with a firm that you have not included in your submitted message. This is because, even if that firm makes an offer to match with you, the computer will reject that offer. Second, the computer always matches you with the highest ranked firm (according to your submitted message) who has made you an offer. If you have an offer from only one firm and that firm is included in your message, then the computer will accept that offer. If you have offers from more than one firm and those firms are included in your message, then the computer will accept the offer from the highest ranked firm in your message and reject all the other offers.

STEP 0: All firms and workers are currently unmatched. Workers (YOU) send messages to the computer. These messages are a ranking of the firms that the computer will use in the steps below.

NOTE: THE REMAINING STEPS ARE PERFORMED BY THE COMPUTER

STEP 1: <u>Firms make offers</u>.

Each firm makes an offer to the first worker on its list.

STEP 2: <u>Workers respond to offers</u>.

(a) If a worker receives no offers, then nothing changes. The worker remains unmatched.

(b) If a worker receives one offer, then the computer uses the message of that worker to decide whether or not to accept the offer. For example, suppose that WORKER A receives an offer from FIRM A.

- If WORKER A included FIRM A in its message, then WORKER A is matched with FIRM A.

- If WORKER A did not include FIRM A in its message, then WORKER A is not matched with FIRM A. In this case, WORKER A "rejects" FIRM A.

(c) If a worker receives more than one offer, then the computer uses the message of that worker to decide which firm to match that worker to (if any). For example, suppose that WORKER A receives offers from both FIRM A and FIRM B.

- If WORKER A did not include either FIRM A or FIRM B in its message, then WORKER A rejects the offers from both FIRM A and FIRM B. WORKER A remains unmatched.

- If WORKER A included FIRM A in its message but not FIRM B, then WORKER A is matched with FIRM A. WORKER A rejects the offer from FIRM B.

- If WORKER A included FIRM B in its message but not FIRM A, then WORKER A is matched with FIRM B. WORKER A rejects the offer from FIRM A.

- If WORKER A included both FIRM A and FIRM B in its message, then the computer looks at the relative positions of FIRM A and FIRM B in WORKER A's message. If WORKER A's message ranks FIRM A in a higher position than FIRM B, then WORKER A is matched with FIRM A and WORKER A rejects the offer from FIRM B. If WORKER A's message ranks FIRM B in a higher position than FIRM A, then WORKER A is matched with FIRM B and WORKER A rejects the offer from FIRM A.

STEP 3: Unmatched firms make new offers.

Each firm that is unmatched makes an offer to the second worker on its list.

STEP 4: Workers respond to offers.

(a) If a worker is unmatched, then refer to STEP 2 to determine how the worker decides among offers.

(b) If a worker is currently matched and receives no new offers, then nothing changes. The worker remains matched to whichever firm they were already matched with.

(c) If a worker is currently matched and receives new offers, then the computer looks at the relative positions of the current match and the new offers in the worker's message. For example, suppose that WORKER A is currently matched with FIRM A and receives an offer from FIRM B.

- If WORKER A did not include FIRM B in its message, then WORKER A rejects the offer from FIRM B. WORKER A is still matched with FIRM A.

- If WORKER A included FIRM B in its message, then the computer looks at the relative positions of FIRM A and FIRM B in WORKER A's message. If WORKER A's message ranks FIRM A in a higher position than FIRM B, then WORKER A is still matched with FIRM A and WORKER A rejects the offer from FIRM B. If WORKER A's message ranks FIRM B in a higher position than FIRM A, then WORKER A's previous match with FIRM A is broken and WORKER A is now matched with FIRM B.

Step 5: <u>Unmatched firms make new offers</u>.

Each firm that is unmatched makes an offer to the "available" worker that is highest on its list. A worker is "available" to a firm if the firm has not already made an offer to that worker and been rejected. In other words, firms are not allowed to repeat offers.

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The procedure continues in this fashion until there are no firms left to make offers. This can happen because all firms are matched or because the only unmatched firms have already been rejected by all of the workers. The final matches for a given round are the matches that are in place when the procedure ends. It is only the final matches that count to determine payments. Matches that are dissolved do not count for payments.

Note that the computer only uses the rankings from your submitted message (not your list of payments) when deciding which firm to match you with. For example, suppose you submit a message with FIRM A ranked as first and FIRM B ranked as second. Suppose also that your list of payments specifies that you would earn $10 if matched with FIRM A and $20 if matched with FIRM B. If you receive offers from both FIRM A and FIRM B, then the computer will accept the offer from FIRM A and reject the offer from FIRM B (since you ranked FIRM A in a higher position than FIRM B in your message). Thus, your corresponding payment would be $10. Again, it is important to emphasize that the computer uses your message to decide who to match you with and uses your list of payments to determine your earnings for that round.

In this experiment, however, if you choose to include a firm in your message, it must be in the same position as in your list of payments. For example, suppose you are WORKER A and your list of payments is as follows:

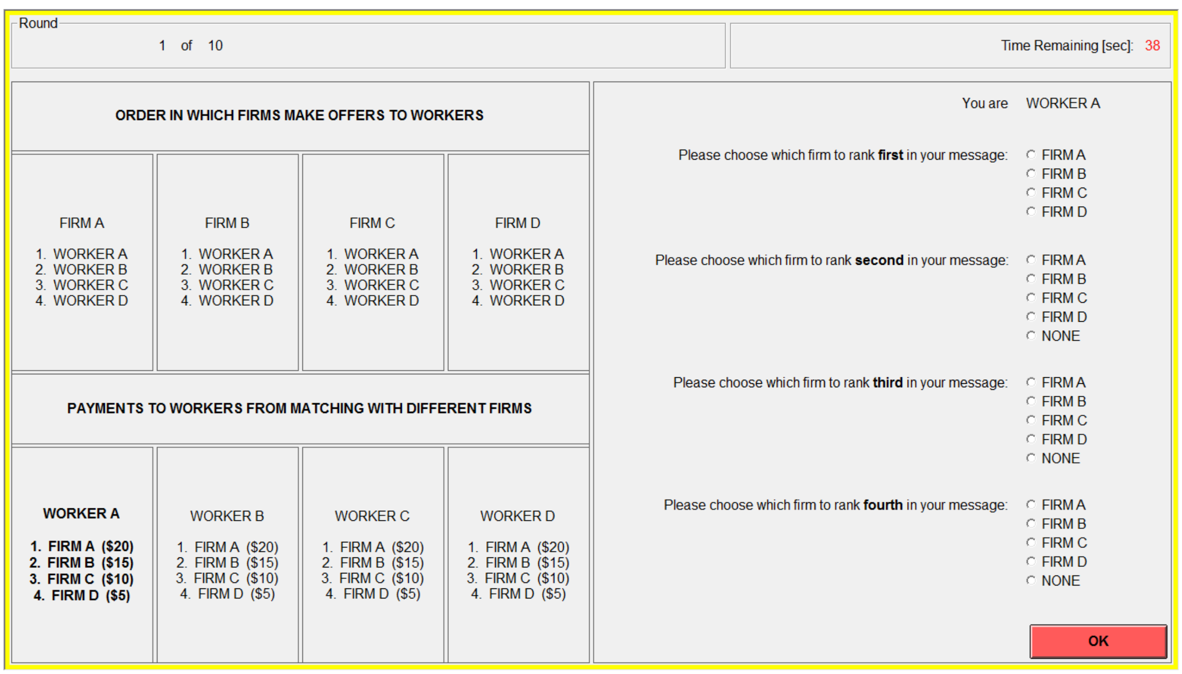
1. FIRM C ($20)
2. FIRM A ($15)
3. FIRM D ($10)
4. FIRM B ($5)

Then, you will only be allowed to submit one of the following four messages:

1. FIRM C	1. FIRM C	1. FIRM C	1. FIRM C
	2. FIRM A	2. FIRM A	2. FIRM A
		3. FIRM D	3. FIRM D
			4. FIRM B

In other words, you are only allowed to choose the length of your message, but you are not allowed to change the order in which firms appear in your payment list.

An example of the experimental interface is shown below. The bar at the top of the screen indicates which round the players are currently in and how much time is left in the round (in seconds). The left hand side of the screen displays the lists for the firms and the workers. Your own list of payments will always be in bold. The right hand side of the screen displays your role in the experiment and asks for your message. The example below is the screen that WORKER A will observe in Round 1 of the experiment.



At the beginning of the experiment, there will be a demonstration of the procedure that the computer uses to determine final matchings. You will walk through the steps discussed above to better understand how the messages that are submitted affect who you are matched with. Again, keep in mind that you will not have to go through a similar process during the actual experiment. In the experiment, the only action that you will take is to submit a message. The computer will go through these steps on its own to determine who you are matched with. It will then report that information to you. The purpose of the example is just to show you in detail the steps the computer is taking to determine the final matchings based on the submitted messages.

To summarize, the order of events in the experiment is as follows:

1. You will go through an example demonstrating the procedure that the computer uses to calculate the final matchings.

2. You are assigned to the role of one of the four workers.

3. You learn your payments (as well as the payments of the other workers) for all the possible matches. You also learn the order in which the firms will make offers to the workers.

4. You submit a ranking to the computer with the order in which you would like to be matched with firms, if given the opportunity. This ranking can contain either one, two, three, or four firms. If you choose to include a firm in your ranking, it must be in the same position as in your payment list. You will have at least 3 minutes to submit your ranking.

5. The computer uses the submitted rankings to calculate the final matchings.

6. The computer reports to you which firm you are matched with and how much money you have earned.

7. You will repeat steps 3-6 nine times (since there are a total of ten rounds in the experiment).

8. At the end of the experiment, one of the ten rounds will be randomly selected and you will be paid your earnings for that round (in addition to the $5 show-up payment). All payments will be made privately and in cash.

If you have any questions at this point, please raise your hand. If not, we will begin the experiment shortly.

Good luck!