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Abstract

We investigate whether an agency can increase employment by strategically coarsening information about workers' skills and abilities to employers. Theoretically, we find that such an increase is possible and a range of employment levels can be supported in equilibrium. We test this possibility using laboratory experiments under three conditions: full information, coarse and verifiable information, and coarse but not verifiable information. We find that, compared with full information, both treatments with coarse information increase employment at the expense of the employers' profits but not to the highest theoretically achievable levels. We also find verifiability affects several aspects of behavior.

Keywords: Job placements, ratings, lab experiments, institutions, information design, unemployment
JEL codes: C9, D82, J6

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1 Introduction

Increasing employment and labor force participation is an objective of most democratically elected governments. Labor markets, as is, may not achieve the best feasible outcome due to imperfections. For instance, minimum wages and reasonable work conditions might make it too expensive to hire a worker who would be hired without regulations. Removing such regulations might not be politically feasible. Also, employing workers has positive externalities - the government might save on welfare benefits and have increased tax revenues. Beyond the monetary savings, workers earning wages rather than receiving benefits could lead to better mental health, reduced crime (Heller, 2014; Gelber et al., 2015), and might be preferred by society (Maimonides, 1168). Also, getting an initial job may break a vicious cycle of not being offered a job because one has been long-term unemployed.

Our study is motivated by the problem of getting low skilled workers into employment in an economy with a minimum wage. The findings could apply more generally to higher skilled workers where the wages are sticky downward or set by a union. We consider the set of workers who would not be hired given the minimum wage and employers' ex-ante expectations about the workers' productivity. We investigate whether a private agency could get some of these workers into employment. We assume the government assigns workers to the agency and pays the agency a fixed amount for each worker placed. The agency can strategically release fine or coarse information about workers. If an agency releases fine information, then employers will be able to identify less desirable workers, thereby, lowering their chances of employment. If an agency releases coarse information by pooling more and less desirable workers together, then an employer may be willing to hire all of them. We have two related research questions. First, can an agency increase employment by releasing coarser information? Second, if so, does the information need to be verifiable?

Revealing coarse information to increase employment is, perhaps surprisingly, similar to the successful use of bundling of goods to increase sales. Stigler (1963) claims that Hollywood studios bundled films to movie theaters in order to increase the number of their films playing. Many supermarkets put fruit in bags rather than sell them individually. This prevents less appealing oranges being left unsold. De Beers has long used a practice of bundling diamonds together. They list only weight and a coarse classification while only allowing buyers to examine the diamonds after the sale (Kenney and Klein, 1983). Similar to the mechanisms in our paper, law schools generally give only partial information about their graduates.[1]

Ratings are commonly used by experts to provide information about restaurants (Michelin), company bonds (Moody, S&P), film and theater (various newspapers) and hotels.[2] Often ratings are coarse, for example, star ratings for movies and UK degree classifications. In principle, the coarseness of these ratings can be used to increase sales and, in the case of students, employment (see Ostrovsky and Schwarz (2010)). In many cases, the relationship between ratings and quality is not predetermined. While these cannot be instantly verifiable, over time they can become credible. For instance, with university graduates, employers may learn the capabilities of a student with a 2.1 from the University of Gallifrey.[3]

In order to answer our research questions, we use theory and experiments to analyze the following environments that vary the coarseness and verifiability of information.[4] *Full information* - agencies provide the skill level of individual workers. *Bundles* - agencies divide workers into groups

[1] At the time of writing this paper, rules vary from Yale that gives no information to Colorado that gives the ranking of the top 1/3 but does not distinguish among those in the bottom two-thirds. Others like Harvard Law School divide students that graduate into those with honors of several types (roughly 25% of the class) and those without honors. They provide no additional information. While many law employers would be happy to hire someone who is in the bottom 75% at Harvard, they would not be willing to hire the person at the bottom of the class.

[2] Dranove and Jin (2010) review the literature on quality disclosure and certification. There are also various crowd-sourced ratings such as Trip-advisor, Uber drivers, and sellers on Amazon/eBay.

[3] Another interesting example of bundling concerns admissions to MA programs at Israeli universities. Admission decisions are not allowed to be based on the undergraduate institution of the candidate. Technically, if a student took the same courses in Technion (a highly ranked university) and received an 85 they would have the same chance of getting in as a student that received an 85 from the local community college. The logic is to allow students from a more diverse socioeconomic background to have a chance of enrolling. This is essentially bundling the two together.

[4] For simplicity, we assume, employers care solely about the skill level of their workers and this skill level has one dimension which then makes match quality identical. With more than one dimension, for example, a worker with high IT skills and low communication skills could be a better fit for a technology company compared to a newspaper.

and provide the average skill of each group. *Stars* - agencies also divide workers into groups but instead provide a star rating for each group. There is no obligation that a worker's star rating corresponds to the skill of the worker.[5]

We start by theoretically exploring the equilibria under the three previously described environments. Using a one-shot, full-information game as a baseline, we find only those with high enough skill are hired. We find that both the bundles and stars environments can have strictly higher employment since low-skill workers can be grouped with higher-skilled workers while still making the expected skill profitable for the employer to hire. With repeated play and sufficiently high discount factors, all three environments have a range of equilibria varying from the one-shot full-information equilibrium to a high-employment low-employer-profit equilibrium.

The problem is a sender-receiver game. The agency (sender) has information about the abilities of workers and sends a signal to the employer (receiver) who must decide whether or not to hire the worker using that signal. Unlike Bayesian persuasion (Kamenica, 2019; Kamenica and Gentzkow, 2011), we do not assume that the agency has the ability to commit to a strategy before seeing the abilities of the workers. Instead, it must rely on verifiable messages (bundles) or cheap talk (stars), as studied in Seidmann and Winter (1997) and Crawford and Sobel (1982), respectively, for the Crawford-Sobel style sender-receiver game.

Our laboratory experiment investigated behavior in the three environments. Subjects played the roles of agencies and employers. We find theoretical predictions for the parameters that we selected. Experiments allow us to determine which equilibrium is likely to be selected.

We experimentally find that coarsening information about workers increases employment, but hurts the employers' profits, and lowers the average skill of the workers employed as suggested possible by our theory. Interestingly, in stars, we found agencies divided employable workers into two categories which gave lower agency profits than the simpler equilibrium where such workers are placed in a single category. Having higher skilled peers helps lower-skilled workers' employment chances in the bundles treat-

[5]Our star environment seems like a natural one to study coarse but non-verifiable information since it corresponds to many rating systems in the real world.

ment but harms them in the stars treatment.

Our findings could contribute to improving government policy. Governments have long attempted to create programs aimed at increasing employment, for instance, the US Department of Labor, Employment and Training Administration funds job training programs, also the UK's Work and Health Programme (Department of Work and Pension, 2017) has agencies help job seekers join the labor force. Even when unemployment is low overall, it can still be high for certain groups such as those with disabilities and health problems, refugees, ex-offenders, etc.[6] As mentioned earlier, reducing long-term unemployment has economic benefits ranging from increased tax revenue to improved mental health.[7] Our paper suggests an alternative, low cost, information-based mechanism, that can be a complement to the strategies tried thus far and would particularly help those that have difficulties finding employment.

Card et al. (2010, 2018) look at a large group of studies on programs to increase employment, they find that programs that are more effective have a greater human capital accumulation aspect. They also find impacts are greater for women, for individuals with long-term unemployment, and for programs during times of recession.[8] We could combine a training program with a mechanism to release coarse information. This would give agencies better information about workers (similar to universities having better information about students). Hence, our mechanism could be used to increase the effectiveness of existing training programs. It also could be used without a training program where the agency just evaluates workers.

There have been a number of studies investigating how information affects hiring in labor markets. Dustmann et al. (2015) find referrals from social networks can lead to better placements evidenced by higher initial wages and lower turnover. There have also been studies using online labor markets, which, albeit are a small part of the economy, have lessons that carry over to the larger labor market. Stanton and Thomas (2016) show

[6]See Putz (2019) for disabled workers, Dumont et al. (2016) for refugees and Holzer (2007) for ex-offenders.

[7]Sen (1997) describes mental and physical health problems, social exclusion, and potential loss of freedom from long-term unemployment. Krueger et al. (2014) find that the longer the workers are unemployed, the more difficult it is for them to get back into the labor force.

[8]For a survey on the related literature see Crépon and Van Den Berg (2016).

that agencies can improve the job prospects of workers. In an online field experiment, Pallais (2014) hired workers for a data entry task and then varied the information provided to future employers. Making information less coarse helped the more productive workers but harmed the less productive ones. We study how agencies can use coarse information to increase employment in a setting where it is common knowledge that the agency has an incentive to increase employment.

Laboratory experiments are useful in increasing our understanding of labor markets and improving the design of institutions (see Charness and Kuhn, 2011). Our work is related to the strand of the experimental literature that focuses on how workers are matched with jobs via institutions (Haruvy et al., 2006; Kagel and Roth, 2000) in that we want to design an institution to help workers find jobs. The difference is that like the search-model literature (Brown et al., 2011; Nalbantian and Schotter, 1995) we have incomplete information, namely employers do not have complete information about the abilities of workers.[9]

In a similar vein to our paper, Siegenthaler (2017) experimentally confirms the theory of Kim (2012) that cheap talk can increase transactions in a goods market in the presence of asymmetric information and matching frictions. This increase leads to a level of transactions that is still less than it would be under full information. Our paper, on the other hand, shows cheap talk (stars) can lead to a higher level of transactions than full information.

In the next section, we build a theoretical model to examine the environment that we test later in the paper.

2 Theory

2.1 Model

There are n_f employers and n_a agencies. Each agency has a continuum of workers of measure one. We think of these workers as the marginal workers

[9]Signaling can also be a means of communication when employers do not have complete information about the worker's abilities (see Miller and Plott, 1985 and Kübler et al., 2008)

that would not be able to find a job without the help of the agencies. Their ex-ante expected productivity is too low to make it worthwhile to hire them. The workers prefer to be employed over being unemployed and have random preferences over employers. There are two states of the world: H and L, with a θ_H chance of the H state and a θ_L of the L state where $\theta_L + \theta_H = 1$ and $\theta_L, \theta_H > 0$. Denote each individual worker i's skill as s_i. The skills of workers have cumulative distribution F_L or F_H (with domain $[0, 1]$) depending upon the state. We note that the state solely represents differences in the distribution of skills of the workers.

An agency knows the skills of the workers and hence the state both of which are hidden from the employers. We assume that the agency has a specialization in evaluating workers (perhaps through economies of scale) or helps provide training for the workers and learn the information in the process. Agencies are paid (by a third party such as the government) a linear function of how many of their workers are hired.

We assume the wage is not flexible. This assumption can be thought of as a regulated wage, a binding minimum wage, or a wage set by a body outside those making hiring decisions. We capture this in our model by using an exogenous wage $w \in (0, 1)$. For each worker hired, an employer earns $s_i - w$. We focus on the case when the wage is higher than the ex-ante expected skill, i.e., $w > \theta_L \int_0^1 s dF_L(s) + \theta_H \int_0^1 s dF_H(s)$. If this condition did not hold, without an agency, there would be full employment, while having an agency that reveals information could decrease employment (such as under full information).

The timing of the model is as follows. First, nature chooses the distribution of workers' skill: either F_L or F_H. Individual skills of workers (and hence the distribution) are seen by the agencies but not the employers. Second, the agencies decide which workers to offer to employers. For each worker offered, a message $m \in M$ is sent to all employers. For simplicity, we restrict this message to either being a number on $[0, 1]$ or $\emptyset$ if no worker is offered, that is, $M = [0, 1] \cup \{\emptyset\}$. For each state t, the agency chooses strategy $g_t : [0, 1] \mapsto M$ where $g_t(s)$ maps skills into messages M. Denote the set of possible g_t functions as G. Let $g = (g_L, g_H)$. There can be restrictions on $g_t(s)$ depending upon the environment (to be described later). Third, the employers observe the messages and decide which of the workers to try to hire. If more than one employer wants to hire a worker, then that worker's preference determines which employer hires him. Fourth, workers are paid wages, employers make profits, and agencies receive payoffs.

We will examine three different environments. In all three environments, agencies can choose whether or not to offer each individual worker to the employers. The environments differ in the form and precision of information that the agencies are able to send.

Full information Agencies must communicate the s_i of each worker, that is, they must tell the exact skill level of the workers offered to the employers. This requires that, for each state, the agency is restricted to using a strategy function $g_t(s) = s$ or $\emptyset$.

Bundles Under bundles, we restrict the agency to sending a message that equals the average skill of workers with that message – they are bundled together and the average skill of the bundle is sent to the employer.

This is equivalent to the following restriction on $g_t(s)$ for each state $t \in \{L, H\}$. For each message $m \neq \emptyset$ used (that is, there exists an s such that $g_t(s) = m$), if there is a unique s such that $g_t(s) = m$, then $g_t(s) = s$, otherwise we have the following property, which formally is the restriction of the message to equal average skill:

$$m \cdot \int_0^1 \mathbf{1}_{g_t(s)=m} dF_t = \int_0^1 \mathbf{1}_{g_t(s)=m} s dF_t. \tag{1}$$

Stars As with the other environments, the employer does not know the state t directly. With stars, there is no restriction on g_t, limiting what the employer can infer from the messages, however, the employer does know the distribution of messages.

This can be thought of as a star rating for each worker where the rating is the message. The employer sees the star rating but does not know the distribution of skills for each rating, just the distribution of ratings.

There are two key dimensions that separate the environments. First, under full information, the agency is restricted to sending fine information in the sense that if two workers have different skills, the employer will receive two different messages. In bundles and stars, the agency can provide coarse information, meaning that they can send the same message for two workers with different skills. Second, in full information and bundles, the content of the messages is determined by the skills of the workers whereas for stars, the agency can choose the messages regardless of the skills of the workers.[10]

For all three environments, in each state $t \in \{L, H\}$, the employer sees the cumulative distribution of messages $z(m)$ generated by g_t and F_t, that is,

$$z(m) = \int_0^1 \mathbf{1}_{g_t(s) \leq m} dF_t. \tag{2}$$

Denote Z as the set of all possible z (cumulative distributions of messages). The employer sees a message for each employee and makes a hiring decision based upon that and the distribution of messages. Thus, $h : M \times Z \mapsto [0, 1]$, which maps the message and the distribution of messages into a probabilistic hiring decision.

Let $q : G \times \{F_L, F_H\} \mapsto Z$ be such that $q(g_t, F_t)$ and g_t satisfy equation (2) for each $t \in \{L, H\}$. The expected utilities of the agency u_a and employer u_e are as follows:

$$u_a(g, h) = \sum_{t \in \{L,H\}} \theta_t \int_0^1 h(g_t(s), q(g_t, F_t)) dF_t,$$

$$u_e(g, h) = \sum_{t \in \{L,H\}} \theta_t \int_0^1 h(g_t(s), q(g_t, F_t))(s - w) dF_t.$$

2.2 Equilibrium concepts

For simplicity, we consider the case of one agency and one employer. We do not assume the agency has the ability to commit to a strategy g.

A **Nash equilibrium** is a set of strategies g^* and h^* where g^* maximizes u_a given h^* and h^* maximizes u_e given g^*.

[10] Note that an alternative to the verifiable communication in bundling would be to allow the agency to send a verifiable signal about the skill level, such as a range that must include the true signal or the agency is given a choice between sending the true skill level or no signal at all as in Jin et al. (2021). Theoretically, these should unravel to reporting the true skill level (Milgrom, 1981).

We use perfect-Bayesian equilibria as a refinement since the employer observes the distribution of messages z but not t or g. The distribution of messages is an information set that may be reached by several branches consisting of different g_t functions and states t. The employer forms beliefs about g and t from z, which we denote by $b : Z \times G \times \{L, H\} \mapsto [0, 1]$. Function b is the employer's belief about the probability of a combination of g and state (L or H) after observing z. Define $G_{t,z} \subset G$ as the set of all g_t functions for state t that generate z. For each z (information set), we have the restriction the sum of probabilities must add to one over the feasible g_t functions, that is,

$$\sum_{t\in\{L,H\}} \int_{g_t\in G_{t,z}} b(z, g_t, t)dg_t = 1 \text{ for all } z \in Z.$$

We call the set of feasible beliefs $\mathcal{B}$.

We now define expected profits of the employer $w_e(z, h, b)$ given beliefs:

$$w_e(z, h, b) = \sum_{t\in\{L,H\}} \theta_t \int_{g_t\in G_{t,z}} b(z, g_t, t) \int_0^1 h(g_t(s), q(g_t, F_t))(s - w)dF_t dg_t.$$

A belief b is consistent with g and θ_t if

$$b(q(g_t, F_t), g_t, t) = \begin{cases} \theta_t & \text{if } q(g_L, F_L) = q(g_H, F_H), \\ 1 & \text{otherwise.} \end{cases}$$

A **perfect-Bayesian equilibrium** is a set of strategies g^* and h^* and beliefs b^* such that (i) h^* maximizes $w_e(z, h)$ given beliefs b^* for all z in Z, (ii) g^* maximizes u_a given h^*, (iii) beliefs b^* are both feasible and consistent with g^* and θ_t.

2.3 Stage game equilibria

While straightforward, we begin by describing equilibrium behavior under full information in a one-shot setting. If offered a worker of skill s_i, an employer would be willing to hire a worker if $s_i \geq w$ and not willing otherwise. Thus, the employer hiring if and only if $s_i \geq w$ can be an equilibrium strategy. On the other side, if an employer uses this strategy, an agency would offer all such workers and be indifferent to offering the other workers (since they would not be hired). This logic leads to the first Proposition.

Proposition 1. *Under full information, there is a perfect-Bayesian equilibrium where a worker is hired if and only if $s_i \geq w$.*

Proof. Say that the agency uses $g_t(s) = s$ and the employer has consistent beliefs and uses

$$h(m, z) = \begin{cases} 1 & \text{if } m \in [w, 1], \\ 0 & \text{otherwise.} \end{cases}$$

In such a case, neither the agency nor the employer has an incentive to change their strategy. For the agency, any change would either lower employment or keep it the same. For the employer, any change would either employ workers with skill less than w or not employ workers with skill greater than w. □

Define $F(s) = \sum_t \theta_t F_t(s)$. From Proposition 1, ex-ante each worker has probability $1 - F(w)$ of being hired. Each employer has expected profits of

$$\int_w^1 (s - w) dF(s). \tag{3}$$

We note that there are also other Nash equilibria. These will consist of equilibria where a subset of the workers are not offered and not hired whether or not they are offered. There is no incentive for either agency or employer to change their strategy. These equilibria are less plausible than the perfect Bayesian equilibrium because the strategy of the employer not hiring all workers where $s > w$ is weakly dominated.

We now look at equilibria under bundles. In the equilibria, workers are divided into two groups: those with higher skills that will be employed and those with lower skills that will not be employed.

Proposition 2. *For any $\hat{m} \geq w$, there exists a Nash equilibrium under bundles where: (i) The employer hires a worker in a bundle if and only if the bundle's average skill is at least $\hat{m}$. (ii) For each state t, the agency offers a single bundle that maximizes the number of workers subject to the average skill of the workers in the bundle is at least $\hat{m}$.*

Proof. Say that the employer uses the following hiring decision:

$$h^b(m, z) = \begin{cases} 1 & \text{if } m \in [\hat{m}, 1], \\ 0 & \text{otherwise.} \end{cases}$$

This means that the employer chooses to hire if the average skill in the bundle is $\hat{m}$ or higher regardless of z. Now say that the agency uses

$$g_t(s) = \frac{\int_{s_t^*}^{1} s dF_t(s)}{\int_{s_t^*}^{1} dF_t(s)}$$

for all $s \geq s_t^*$ and 0 otherwise, where

$$s_t^* = \min\{\hat{s} : \int_{\hat{s}}^{1} s dF_t(s) - \hat{m} \int_{\hat{s}}^{1} dF_t(s) \geq 0\}.$$

Neither the agency nor the employer has an incentive to deviate. If the agency increases the number of workers in the bundle, it would lower the average skill to below $\hat{m}$ and none will be hired (and there is no incentive to decrease the number of workers). The employer accepts all profitable bundles sent in equilibrium so deviating to accepting less will be costly and there is no incentive to lower the standard of acceptance to below $\hat{m}$ since in equilibrium those bundles will not be sent. In addition, this maximizes employment for each state t subject to the average skill being at least $\hat{m}$. □

Corollary 1. *In a Nash equilibrium, employment may be higher in bundles than in full information.*

Proof. Take $F_L(s) = F_h(s) = s$ and $w = 0.6$. With full information, only those with skills above 0.6 will be hired. Under bundles there is an equilibrium where $g_t(s) = 0.6$ for all $s \geq 0.2$. □

Remark 1. *There exists a Nash equilibrium with multiple messages that have workers hired on more than one message. Take $F_l(s) = F_h(s) = s$ and $w = 0.6$. We can have*

$$g_t(s) = \begin{cases} 0.875 & \textit{if } 0.75 \leq s, \\ 0.625 & \textit{if } 0.5 \leq s < 0.75, \\ \emptyset & \textit{otherwise.} \end{cases}$$

The employers will accept workers from bundles if the distribution of messages overall has at least half the workers given the message of $\emptyset$*.*

When $F_L(s) = F_H(s) = s$ for all s, an equilibrium with the highest level of employer profit has $g_t^*(s) = \emptyset$ if $s < w$ and $(1 + w)/2$ otherwise. For general distributions, this is true for $g_t^*(s) = \emptyset$ if $s < w$ and $\int_w^1 x dF_t(x) / \int_w^1 dF_t(x)$ otherwise. This ensures that the employer hires a worker if and only if for his/her skill level it is profitable to do so.

Proposition 3. *Under bundles, the perfect-Bayesian equilibrium results in the highest level of employment achievable in a Nash equilibrium.*

Proof. In a perfect-Bayesian equilibrium, the employer must hire all workers with a message greater than w (and won't hire workers with a message strictly less than w). Thus, so that the agency has no incentive to deviate, they should not be able to add workers to a bundle while keeping the message greater than w. Hence, for each state t, any message where workers are hired should either have an average skill equal to w for that message or all workers are hired for state t (whereupon the average skill could be strictly higher than w). Let us call this condition **minimum bundle skill**. Note that minimum bundle skill implies that, in equilibrium, if some workers are not hired in state t, then all workers hired in state t must be in the same bundle (there is only one message sent for workers that are hired).[11]

Furthermore, if the average skill for a message is w, then, in equilibrium, there must be **monotonicity** of hiring in skill level - if a worker of level s is hired, then a worker of skill level $s' > s$ is also hired. If monotonicity does not hold, the agency can replace the lower skill worker with a higher skill worker and increase the average skill to strictly above w. This would allow the agency to expand the number of workers since the bundle would then violate the prior condition of minimum bundle skill.

[11] Recall that the message sent is the average skill of the bundle. Hence, if we had two different bundles of workers, they must have different average skill levels. This would imply that at least one would have a skill level not equal to w. Under minimum bundle skill, this can only happen if all workers are hired, which is not the case.

Monotonicity and minimum bundle skill imply that for each state t one message will be sent that includes all workers with skills above a cutoff such that either all workers are included or the average skill above the cutoff equals w.

The outcome of this perfect-Bayesian equilibrium is the same outcome of the Nash equilibrium in Proposition 2 for $\hat{m} = w$. This is the highest employment Nash equilibrium. $\square$

We can use the example in Remark 1 to illustrate Proposition 3 demonstrating that there is a profitable deviation by the agency. Denote the g_t function in Remark 1 as g_t^r. Employers will accept half the workers (all those offered). However, consider the following g functions

$$g_t^d(s) = \begin{cases} 0.65 & \text{if } 0.3 \leq s, \\ s & \text{otherwise.} \end{cases}$$

This would generate the z function of

$$z^d(m) = \begin{cases} m & \text{if } m \leq 0.3, \\ 0.3 & \text{if } 0.3 < m \leq 0.65, \\ 1 & \text{otherwise.} \end{cases}$$

In a PB equilibrium beliefs b^* from seeing z^d (in bundles) must be consistent with having g_t^d being the g function generating it. Hence, the employer will hire all workers with message 0.65 which leads to employment of 70% of the workers, a profitable deviation from g_t^r.

We now start to examine the equilibria in stars with the following proposition.

Proposition 4. *In stars:*
(i) There exists a Nash equilibrium where a constant fraction of workers are hired (independent of state).
(ii) There does not exist a separating equilibrium where the employer hires different fractions of workers depending upon the state.

Proof. (i) There exists two equilibrium cutoffs s_L and s_H where $F_H(s_H) = F_L(s_L)$ and $\hat{s} = \frac{\theta_L \int_{s_L}^1 s dF_L + \theta_H \int_{s_H}^1 s dF_H}{1 - F_L(s_L)}$ for some $\hat{s}$ where $1 > \hat{s} \geq w$ and

$F_H(\hat{s}) < 1$. All workers with skill above their respective cutoffs will be hired with the following equilibrium strategies for $\hat{m} > 0$.

$$g_t^*(s) = \begin{cases} \hat{m} & \text{if } s \geq s_t, \\ \emptyset & \text{otherwise.} \end{cases}$$

The employer only hires a worker if the message is $\hat{m}$ and the distribution of messages is $q(g_t^*, F_L)$, that is,

$$h^*(m, z) = \begin{cases} 1 & \text{if } m = \hat{m} \text{ and } z = q(g_t^*, F_L), \\ 0 & \text{otherwise.} \end{cases}$$

Note that in the above F_L and F_H are interchangeable.

(ii) Suppose that there exists such a separating equilibrium. If in state t' there is a higher fraction hired than in state t'', the agency can imitate the strategy of state t' when the state is t''. It can do so by sending $g_{t''}(s) = g_{t'}(F_{t'}^{-1}(F_{t''}(s)))$. This sends the same distribution of messages by sending the same message by percentile of skill in each state t'' as in state s'. □

Corollary 2. *In stars when $F_L = F_H$, there exists a Nash equilibrium where for each state the average skill of those hired is at least w.*

We now wish to refine the set of Nash equilibria, using PB equilibria with a certain type of beliefs of the employers which we call ***sorted***. Simply put, the employer believes that a higher message implies a weakly higher skill level. In terms of the belief function, $b^*(z, g, t)$, it requires that $b^*(z, g, t) = 0$ if g is not weakly monotonic in skill.

This monotonicity seems natural with star ratings, namely that higher stars imply a high skill level.

We now define the requirement that beliefs have to be feasible. A **feasible** belief $b(z, g)$ has two conditions: (i) If for all z, g and t where $b(z, g, t) > 0$, we have $z = q(g)$, and (ii) For all z, we have

$$\int_{G, t \in \{L, H\}} b^*(z, g, t) dg = 1.$$

Proposition 5. *When $F_L = F_H$, under sorted beliefs, the PB equilibrium in stars with identical outcomes to the PB equilibrium in bundles.*

Proof. Since $F_L = F_H$, we can have beliefs independent of state which we will denote as $b(z, g)$. Now we can show the following: When beliefs are sorted and feasible, for each z, there is a unique g' such that $b(z, g') = 1$ (and hence $b(z, g) = 0$ for all $g \neq g'$.)[12]

Let us say that there are two functions g' and g'' where $g'' \neq g'$ such that $b(z, g'), b(z, g'') > 0$. For feasibility, we must have $z = q(g') = q(g'')$. Since $g' \neq g''$, there must exist an s' such that $g'(s') \neq g''(s')$. Without loss of generality assume $g'(s') > g''(s')$. Sorted beliefs implies that both g' and g'' are weakly monotonic. Since $q(g') = q(g'')$, we must have

$$z(g'(s')) = z(g''(s')) = F(s'). \tag{4}$$

However, since $g' \neq g''$, there must be an $s'' > s'$ such that $g''(s'') = g'(s')$. From substituting $g''(s'')$ for $g'(s')$ into equation 4 , we have $z(g''(s'')) = F(s')$. We must also have $z(g''(s'')) = F(s'')$ by definition of z. This leads to a contradiction.

Since the employer can now determine which g function is used by the agency, the employer can infer the true expected skill of the worker for each message sent. Thus, the game is equivalent to that under bundles and it leads to the same PB equilibrium. □

Proposition 6. *(i) When $F_L \neq F_H$, the PB equilibrium in stars can lead to higher employment than the PB equilibrium in bundles.*
(ii) When $F_L \neq F_H$, the PB equilibrium in stars can lead to lower employment than the PB equilibrium in bundles.

Proof. We will prove both parts by way of example.

(i) Take F_L is uniform on $[0, 1/2]$ and F_H is uniform on $[1/2, 1]$, $\theta_L = 3/5$, $\theta_H = 2/5$ and $w = 1/2$. It is an equilibrium in stars, if the agency gives its top 80% workers a 5* rating and the 20% rest a 1* rating. Then, the average skill of those workers in the low state and high state are 0.3 and 0.8, respectively. Since $0.3 \cdot 0.6 + 0.8 \cdot 0.4 = 0.5$, the employer would agree to hire. Hence, 80% of the workers will be employed as opposed to 0 under

[12] We use this notation for simplicity, but technically we should be defining b as a Dirac delta function where $b(z, g') = \infty$ and hence $b(z, g) = 0$ for all $g \neq g'$ while $\int_G b^*(z, g, t)dg = \theta_t$.

no information and 40% under full information and bundles.[13]

(ii) Take F_L uniform on $[0, 0.1]$, F_H uniform on $[0.9, 1]$, $\theta_L = .6$, and $\theta_H = 0.4$. In this case, no one would be hired under stars while under full information and bundles all those in the high state will be hired. [14] $\square$

Aggregate uncertainty ($F_L \neq F_H$) allows us to understand the pros and cons of bundles and stars. Stars has the advantage of hiding the state when it is low so lets more workers be hired in the low state. Bundles has the advantage of variability so lets more workers be hired in the high state. Essentially, stars allows the state to remain hidden, while bundles allows the state to be revealed.

With full commitment by the agency to a strategy (Bayesian Persuasion), the agency can mimic either stars or bundles, whichever does the best. The agency may be able to strictly better by committing to a mixed strategy. We see this in the example in the proof of Proposition 6(ii). If the state is L, the agency can send 1* one-third of the time for all the workers and 5* two-thirds of the time for all the workers. If the state is H, the agency can send 5* all the time. With this strategy, the average skill for those with 5* will be precisely 0.5. An equilibrium thus exists with all workers with 5* getting hired. This will have 80% of the workers being hired. This is higher than the 0% employment in stars and 40% employment in bundles.

The preceding arguments lead to the following remark.

Remark 2. *Full commitment by the agency to a mixed strategy (Bayesian Persuasion) will do at least as well as either bundles or stars and can potentially do strictly better.*[15]

[13]Example (i) is like the UC system admitting students from California in the top 9 percent of their high school class independent of high school via the Eligibility in the Local Context program (the top 9% was the cutoff at the time of writing of this paper in 2021). This policy allows for more students from public schools to be admitted rather than relying on SATs or discriminating between high schools.

[14]Example (ii) This is like admissions to the top Economics PhD programs. Even the top student from certain universities will usually not be admitted. It is also true for hiring faculty. The best PhD students from certain lower-ranked schools will usually not be hired.

[15]We conjecture that full commitment is strictly better if the highest employment equilibrium from either bundles or stars leaves the employer strictly positive profit.

2.4 Punishment strategy equilibria

The equilibria described so far sometimes leave the employer with positive profit. In this section, we consider whether repeated interaction and punishment can change the range of employment levels obtainable. First, we note that any stage game equilibrium can also be an equilibrium in a repeated setting. There can also be repeated game equilibria, where a higher level of employment or employer profits can be supported by repeated interaction and punishment. To examine this, we assume that the stage game is repeated for an infinite number of periods and there is a discount factor $\delta \in (0,1)$ where a profit of one in period $t+1$ is worth δ in period t. After each period, the employers learn the skill of the workers that they hired. The agency learns who was hired and by which employer.

In the employer-agency relationship, both sides can punish the other. Employers can punish agencies by not hiring workers. Agencies can punish employers by not offering workers (withholding workers).

In the following proposition, we characterize the range of possible employment levels.

Proposition 7. *When $F_L = F_H$, repeated play can increase the range of equilibrium employment levels compared to one-shot play under full information but not bundles and stars.*

Proof. As with the proof of Proposition 4, let s' be the value that solves $w = \frac{\int_{s'}^{1} sdF}{1-F(s')}$. Under full information, for any ρ satisfying $s' < \rho \leq w$, there exists a large enough discount rate δ, such that there exists an equilibrium where workers with skill level above ρ are employed. The strongest punishment strategy when implemented yields zero profits to both parties. Hence, any equilibrium with positive profit for the employer can be supported. To see this, denote e as the employer period earnings. Denote m as the maximum profit earned by the employer by deviating from this equilibrium. Deviations are not profitable if $m < \frac{e}{1-\delta}$.

There is no improvement in bundles or stars, since by Proposition 2 and 4, this level is already potentially a Nash equilibrium. $\square$

While the above proposition states that repeated game effects cannot increase the range of equilibria in bundles and stars when $F_L = F_H$, we can have an improvement when $F_L \neq F_H$ as seen in the next proposition.

Proposition 8. *When $F_L \neq F_H$, under certain distributions, the repeated game equilibrium may improve employment over the one-shot equilibrium by using a particular cutoff skill level for employment (being offered).*

Proof. We will prove this by way of example.

Take F_L is uniform on $[0, 2/3]$, F_H is uniform $[1/3, 1]$, $\theta_H = \theta_L = 1/2$, $w = 2/3$. In the one shot equilibria, the highest employment equilibria will be as follows: under full information, only 25% of the workers will be employed (half the workers in the high state); under bundles, 50% of the workers will be employed (only the workers in the high state); and under stars, 50% of the workers will be hired (half in each state).

With repeated game considerations, employment can be increased under all three conditions to 60% by having only workers with skill above 13/30 being offered in either state with employers hiring them. In the low state, the employer hires 35% of workers with average skill of 0.55. In the high state, the employer is hiring workers 85% of workers with an average skill of 0.717. Overall, the average skills of those hired is slightly higher than 2/3. This is better for both parties.

This can be supported by the agency withholding workers if the employer deviates or the employer not hiring if the agency deviates. □

In the full information environment, the set of repeated equilibria is larger than the set of one-shot equilibria. In particular, in one-shot, no worker with a skill level strictly under w can be hired in equilibrium, but this can be supported in repeated play by withholding workers to punish the employers. While for bundles and stars, the range of equilibria is the same for both repeated and one-shot games, the mechanism supporting them can be very different. For instance, the high employer profit equilibrium can only be supported as a Nash equilibrium under one-shot with bundles since the employer would not refuse a bundle offering positive profit. However, this can be supported under repeated play since the employer would refuse a lower bundle if it would maintain a higher profit equilibrium in the future.

While in this theory section, we assumed a continuum of workers, our experiment had a finite number of workers. We discuss in Section 4 how this affects our results in particular with bundles for the high employment equilibrium, employers would sometimes have bundles where profits are negative. There is a limit to how much of a loss the employers would be willing to accept.

Finally, we note that our one-shot equilibria have some complementarities in that for a worker of a certain skill it is weakly better for the state to be H than L in bundles, while in stars it is weakly better for the state to be L than H. Both are strictly better for certain skill levels when $F_L \neq F_H$.

3 Design

A total of 240 subjects participated in the experiment, 80 in each of 3 treatments. The experiment was conducted in the FEELE lab at the University of Exeter and subjects were undergraduate students. Subjects played the agencies and the employers in equal numbers over a series of periods. The workers' decisions were made by a computer.[16] In each period, each agency received five workers each with skill s drawn *iid* from $(0, 1, \cdots, 10)$ with each value equally likely. Since skills are drawn *iid*, the particular draw of skill levels for all five workers can be relatively high or low similar to the two states of nature in the theory section.[17] Employers could hire up to five workers. For each worker hired, the agency earned one point and the employer earned $s - w$ where s was the worker's skill and w represented the wage and was fixed at 6. The wage was set to 6 in order for both the wage to be above the expected skill of the workers (which is 5) and to leave the possibility that a large number of workers are hired.

The timing of the experiment was as follows. At the start of the experiment, subjects read through a set of paper instructions.[18] Then each participant practiced both the role of the agency and the employer before being assigned a fixed role and group. The worker skill levels were redrawn for each agency each period. However, the same sequences of draws were used for each treatment. For example, agency 3 in period 4 would have the same worker skill draws in each of the treatments. An HTML5 user

[16]Workers always preferred to work and had random preferences over employers. We did not use subjects as workers since the decisions for them were fairly uninteresting.

[17]The number of different combinations of skill level of 5 workers with 11 different possible skills is 3003.

[18]A sample set of instructions is included as a supplementary file.

interface was used which enabled agencies and employers to make their decisions by dragging and dropping workers into bundles or rankings. Within each period, agencies chose which workers to offer and what information to reveal about their workers to employers. After seeing information about the workers from the agencies, employers decided which workers to send offers to.

From the 10$^{\text{th}}$ period onwards, there was a 10 percent chance of the game ending after each period. The number of periods differed between groups within a treatment but had equivalent groups between treatments. For example, group 2 lasted 17 periods in all treatments, while group 3 lasted 26 periods. The experiment lasted from 11 periods to 30 periods (average of 18.1 periods). Participants were paid for the last 10 periods completed.[19] For example, if the game ends after the 17$^{\text{th}}$ period, they would be paid based on their points from periods 8 to 17. Subjects received a show-up fee of £5 and £0.20 for each point earned in the ten paid periods. The experiment lasted between 45 and 75 minutes and the average payment was approximately £10.

We use a design consisting of three information structures. The information structures vary in how much an agency reveals to the employers about the skills of their workers:

Full information Agencies must tell the precise skill level of the workers offered. In the full-information treatments, the employer observes the skill of each worker before deciding which workers to hire.

Bundles The agency placed the workers into bundles of one or more workers. The mean skill and range of skills of workers in a bundle were revealed. The employers learned the true skill of individual workers only after they were hired.[20]

Stars The agency assigned each worker a star rating (1 to 5). There was no obligation that the star rating corresponded to the skill of the worker. The workers' true skill levels were only revealed to the employer if the employer actually hired them.

[19]Theoretically, this will be no different than paying for all the periods.

[20]If the bundle consists of one worker, then the employer learns the skill level at the time of hiring.

See the respective screenshots of each information structure in Appendices B, C, and D. Note that the full-information treatment can be regarded as the baseline.

4 Predictions

In this section, we apply our theoretical results to the parameters detailed in the design section accounting for a finite number of workers. There is generally a range of equilibria which we highlight below.

4.1 Stage game equilibria

With full information if subjects play as if they are in a one-shot game, in a subgame-perfect equilibrium all workers with skill 7 or higher would be hired and those with skill 5 or less would not be hired, those with skill 6 could either be hired or not be hired. This results in 36-45% being hired with the corresponding average skill of workers from 8.5 to 8, respectively.

With bundling, in a subgame perfect equilibrium, the agency creates a bundle by adding the worker with the highest skill not in the bundle until adding the worker would cause the bundle average skill to fall below 6. In expectation, this yields 67.2% being hired with average skill 6.5. We note that 11.5% of the workers with skill level 0 and 1 will be hired.

With stars, the highest employment can be achieved in equilibrium when the agency rates the three best workers 5-stars and the rest lower than 5-star (this is sustained since employer beliefs depend upon the number of workers in a particular category). This gives 60% employment and average skill 6.8. We note that 5.5% of workers with level 0 and 1 will be hired in such an equilibrium. The equilibrium with the highest employer profit has only two workers being offered (or given the highest rating).

4.2 Punishment strategy equilibria

In addition to the stage game equilibria, in repeated games we can have equilibria sustained with the threat of punishment. The agency can punish employers by withholding workers in subsequent periods. Employers can punish agencies by not hiring in subsequent periods. Punishment is limited by the 10% chance of the experiment ending after the tenth period. Some punishments may be less plausible than others, for instance, under full information an agency withholding workers that would be attractive to an employer or an employer not hiring a worker that would yield profit might not be credible, but under stars this could be more palatable since true skill is not known to the employer.

There is a straightforward equilibrium where employers make their maximal profits. Agencies offer all workers at level 6 or above, 45% of workers (also, 7 or above, 35% of workers, is a similar equilibrium). Employers punish if a worker is offered that does not satisfy this criterion. Agencies do not have an incentive to deviate by offering fewer workers (which would not be detected) and would be punished by offering more workers. This is the case under full information, bundles, and stars.

Under full information, an agency can use the threat of withholding workers to have all workers with 3 or above hired. The employer would still hire all 5 workers even if they all have a skill level of 3. The average skill level of a worker given that they have a skill level of 3 or higher is 6.5. There is an 8/11 chance of a worker having a 3+ skill level. Hence, each period the employer expects to make $(8/11) \cdot 5 \cdot (6.5 - 6)$. Discounting the expected stream of profits yields 16.4 which is higher than the cost of hiring 5 workers with skill level of 3. We note that there are more complicated equilibria where some of the workers with skill level 2 are hired.

With bundles, the agency can increase bundle size up to a certain limit and still have an employer hire everyone in the bundle. By doing so, an employer may lose a certain amount. If the agency limits this amount to L, the employer may be willing to bear this loss if the future expectation of such an arrangement is high enough. For instance, say the agency sets $L = 3$ and if bundling all 5 workers yields a loss larger than 3, the agency will see if offering the best 4 workers yields a loss larger than 3. Again, if so, this can be repeated by offering the best 3 workers and so on. By computation, using $L = 3$ yields an employer profit of 0.020 versus using $L = 2$ yields a profit of 0.656. We see that a loss of 3 would not be tolerable to an employer with a discount rate of 0.9. However, losing 2 today is well worth an expected stream of profits equaling 0.656. In this case, employment will be 75.8% and average skill 6.2.

Under stars, there can be higher employment in equilibrium than with bundles. This is because with stars the employer knows the expected skill when deciding whom to hire and only sees the actual skill after hiring workers. The agency can give a 5-star rating to all those workers with skill level of 2+ (and workers with skill level of 1 or 0 a rating of 1-star). This on average would leave the employer with zero profits but would still be an equilibrium. In each period, after seeing the workers offered, the expected profit would be 0 for an employer.[21] Any deviation by the agency can be detected by the employer and can be punished by no hiring in the future. At most, the agency can have five more workers hired by giving five skill 0 workers a 5-star rating. Doing so, would not be worthwhile since it would lose an average of 4.1 workers being hired in each future period.

Finally, in all cases, there are other equilibria between the two extremes. Note that the use of repeated game strategies can increase employment in equilibrium. Under full information and stars, there will be no skill level 0 and 1 hired in the equilibrium that we examine. Under bundles this would happen some of the time such as when one worker has skill level 0 and the other workers have a skill level of 7+. In our repeated game equilibrium, 20.3% of level 0 and 1 workers will be hired in equilibrium.

5 Results

We start by looking at the employment, employer profits and average skill level of employed workers in each treatment. There is a constraint restricting the average skill of employed workers and the level of employment achievable. The outcomes of each treatment and the employment-average skill trade-off as well as the theoretical limits of employment are illustrated in Figure 1. The frontier (solid line) shows the trade-off and the iso-profit lines show combinations of employment and average skill that give the employer the same profit. Note that points `stage game 1, full info` and

[21] We can give an employer an arbitrarily small amount of profit with the following strategy. The agency gives a 5-star rating to all workers with skill level 2 or above when there are two or more workers. When there is a single worker with a skill level of 2+, the agency only gives a 5-star rating to this worker when the skill level is 3+. This can be done every n periods to make the profit arbitrarily small.

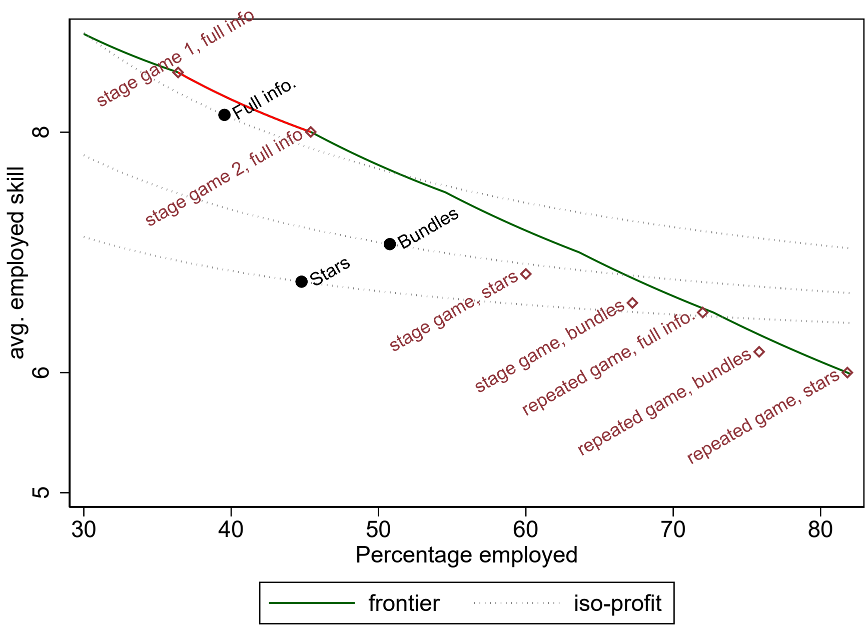


Figure 1: Plot of the average skill level of employed workers versus the number employed for each treatment. The solid dots are the empirical observations, while the hollow dots are the theoretical limits of employment. Treatment averages are the average of group averages, so that all groups have equal weight. The isoprofit curves of employers are dashed. The solid curve is the limit of the feasible possibilities. The points on the section of the curve labeled `stage game 1, full info` and `stage game 2, full info` are the feasible combinations that give the highest profit curve.

`stage game 2, full info` in Figure 1, correspond to the endpoints of the range given in Section 4.1 that are achievable in a stage game equilibrium under full information, that is, when the workers with skill 6 are never hired and always hired, respectively. Numerical values are reported in Table 1. For employment, bundles did the best and full information did the worst. For employer profits, full information did the best and stars did the worst. For average skill, full information did the best and stars did the worst.[22]

After establishing full information as a benchmark, we are ready to

[22]In our sample, if all skill 6 and above are employed, the level of employment is 821 (out of 1810) with average skill of 8.02. If only skill 7 and above are employed, the level of employment is 673 with average skill of 8.47. In both cases, there are employer profits of 0.917 per worker (including those unemployed). This compares with section 4.1 prediction of an average skill level of 8 and 8.5, respectively and profits of .909.

Table 1: Average profits and employed skill for each treatment

treatment	agency-profits	employer-profits	employed avg. skill
full info	0.395	**0.841**	**8.144**
bundles	**0.508**	0.505	7.069
stars	0.448	0.328	6.757

Notes: Different groups completed different numbers of periods. Hence, treatment averages are calculated from group averages. The highest figure in each column is in bold.

Figure 2: Number of workers offered and employed by skill level for each treatment

examine the effect of moving away from full information. This leads to the first result of our paper.

Result 1. *Coarsening of information about workers increased employment at the expense of employer profits.*

We can see from Figure 1 and Table 1 that the employment is higher in the bundles and stars treatments where the agencies could release coarse information. This is supported by regression 1 of Table 2 where the probability of employment increases by 5 percentage points if information is coarse (in the bundles or stars treatments) compared to full information. Regression 2 disaggregates the effects of stars and bundles. The effect sizes for stars and bundles are similar to the effect size of coarse information in

Table 2: Probability of a worker being employed based upon treatment

	(1)	(2)
coarse-information	0.081***	
	(0.02)	
bundles		0.111***
		(0.02)
stars		0.051*
		(0.02)
constant	0.396***	0.396***
	(0.01)	(0.01)
clusters	120	120
N	11550	11550

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Linear probability models are estimated with one observation per worker per period. The dependent variable is whether the worker is employed. *Coarse information* equals one for the stars and bundles treatments and zero otherwise. *Stars, bundles and full-information* equal one for the respective treatments and zero otherwise. Standard errors are shown in parentheses with clustering at the level of agencies.

Table 3: Number of workers employed based upon skill

Treatment	$skill < 6$	$skill = 6$	$skill > 6$	total
full information	24	183	1,319	1,526
bundles	483	243	1,228	1,954
stars	484	188	1,051	1,723

regression 1, although for stars, it is not statistically significant at the 5% level (but is at the 10% level). We note that while there is an increase in employment, this is still far from the theoretical possible as one can see in Figure 1.

This can only happen if workers of level 5 skill or lower are hired. Indeed, Table 3 and Figure 2 show that employment increases are due to more low-skill workers being hired albeit at some cost of less high-skill workers being hired.[23]

We can see the change in both employment and employer profits in Figure 1. The coarsening of information decreased employer profits in all cases. The coarsening caused the employer profits to drop from 0.808 with full information to 0.522 with bundles and 0.245 with stars (see Table 1).

The coarsening of information also reduced the average skill of the employed. The coarsening caused the average skill of workers employed to drop from 8.031 with full information to 7.053 with bundles and 6.578 with stars (see Table 1).

Our next result, which might be our most interesting, shows a surprising yet intuitive difference between stars and bundles in how employment of lower-skilled workers is affected by other workers from the same agency.

Result 2. *With bundles, lower-skilled workers benefit when other workers are higher skilled, the opposite occurs in stars.*

The evidence of this result is in Table 4 which displays regressions examining the effect of others' skill on employment of low-skill workers. The dependent variable is being employed. There is one observation per worker with skill less than 6. Separate regressions are run for the bundles and stars treatments. There is a positive relationship to the average skill of others with bundles and a negative one with stars. The effect is statistically significant.

We see that low-skill workers are a complement to high-skill workers in bundles. This result comes from agencies including low-skill workers in bundles with high-skill workers while ensuring the average bundle skill is

[23] Note that from Figure 2 we see that in the star treatment there are more lower skilled workers hired (such as 0, 1, 2). This varied significantly based upon group. See Figure 4 in Appendix A.

Table 4: Regressions on low-skill workers where the dependent variable is being employed.

	(1) bundles	(2) stars
mean others' skill	0.060***	-0.041***
	(0.01)	(0.01)
period	-0.000	-0.006*
	(0.00)	(0.00)
constant	-0.070	0.503***
	(0.05)	(0.05)
clusters	40	40
N	2091	2091

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Linear probability models are estimated with one observation per worker per period. `'Mean other's skill'` is the average skill of the agency's other workers. The model is estimated separately using data from each of the treatments with coarse information. Standard errors are shown in parentheses with clustering at the level of agencies.

greater than 6. When the skill of the other workers goes up, the possibility of forming such a bundle that includes a low-skill worker goes up. This is consistent with the stage-game equilibria analysis for bundles of Section 4.1.

In contrast, high-skill workers are substitutes for low-skill workers with stars. This indicates that the agency is using a target for the number of 4 and 5 stars given out. When they fail to have the number of workers achieving the target with high skill levels, they use low skill levels to increase the number of workers.[24] This is consistent with the stage-game analysis for stars where the highest employment equilibria had the top 3 workers offered each time and the highest employer profit equilibria had the top 2 being offered each period. Hence, low-skill workers act as substitutes for high-skill workers.

Our next result was unanticipated and in order to precisely explain it, we need to introduce three definitions. For the star ratings, the agency

[24]We find empirical support for such behavior in that a regression of a worker being rated a 4-star or 5-star is negative in the average skill of the other workers. For brevity, we leave a table of these results out of the paper.

Figure 3: The breakdown of skills offered and hired for each rating star.

and employer can think of certain star ratings as a category for outstanding workers, like what we think of 5-stars in regards to hotels. Here we define such an **outstanding category** as one where the skill level guarantees a profit, namely, of skill 7 or higher. We also define a **borderline skill category** as one with skill levels of 5 or 6, for which the employer would be either indifferent or suffer a minor loss for hiring such a worker. We also introduce the definition of a worker being **employable** as when the employer would not lose by hiring that worker, that is, a skill greater than or equal to 6. We can now use the above nomenclature to describe our next result about how there were different star rating categories.

Result 3. *With stars, there were two main categories where workers of employable skills were both classified and employed. The 5-star category was for outstanding workers. The 4-star category was mostly for borderline workers.*

Our theory section finds that only one category of employable workers is sufficient to achieve the highest level of employment. Hence, the agencies' and employers' use of more than one category is not consistent with this.

We find support for Result 3 visually in Figure 3. For the 5-star rating, 68% of workers offered are outstanding workers compared with 8%, 10%, 17%, and 34%, for 1-star, 2-star, 3-star, and 4-star categories, respectively. For the 4-star rating, 29% of workers offered are borderline skill workers

Table 5: Number and average skill of those offered and employed for each star level

Star	Num. Offered	Num. Employed	$skill \geq 6$	Skill of Offered	Skill of Employed
5	1511	1178	1187	7.14	7.37
4	665	318	320	5.21	5.81
3	487	134	132	4.32	4.90
2	380	46	56	3.12	3.82
1	537	47	57	2.19	3.98

compared with 7%, 11%, 26% and 15%, for 1-star, 2-star, 3-star, and 5-star categories, respectively. While 3-star is also used for employable workers, the percentage of borderline and outstanding workers drops to 43% from 63% compared to 4-star.

We also see that from Table 5, the average skill level of a 5-star rating is 7.14 and the average skill level of a 4-star rating is 5.21. We would expect agencies to only make use of the 5-star category, but they put employable workers (those with skills greater than or equal to six) in the 4-star and 5-star categories. The 5-star is highly profitable for the employer, the 4-star is borderline. Employers respond by almost always hiring the 5-star workers and hiring some of the 4-star workers.[25] It is also interesting to note that the other star categories are meaningfully used in the sense that skill level is increasing going from 1-star to 2-star and from 2-star to 3-star. Theoretically, there is no reason for such behavior (nor a reason against it) since the expected skill of the workers in these categories is too low to be profitably employed.

In the second half of the experiment,[26] workers were increasingly hired only from the 5-star category. Overall, 68% of workers hired were from the 5-star category, while in the second half, 74% of workers hired were from the 5-star category. Thus, subjects behave closer to the theoretical predictions when they become more experienced.

Finally, we note that there is a degree of heterogeneity in individual

[25]One possible explanation for the use of a 4-star category in addition to the 5-star category is something similar to lying aversion (see Sánchez-Pagés and Vorsatz (2007)) where classifying mid-skilled workers as high skilled (via the 5-star category) would be distasteful for the agents and perhaps punished by the employers.

[26]Since the length of the experiment was randomly determined, we used the median decision to determine that the second half of the experiment started in round 10.

agency behavior. In Appendix A, Figure 4 displays the range of worker skills for each individual agency. While most have a strictly positive relationship between skills and star ratings, we see, for instance, Agency 7 in Figure 4 consistently only offered workers of skill 6 and above and only labeled them 5-star.

We wish to examine whether or not the agencies can create a reputation. To do so, we analyze decisions of the employers based upon the observed skills of the workers previously hired from the agency. Our findings are summarized in the following result.

Result 4. *With star ratings, the reputation of an agency affects the employers' willingness to employ a worker, namely, higher previous observed skill in the star category from the agency increased the likelihood of a worker receiving an acceptance.*

Models are estimated using workers with 4 or 5 star ratings. See the regression reported in Table 6. For instance, model (1) considers workers with a 4-star rating. The dependent variable is 1 if the employer was willing to hire the worker and 0 otherwise. The explanatory variables are as follows. *Unobserved* is 1 if the employer has never hired a worker with the current star rating from the agency offering the worker and 0 otherwise. *Observed* is the mean skill of workers with the current star rating that the employer has previously hired from the agency offering the worker or 0 if no such workers have been hired. *Period* is the period number.

The coefficient on *observed* is positive and significant for both models. This suggests that employers were more willing to hire workers with a given star rating the higher the skill of previously hired workers from the same agency with the same star rating. This in turn suggests there was some learning rather than immediate coordination between the agency and the employer on the meaning of star ratings. Furthermore, the expectations of skill level are higher for 5-star than 4-star. By looking at the ratio of the coefficients for unobserved to observed, there is a drop in willingness to hire if the skill level averages below 4.96 for 4-star, but 8.83 for 5-star. This indicates a very high initial expectation for a 5-star category. Theoretically, this should be much lower.

Table 6: Willingness to hire workers given the observed skill of previous workers with the same star rating

	(1)	(2)
	4 stars	5 stars
unobserved	0.551^{*}	0.627^{**}
	(0.23)	(0.20)
observed	0.111^{***}	0.071^{**}
	(0.03)	(0.02)
round	-0.012^{*}	0.004
	(0.01)	(0.00)
constant	-0.010	0.219
	(0.19)	(0.20)
clusters	39	40
N	665	1511

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Linear probability models are estimated with one observation per worker per employer. Models are estimated using workers from a particular treatment with a particular star rating. Standard errors are shown in parentheses with clustering at the level of groups.

6 Discussion

Our theoretical analysis shows that employment can be higher (than full information) in both bundles and stars by releasing coarse information. In some environments stars can achieve higher employment than bundles and in other environments bundles can achieve higher employment than stars. However, there is a range of possible equilibria that may occur in an agency-employer game. We then use experiments to examine what is likely to play out in practice. Doing so, we find that an agency can increase worker employment by only revealing coarse information about workers (our bundle treatment) and this information does not have to be verifiable (our stars treatment).

While in theory we found a possible alternative means for increasing employment by an agency punishing employers through withholding high-skill workers, we did not see the high level of employment that this would induce.

In our experiment, bundles and stars both yielded higher employment than full information, but bundles outside the lab might be harder to implement since it requires verification. Our experimental results suggest that this extra cost of using verifiable information might not be necessary. One difference that we find between stars and bundles is that with stars, workers with high and low skills are substitutes whereas with bundles they are complements. This is like being a sprinter in the Olympics. Strong teammates hurt your chances of making the Olympics in an individual event but increase your chances of making the Olympics in the relay races.

One may worry that the proposed mechanism might only temporarily increase employment. The employer may wish to dismiss workers after discovering that they are low skilled. While indeed an employer may eventually discover this, the employer may still want to retain a significant portion of these workers. There are three reasons for this beyond basic switching costs. First, some workers may learn valuable skills (some firm-specific) on the job. This learning may be a result of considerable sunk-cost investment by the firm. Second, some of the workers might be underrated: the initial signal might not fully represent the worker's ability. Once given the chance to prove himself/herself, the worker may shine. This could be particularly true for workers caught in a trap of not being given a chance after an initial lower signal or in the case of a first job (see Stanton and Thomas, 2016). Bleemer (2021) finds a similar benefit to these first two points holding for the California ELC program with admissions to the UC universities. While those admitted solely by being in the top 9% of their high school class had test scores only on the 12$^{\text{th}}$ percentile of those admitted, there was a significant and substantial benefit to their future earnings.[27] Finally, for worker retention there could be a multiplier effect in that a firm's willingness to hire workers increases with other firms hiring workers (due to increased demand).

There is growing governmental interest in involving the private sector to help with job placements. The success is mixed. In 2010, the UK government adopted a series of steps to help unemployed people back to work. The program which is currently called the Work and Health Programme is designed to help long-term unemployed, people with disabilities, and people

[27]Being admitted via this program increased the five-year degree attainment by 30 percentage points and annual early-career wages by up to $25,000.

who are considered vulnerable find employment.[28] The program includes offering training, help in writing CVs, etc. Providers were paid according to the number of unemployed who were placed. Between November 2017 and November 2019, a total of 121,710 individuals in England and Wales were referred (a fifth of whom were long-term unemployed) and resulted in 10,260 jobs. Given the low success thus far, our results suggest that there is room for a government to delegate job placement to an agency that has the authority to restrict information about workers. This can be a low-cost complement to existing government programs.

Our approach could also be used to improve the employment prospects of refugees. Dumont et al. (2016) report that the employment rate of refugees in the EU is nine percentage points lower than native-born persons and that it can take 20 years before refugees have similar employment prospects. While refugees are on average less educated than natives, employed well-educated refugees are more likely to be overqualified for their jobs than natives. This suggests that at least part of the problem relates to information. Employers will often have difficulties evaluating refugees' qualifications, particularly if documentation is missing or not verifiable. It seems there is a natural role for an agency to provide information about skills of refugees in this setting. Our work suggests that full disclosure might not maximize employment.

While there is potential to improve employment with our suggestion, care must be taken when trying to implement this as a policy tool. It is necessary that those bundled together have the same expected skill conditional on observable characteristics. Otherwise, it is possible that employers further divide by this characteristic (use statistical discrimination). Indeed, Doleac and Hansen (2020) find that an attempt to increase the employment of those with criminal records by banning a question about it early in the hiring process had the unintended consequence of decreasing employment of young black men (presumably since they were all grouped together). Also, while we take skills of workers as exogenous, further work may consider the impact the design of the rating system will have on workers acquiring skills. Research by Jin and Leslie (2003) discovered that having food

[28]Eriksson and Rooth (2014) confirm with a field experiment the difficulty for the longterm unemployed to get back to work.

hygiene ratings displayed in restaurant windows led to not only customers switching to more hygienic restaurants but the restaurants themselves improving hygiene.

While our intent was to look at worker placement programs, our results have wider implications. In particular, we shed light on whether or not rating agencies should be regulated. In the US, farm produce quality is classified by the USDA. There is scope for a classification of mixed quality, making it easier to sell low quality produce and avoid waste. For financial products, regulation may be in order since it may be undesirable that high risk bonds, mortgages, etc. are sold (as part of a bundle) without the purchaser being aware of the details. Once purchased, the new owner may not learn the true risk, only the realization of the risk. The ratings of hotels both through a star rating and brand categories such as Marriott, Hilton and IHG (Holiday Inn) tend to be unregulated. Our stars treatment shows that such a mechanism can work even if what makes a 5-star hotel is not always codified.

References

Bleemer, Z.: 2021, 'Top percent policies and the return to postsecondary selectivity'. *Working Paper, SSRN 3272618.*

Brown, M., C. J. Flinn, and A. Schotter: 2011, 'Real-time search in the laboratory and the market'. *American Economic Review* **101**(2), 948–74.

Card, D., J. Kluve, and A. Weber: 2010, 'Active labour market policy evaluations: A meta-analysis'. *The Economic Journal* **120**(548), F452–F477.

Card, D., J. Kluve, and A. Weber: 2018, 'What works? A meta analysis of recent active labor market program evaluations'. *Journal of the European Economic Association* **16**(3), 894–931.

Charness, G. and P. Kuhn: 2011, 'Lab labor: What can labor economists learn from the lab?'. In: *Handbook of Labor Economics*, Vol. 4. Elsevier, pp. 229–330.

Crawford, V. P. and J. Sobel: 1982, 'Strategic information transmission'. *Econometrica: Journal of the Econometric Society* pp. 1431–1451.

Crépon, B. and G. J. Van Den Berg: 2016, 'Active labor market policies'. *Annual Review of Economics* **8**, 521–546.

Doleac, J. L. and B. Hansen: 2020, 'The Unintended Consequences of "Ban the Box": Statistical Discrimination and Employment Outcomes When Criminal Histories Are Hidden'. *Journal of Labor Economics* **38**(2), 321–374.

Dranove, D. and G. Z. Jin: 2010, 'Quality Disclosure and Certification: Theory and Practice'. *Journal of Economic Literature* **48**(4), 935–63.

Dumont, J.-C., T. Liebig, J. Peschner, F. Tanay, and T. Xenogiani: 2016, 'How are refugees faring on the Labour Market in Europe? A first evaluation based on the 2014 EU Labour Force Survey ad hoc module'. Technical Report 1, European Commission DG Employment Working Paper.

Dustmann, C., A. Glitz, U. Schönberg, and H. Brücker: 2015, 'Referral-based Job Search Networks'. *The Review of Economic Studies* **83**(2), 514–546.

Eriksson, S. and D.-O. Rooth: 2014, 'Do employers use unemployment as a sorting criterion when hiring? Evidence from a field experiment'. *American Economic Review* **104**(3), 1014–39.

Gelber, A., A. Isen, and J. B. Kessler: 2015, ' The Effects of Youth Employment: Evidence from New York City Lotteries'. *The Quarterly Journal of Economics* **131**(1), 423–460.

Haruvy, E., A. E. Roth, and M. U. Ünver: 2006, 'The dynamics of law clerk matching: An experimental and computational investigation of proposals for reform of the market'. *Journal of Economic Dynamics and Control* **30**(3), 457–486.

Heller, S. B.: 2014, 'Summer jobs reduce violence among disadvantaged youth'. *Science* **346**(6214), 1219–1223.

Holzer, H. J.: 2007, 'Collateral Costs: The Effects of Incarceration on the Employment and Earnings of Young Workers'. IZA Discussion Papers 3118, Institute of Labor Economics (IZA).

Jin, G. Z. and P. Leslie: 2003, 'The Effect of Information on Product Quality: Evidence from Restaurant Hygiene Grade Cards'. *The Quarterly Journal of Economics* **118**(2), 409–451.

Jin, G. Z., M. Luca, and D. Martin: 2021, 'Is No News (Perceived As) Bad News? An Experimental Investigation of Information Disclosure'. *American Economic Journal: Microeconomics* **13**(2), 141–73.

Kagel, J. H. and A. E. Roth: 2000, 'The dynamics of reorganization in matching markets: A laboratory experiment motivated by a natural experiment'. *The Quarterly Journal of Economics* **115**(1), 201–235.

Kamenica, E.: 2019, 'Bayesian Persuasion and Information Design'. *Annual Review of Economics* **11**(1), 249–272.

Kamenica, E. and M. Gentzkow: 2011, 'Bayesian Persuasion'. *American Economic Review* **101**(6), 2590–2615.

Kenney, R. W. and B. Klein: 1983, 'The economics of block booking'. *The Journal of Law and Economics* **26**(3), 497–540.

Kim, K.: 2012, 'Endogenous market segmentation for lemons'. *The RAND Journal of Economics* **43**(3), 562–576.

Krueger, A. B., J. Cramer, and D. Cho: 2014, 'Are the long-term unemployed on the margins of the labor market?'. *Brookings Papers on Economic Activity* **2014**(1), 229–299.

Kübler, D., W. Müller, and H.-T. Normann: 2008, 'Job-market signaling and screening: An experimental comparison'. *Games and Economic Behavior* **64**(1), 219 – 236.

Maimonides, M.: 1168, *The Code of Maimonides (Misheneh Torah): trans. Klein I.* Yale University Press New Haven Connecticut.

Milgrom, P. R.: 1981, 'Good News and Bad News: Representation Theorems and Applications'. *The Bell Journal of Economics* **12**(2), 380–391.

Miller, R. M. and C. R. Plott: 1985, 'Product Quality Signaling in Experimental Markets'. *Econometrica* **53**(4), 837–872.

Nalbantian, H. R. and A. Schotter: 1995, 'Matching and efficiency in the baseball free-agent system: an experimental examination'. *Journal of Labor Economics* **13**(1), 1–31.

Ostrovsky, M. and M. Schwarz: 2010, 'Information Disclosure and Unraveling in Matching Markets'. *American Economic Journal: Microeconomics* **2**(2), 34–63.

Pallais, A.: 2014, 'Inefficient hiring in entry-level labor markets'. *American Economic Review* **104**(11), 3565–99.

Putz, C.: 2019, 'Disability and employment, UK: 2019'. Technical report, ONS.

Seidmann, D. J. and E. Winter: 1997, 'Strategic information transmission with verifiable messages'. *Econometrica: Journal of the Econometric Society* pp. 163–169.

Sen, A.: 1997, 'Inequality, unemployment and contemporary Europe'. *International Labour Review* **136**, 155.

Siegenthaler, S.: 2017, 'Meet the lemons: An experiment on how cheap-talk overcomes adverse selection in decentralized markets'. *Games and Economic Behavior* **102**, 147–161.

Stanton, C. T. and C. Thomas: 2016, 'Landing the first job: The value of intermediaries in online hiring'. *The Review of Economic Studies* **83**(2), 810–854.

Stigler, G. J.: 1963, 'United States v. Loew's Inc.: A note on block-booking'. *The Supreme Court Review* **1963**, 152–157.

Sánchez-Pagés, S. and M. Vorsatz: 2007, 'An experimental study of truth-telling in a sender–receiver game'. *Games and Economic Behavior* **61**(1), 86–112.

Appendix

A Star Ratings of Individual Agencies

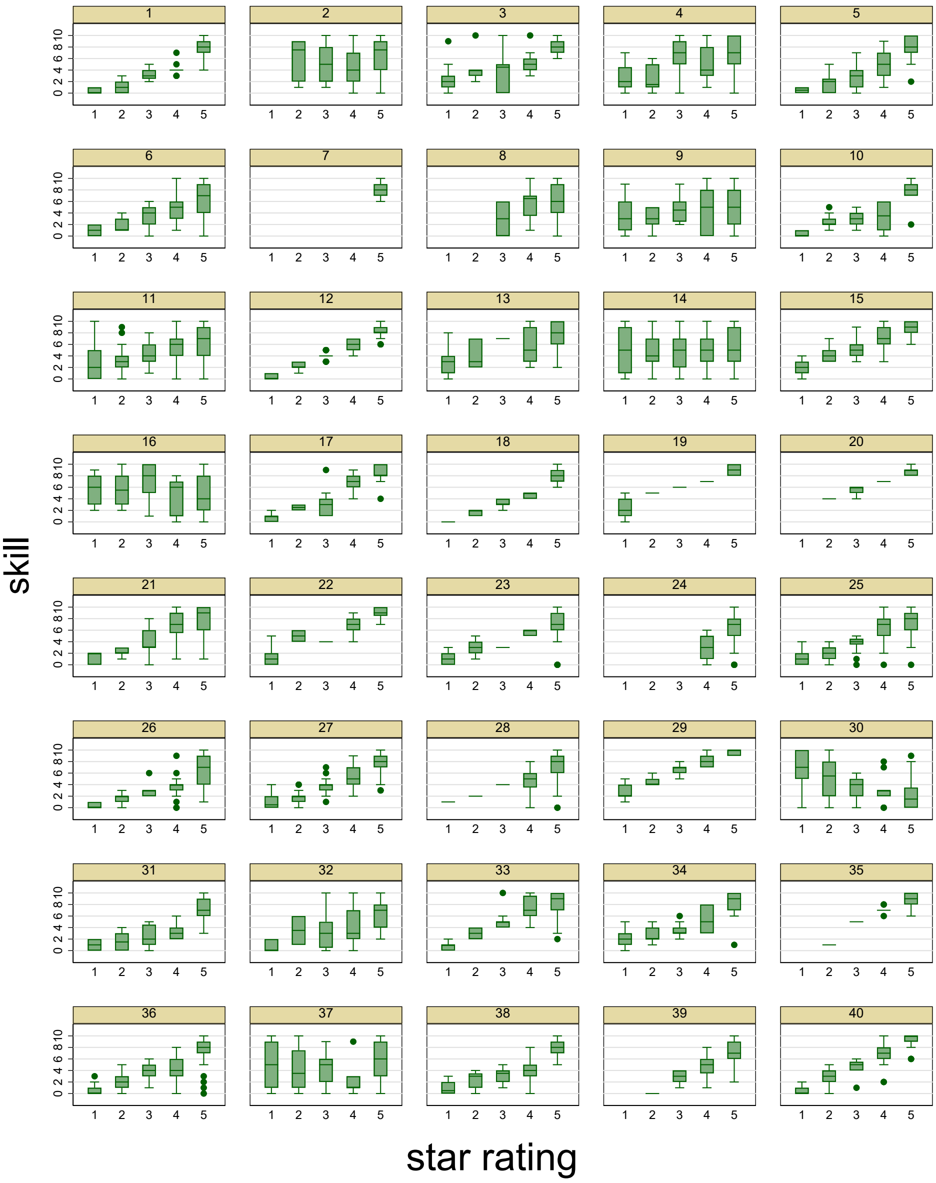
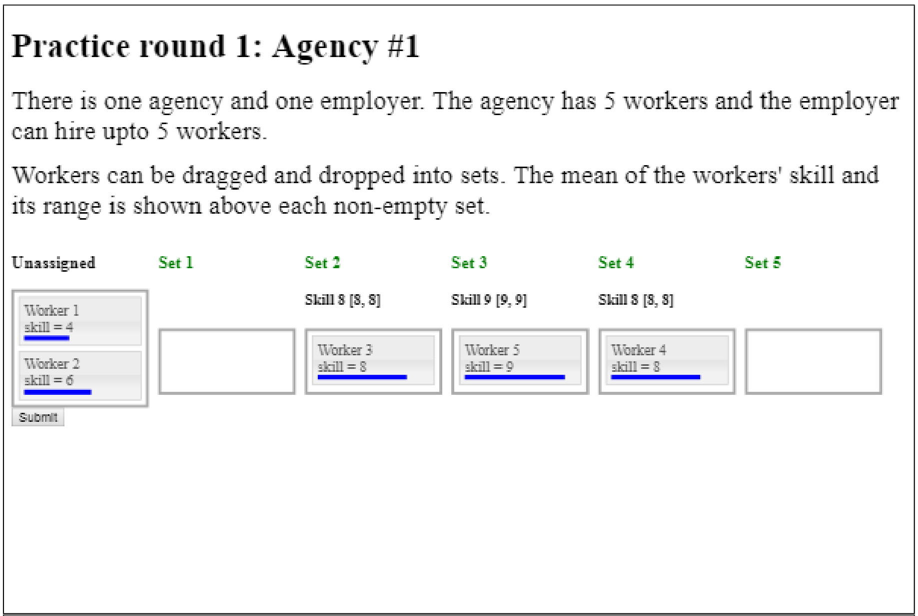
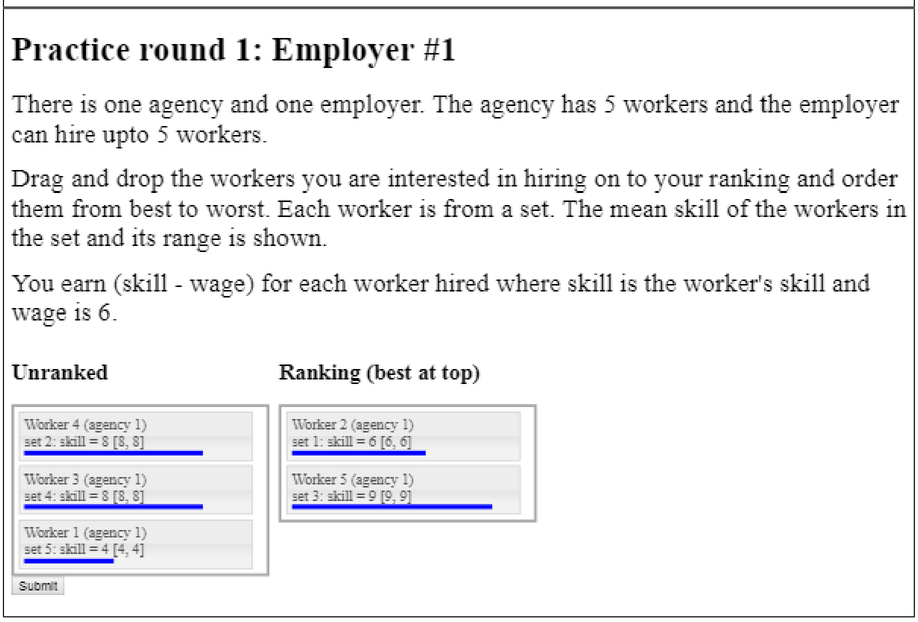


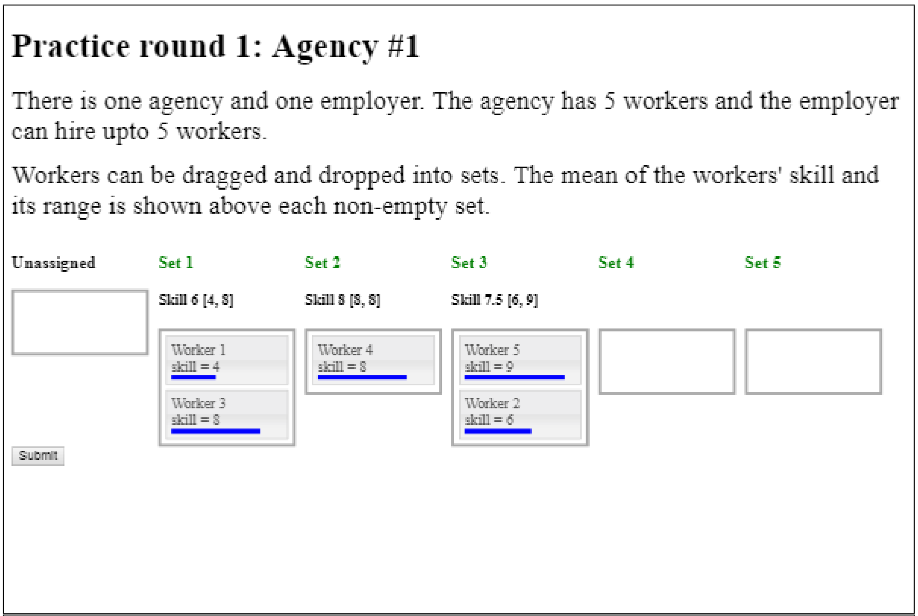
Figure 4: The range of worker skills for star ratings of workers by individual agency.

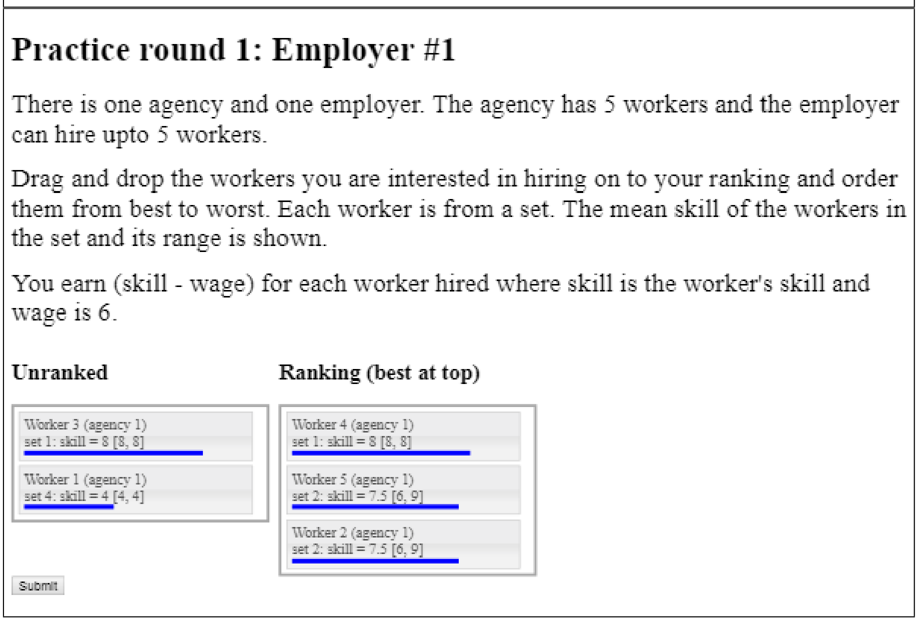
B Screenshots: full information





C Screenshots: bundles





D Screenshots: star ratings