Likes*

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Abstract

A principal faces n agents. She privately favors a subset of these agents but wants as many agents as possible to believe they are favored. To communicate, the principal uses public "likes." We characterize the "liking strategies" that can be sustained in a robust equilibrium and show that they must involve a fixed and constant number of likes. Additionally, we describe conditions for when monotone liking strategies can and cannot be sustained as an equilibrium, regardless of robustness. We apply the model to workplace promotion promises, grade inflation, political campaigns, and liking on social media.

Keywords: cheap-talk, multiple receivers, communication game, promises.

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1 Introduction

A principal (she) faces n agents. The principal privately favors only $k \leq n$ of these agents, but wants as many as possible of the agents to believe she truly favors them. The principal communicates with the agents by giving them public "likes," which are observable by all agents. The principal's objective is to maximize the weighted sum of the individual agents' posterior beliefs that they are genuinely favored, where a greater weight is placed on the beliefs of the agents who are indeed favored. In this paper, we study the "liking strategy" that maximizes this objective function.

This stylized description can be applied to various situations. For instance, the principal could represent a manager who oversees n interns. It is assumed that the interns' level of effort, which is not explicitly modeled, increases based on their belief of being selected to join the firm. The manager assigns greater importance to the beliefs of the truly favored interns because their efforts are more productive.

Another example is that of a teacher who interacts with a group of students. Similar to the previous example, the students' level of effort (which is not explicitly modeled) is expected to increase based on their belief that they are good students. The teacher desires for all students to believe in their own abilities and perceive themselves as good students, but holds a greater affinity for the genuinely better students.

Alternatively, a politician running for office may encounter various interest groups. The politician may only be able to answer the demands of some of these groups. However, the politician aims to create an impression that she is committed to fulfilling the demands of all interest groups since their support is useful for securing her election. And, the politician values the beliefs of the interest groups she can assist more, because they are more likely to extend their support to her in the future. Or, an individual who actively engages on social media wishes for as many of her friends to believe that she enjoyed their recent posts, but places a larger weight on the beliefs of those of her friends whose posts she genuinely favored.[1]

Importantly, we make the assumption that the likes given by the principal to the agents are merely "cheap-talk." In other words, giving a like has no direct cost, and the principal cannot commit to a specific liking strategy beforehand. The principal's actions are solely driven by the objective of maximizing the weighted sum of the agents'

[1] Indeed, studies in social psychology confirm that "paralinguistic digital affordances" such as likes are sought out by social media users and serve an important function of enhancing social reputation (Shabahang et al., 2022; H. Y. Lee et al., 2020). Moreover, people seem to make inferences about the credibility of likes, and consequently "high as well as low likes-to-followers ratios negatively influence [...] perceived credibility" (De Vries, 2019; Mattke et al., 2020).

beliefs, and the agents are aware of this. The question then becomes whether the principal can communicate any information to the agents under these conditions, and if so, how? Specifically, we are interested in the question of whether the number of likes is indicative of the number of favored agents.

We define an equilibrium of the game as "robust" if it can be sustained for any ratio of weights assigned to the beliefs of favored and non-favored agents. Robust equilibria are more plausible in situations where the principal's objectives are not commonly known among the principal and agents.

Our first main result is that a strategy can be sustained in a robust equilibrium if and only if the principal likes a constant and fixed number of agents, regardless of the number of genuinely favored agents. Intuitively, one would expect the principal to adopt a monotone strategy in equilibrium, where the number of likes increases in the number of favored agents. However, our first main result indicates that monotone liking strategies cannot be robustly sustained in equilibrium. This raises the question of whether monotone strategies can be sustained in equilibrium if we do not require the equilibrium to be robust. The answer to this question is both positive and negative. Our second main result demonstrates that, under a simple assumption regarding the distribution of favored agents, no monotone strategy can be sustained in any equilibrium, whether robust or not. However, we provide an example of a (non-robust) monotone equilibrium when this assumption is violated.

The liking strategy in which the principal likes a constant and fixed number of agents, regardless of the number of favored agents, resembles the policy implemented by the American Economic Association, according to which job candidates are permitted to indicate up to two "liked economic departments" (Coles et al., 2010). However, in practical situations such as social media likes, high school grades, and campaign promises the number of "likes" is not held fixed. In our concluding remarks, we explain why restricting the number of likes is sensible in some contexts, but not in others.

Related Literature

We consider a model of cheap-talk communication between an informed sender and multiple uninformed receivers. The study of cheap-talk communication was pioneered by Crawford and Sobel (1982) who studied a model with an informed sender and a single uninformed receiver. They demonstrated that the equilibrium level of transmitted information depends on the extent of conflicting interests between the sender and receiver, which can be measured by the disparity between their optimal decisions. As this disparity increases, the capacity for information transmission decreases. If the bias surpasses a specific threshold, only completely non-informative equilibria can be sustained. In contrast, within our framework, even though all types of the principal exhibit a "complete bias" toward inducing the belief that all agents are genuinely favored, the structure of the state space allows for the existence of informative equilibria.

The literature on cheap-talk communication with multiple receivers is relatively small. Farrell and Gibbons (1989) were the first to study cheap-talk communication between one sender and more than one receiver. They considered a simple model with two receivers and two states, and focused on the comparison between private and public communication. They showed that informative communication may be impossible under private communication, but possible under public communication, and vice-versa. In our model, informative private communication is impossible, but public informative communication is. Goltsman and Pavlov (2011) study a version of Crawford and Sobel (1982)'s model with two receivers. Salcedo (2019) considers cheap-talk with n receivers with both private and public communication, where the sender only cares about communicating with a segment of her audience.

The model presented here can also be interpreted as a communication game between one informed sender and one uninformed receiver, about a state that has n distinct features, or dimensions. However, under this interpretation, it is less clear how to motivate the assumption that the principal in our model cares about some dimensions of the state more than others. Chakraborty and Harbaugh (2010) consider multi-dimensional cheap-talk between a sender and a single receiver with state-independent preferences. Within their framework, the sender can effectively communicate by utilizing the various dimensions of the state, employing what they term "comparative statements" such as "this is better than that." A similar mechanism operates in our scenario, where the principal's capacity to like one agent but not another offers a credible means to communicate her genuine preference for the former. Other papers that study multi-dimensional cheap-talk include Battaglini (2002), Levy and Razin (2007) and Chakraborty and Harbaugh (2007).

Several authors have studied specific models of some of the applications presented above. Popov and Bernhardt (2013) and Boleslavsky and Cotton (2015) study grading as a game of strategic communication between competing universities and potential employers, under the assumption that universities can commit to a grading strategy. Chan et al. (2007) model the university-employer interaction as a signaling game in which universities cannot commit to a grading strategy. See also Bizzotto and Vigier (2023) for related work on grading, and school-based statistical discrimination. These works provide theoretical support for the popular claim that the extent of grade inflation increases with the quality of the student body.

In the context of campaign promises, Royed and Borrelli (1997), Thomson et al. (2017), and the references therein, provide empirical evidence that suggests that, contrary to public perception, in many western democracies the majority of politicians do in fact fulfill a majority of their campaign promises. Following this evidence, several authors attempted to provide theoretical explanations for the striking contrast between the cheap-talk nature of campaign messages and their apparent informativeness regarding subsequent behavior once in office. An early model of informative cheap-talk in elections is Harrington Jr (1992), who highlights a candidate's preference toward being elected when his true preferences have public support as a central requirement for informative equilibria. In Kartik and Van Weelden (2019) an informative equilibrium is possible due to an endogenous voter preference for a "known devil" over an "unknown angel". Salcedo (2019) describes an equilibrium in which a politician gains credibility by speaking truthfully to some receivers while lying to others.[2] The model presented in this paper provides a novel explanation for the informativeness of campaign promises — namely, a preference towards persuading those voters to whom the candidate can keep her promises.

The rest of the paper proceeds as follows. In Section 2 we present the model. In Section 3 we introduce the class of impersonal and favored-first strategies. In Section 4 we present our first main result, which is the characterization of robust equilibria. In Section 5 we introduce monotone strategies and show when they can and cannot be sustained as equilibria. Section 6 offers concluding remarks. All proofs are relegated to the Appendix.

2 Model

A principal (she) communicates with n agents (he). The state $s = (s_1, \ldots, s_n) \in \{0,1\}^n$ describes which agents are genuinely favored (henceforth, favored) by the principal. We say that agent i is favored if and only if $s_i = 1$. The number of favored agents in state s is denoted by $k(s) = \sum_{i=1}^{n} s_i$. The number $k(s)$, is stochastic and distributed according to a prior distribution function $\pi : \{0, \ldots, n\} \to [0,1]$. We assume that the underlying distribution of favored agents is symmetric. Namely, any two states s and s' with an equal number of favored agents (i.e., such that $k(s) = k(s')$) are equally likely.

The principal observes the state and sends a public message $m = (m_1, \ldots, m_n) \in \{0,1\}^n$ to the agents. We interpret the message as public "likes" that the principal gives the agents. We say that the principal "likes" agent i if and only if $m_i = 1$.

[2]Relatedly, Chen and Suen (2021) study a model in which a political leader of an unknown type tries to signal to followers about whether the current political regime is good or bad.

A liking strategy for the principal is a function that maps the state space into distributions over messages, $\sigma : \{0,1\}^n \to \Delta(\{0,1\}^n)$. An agent i who believes that the principal is using the liking strategy σ and observes the message m uses Bayesian updating to compute the posterior probability that he is favored by the principal, denoted $q_i(\sigma, m)$.[3]

The principal's payoff in state $s \in \{0,1\}^n$, when she is believed to be playing the liking strategy σ, and sends the message m, is given by:

$$\sum_{\{i\,:\,s_i=1\}} q_i(\sigma, m) + \sum_{\{j\,:\,s_j=0\}} \beta q_j(\sigma, m) \tag{1}$$

where $\beta \in [0,1)$ is a parameter that captures the relative weight that the principal puts on the posterior beliefs of those agents who are not favored. The principal's payoff is increasing in the posterior beliefs of all agents, but more so in the beliefs of favored agents.

A liking strategy σ is said to be an *equilibrium strategy* if the principal cannot benefit from deviating from it in any state, given that the agents' beliefs $q_i(\sigma, m)$ are computed using Bayes law, whenever possible.

If $\beta = 0$, then the principal gains nothing from persuading non-favored agents that they are favored. In this case, it can be shown that the truthful strategy, in which the principal likes an agent if and only if the agent is favored, is the principal-optimal equilibrium. However, if $\beta > 0$, then if the agents believe the principal is being truthful, the principal can gain by persuading non-favored agents that they are favored, and so the truthful strategy cannot be an equilibrium.

Another notable observation is that a principal who communicates with only one agent is unable to convey any information to this agent. In other words, when $n = 1$, only "babbling" equilibria, which are supported by strategies in which the principal's message is independent of the state, and so conveys no information to the agent, exist. This is because a principal who faces only one agent would always want to induce the highest possible belief that the agent is favored. Importantly, this implies that a principal who communicates *privately* with each of the n agents and is barred from sending them public messages will be just as limited, and will be unable to communicate any information to the agents. In fact, it is the principal's ability to announce *publicly* that she likes one agent and not another that provides credibility to the principal's "likes," thereby facilitating informative communication.

[3]We assume that if an agent observes a message that is not supposed to be sent by σ, then he computes his posterior belief as if he saw another message that is chosen randomly from the support of σ (this is a standard assumption, see, e.g., Ottaviani and Sørensen, 2006). It follows that if the agents believe that the principal is using a liking strategy σ, then she cannot benefit from deviating to a liking strategy that has a different support than σ.

3 Impersonal and Favored-First Strategies

Given the symmetric nature of the game, it is natural to focus our analysis on the study of equilibria that are supported by a type of symmetric strategies, which we refer to as impersonal strategies, in which the principal ignores the identities of the agents. Specifically, we define an *impersonal strategy* σ as a strategy where an agent's likelihood of receiving a "like" is solely determined by the number of favored agents and whether or not the agent himself is favored.

For an impersonal strategy σ, we define $q^Y(\sigma, l)$ and $q^N(\sigma, l)$ to be the posterior probabilities that an agent who received, and did not receive, a like is favored, respectively, given that the principal is using the impersonal strategy σ and has given a total number of l likes. If σ is an impersonal strategy, then for any message m in the support of σ that gives l likes: for any agent i who received a like, $q_i(\sigma, m) = q^Y(\sigma, l)$, and for any agent j who did not receive a like, $q_j(\sigma, m) = q^N(\sigma, l)$.

In practice, receiving a like supposedly conveys good news. Thus, it is natural to further restrict our attention to equilibria that are supported by strategies that are also "favored-first," which are defined as follows. A strategy σ is a *favored-first* strategy if the principal always gives likes to favored agents before non-favored agents. Namely, the principal never likes an non-favored agent unless all the favored agents are also liked. Formally, for every state $s \in \{0,1\}^n$, if $s_i = 1$ but $m_i = 0$, then $s_j = 0$ implies $m_j = 0$. It is straightforward to show that if σ is an impersonal equilibrium strategy, then σ is a favored-first strategy if and only if for every number of likes $l \in \{1, \ldots, n-1\}$, receiving a like is indeed good news, or $q^Y(\sigma, l) > q^N(\sigma, l)$.

A pure, impersonal, favored-first strategy σ is fully specified by a function $l_\sigma(k)$: $\{0, \ldots, n\} \mapsto \{0, \ldots, n\}$ that describes the number of likes that are given for any number of favored agents. A general impersonal, favored-first, strategy is fully specified by a set of cumulative distributions $\{F_\sigma(k)(\cdot)\}_{k \in \{0,\ldots,n\}}$ that describe the number of likes given by the principal for any number of favored agents, k. We denote the set of numbers of likes that are given with a positive probability by an impersonal and favored-first strategy σ, or the range of σ, by $L_\sigma \subseteq \{0, \ldots, n\}$.

The next example describes three different equilibria in impersonal and favored-first strategies.

Example 1. Suppose $n = 2$ and that the number of favored agents is binomial with parameter $p = \frac{1}{2}$. The payoff to the principal in a babbling equilibrium is
$\frac{1}{4}(\frac{\beta}{2} + \frac{\beta}{2}) + \frac{1}{2}(\frac{1}{2} + \frac{\beta}{2}) + \frac{1}{4}(\frac{1}{2} + \frac{1}{2}) = \frac{1+\beta}{2}$.

Consider an impersonal and favored-first strategy σ^1 that always gives one like. Our assumption that the agents respond to out-of-equilibrium messages in the same way they respond to a randomly generated equilibrium message implies that σ^1 is an impersonal and favored-first equilibrium strategy, for any value of $\beta \in (0,1)$. The agents' posterior beliefs under σ^1 are $q_i^Y(\sigma^1, 1) = \frac{3}{4}$ and $q_i^N(\sigma^1, 1) = \frac{1}{4}$, for the agent who received and did not receive a like, respectively. The principal's expected payoff under this equilibrium strategy is $\frac{1}{4}(\frac{3\beta}{4} + \frac{\beta}{4}) + \frac{1}{2}(\frac{3}{4} + \frac{\beta}{4}) + \frac{1}{4}(\frac{3}{4} + \frac{1}{4}) = \frac{5+3\beta}{8}$, which is better than babbling.

However, it can be shown that another impersonal and favored-first strategy generates an even higher expected payoff to the principal. Let σ^2 denote the strategy that gives a like to the favored agent when there is a single favored agent, and that gives two (or no) likes otherwise. The liking strategy σ^2 is also an equilibrium strategy for any value of $\beta \in (0,1)$. It generates an expected payoff of $\frac{1}{4}(\frac{\beta}{2} + \frac{\beta}{2}) + \frac{1}{2}(1+0) + \frac{1}{4}(\frac{1}{2} + \frac{1}{2}) = \frac{3+\beta}{3}$ to the principal.[4] $\square$

4 Robust Equilibria

Because the principal's preferences depend on the value of the parameter β, whether or not a given strategy σ is an equilibrium may also depend on β. An equilibrium is said to be *robust*, if it can be sustained for any value of the parameter $\beta \in [0,1)$. Accordingly, a liking strategy σ is a robust equilibrium strategy if it is an equilibrium strategy for every value of the parameter $\beta \in [0,1)$.

Robust equilibria are more plausible when agents are uncertain about the value of β. This is because agents who are uncertain about β cannot be sure if the principal has deviated from her equilibrium strategy, potentially due to a different β value than they initially assumed. Moreover, a principal who recognizes this uncertainty can effortlessly exploit it. However, if the equilibrium is robust, these difficulties do not arise.

Robust equilibria exist. Babbling is a (trivial) example of a robust equilibrium strategy. The next theorem provides a characterization of the robust equilibria of the game. The theorem relies on the assumption that it is commonly that the principal favors at least one agent but never favors all the agents. This is a mild assumption when n is large.

Theorem 1. *Suppose that it is commonly known that the principal always favors at least one agent, and never favors all the agents, namely $\pi(0) = \pi(n) = 0$. Then, an impersonal and favored-first strategy is an informative and robust equilibrium strategy if and only if it is a strategy that gives a constant and fixed number of likes.*[5]

[4] In fact, it can be shown that when $n = 2$, the strategy σ^2 is the principal-optimal equilibrium for any symmetric prior distribution π.

[5] Notice that a babbling equilibrium is robust. "Informative" means any strategy that is not babbling.

The intuition for the proof of Theorem 1 is the following. As explained in Example 1 above, the assumption that the agents respond to out-of-equilibrium messages in the same way they respond to a randomly generated equilibrium message implies that an impersonal and favored-first strategy that gives a constant and fixed number of likes is a robust equilibrium strategy. The proof that no other impersonal and favored-first strategy can be a robust equilibrium is based on the following argument that consists of three steps.

First, the next lemma implies that an impersonal and favored-first strategy that is also a robust equilibrium strategy is a "constant-expectation strategy." Let $\mathbb{E}[k|\sigma, l]$ denote the expected number of favored agents conditional on observing l likes under an impersonal and favored-first strategy σ. The strategy σ is said to be a *constant-expectation strategy* if $\mathbb{E}[k|\sigma, l] \equiv \mathbb{E}[k]$ for any number of likes $l \in L_\sigma$ in the range of σ. Here, $\mathbb{E}[k]$ denotes the expected number of favored agents under the prior distribution π.

Lemma 1. *If an impersonal and favored-first strategy σ is a robust equilibrium strategy then σ is a constant-expectation strategy.*

Notice that Lemma 1 does not require any assumptions on the support of the prior belief π. Thus, Lemma 1 implies that it is impossible to convey information regarding the expected number of favored agents in a robust equilibrium, regardless of the prior.

The intuition for the proof of Lemma 1 is that for values of β that are close to one, the principal cares about the beliefs of the non-favored agents almost as much as she cares about the beliefs of the favored agents. So, the principal would prefer to give the number of likes that induces the highest posterior belief regarding the number of favored agents. It follows that giving two different numbers of likes, which induce two different conditionally expected numbers of favored agents, cannot be sustained in a robust equilibrium.

Second, the argument makes use of the following geometric characterization of the principal's payoff function. Suppose that the principal employs an impersonal and favored-first equilibrium strategy σ. Denote the principal's payoff from giving $l \in L_\sigma$ likes when the number of favored agents is k by $u_\sigma(k, l)$. The way in which impersonal and favored-first strategies give likes to favored and non-favored agents implies that for any number of favored agents, k, and likes, $l \in L_\sigma$,

$$u_\sigma(k,l) = \begin{cases} kq^Y(\sigma,l) + \beta(l-k)q^Y(\sigma,l) + \beta(n-l)q^N(\sigma,l) & 0 \le k \le l \\ lq^Y(\sigma,l) + (k-l)q^N(\sigma,l) + \beta(n-k)q^N(\sigma,l) & l \le k \le n, \end{cases} \tag{2}$$
$$= \begin{cases} (1-\beta)q^Y(\sigma,l)\cdot k + \beta l\left(q^Y(\sigma,l) - q^N(\sigma,l)\right) + \beta n q^N(\sigma,l) & 0 \le k \le l \\ (1-\beta)q^N(\sigma,l)\cdot k + l\left(q^Y(\sigma,l) - q^N(\sigma,l)\right) + \beta n q^N(\sigma,l) & l \le k \le n. \end{cases}$$

Observe that although the number of favored agents $k \in \{0,\ldots,n\}$ is discrete, the function $u_\sigma(k,l)$ that is defined in Eq. (2) is well defined for every value of $k \in [0,n]$. Moreover, inspection of Eq. (2) reveals that when viewed as such, the function $u_\sigma(k,l)$ is piecewise linear, increasing, and concave in $k \in [0,n]$. Furthermore, we have:

Lemma 2. *Let σ be an impersonal and favored-first equilibrium strategy, and let $l \in \{1,\ldots,n-1\} \cap L_\sigma$. Then:*

1. *The slope of the function $u_\sigma(\cdot,l)$ is equal to $(1-\beta)q^Y(\sigma,l)$ in the interval $k \in [0,l]$.*
2. *The slope of the function $u_\sigma(\cdot,l)$ is strictly smaller and is equal to $(1-\beta)q^N(\sigma,l)$ in the interval $k \in [l,n]$.*
3. *$u_\sigma(0,l) = \beta\mathbb{E}[k|\sigma,l]$ and $u_\sigma(n,l) = \mathbb{E}[k|\sigma,l]$.*

If, instead, $l \in \{0,n\} \cap L_\sigma$, then the function $u_\sigma(k,l)$ is linear on the interval $k \in [0,n]$, $u_\sigma(0,l) = \beta\mathbb{E}[k|\sigma,l]$ and $u_\sigma(n,l) = \mathbb{E}[k|\sigma,l]$.

Given an impersonal, favored-first equilibrium strategy σ, Lemma 2 implies that the collection of functions $\{u_\sigma(\cdot,l)\}_{l\in L_\sigma}$ all coincide on the endpoints of the interval $[0,n]$. The next result shows that the functions in this collection also satisfy the following "single crossing property."

Lemma 3. *Let σ be an impersonal, favored-first, equilibrium strategy. Then, for any two numbers of likes $l, l' \in L_\sigma$ that are such that $0 < l < l' < n$, there exists at most one value $r \in (0,n)$ such that $u_\sigma(r,l) = u_\sigma(r,l')$.*

Two increasing and concave functions that coincide at the endpoints of an interval can intersect at most once within the interval. Additionally, the proof of Lemma 3 shows that $u_\sigma(\cdot,l)$ and $u_\sigma(\cdot,l')$ cannot overlap on any subset of the interval. Thus, Lemma 3 implies that any two functions in the collection $\{u_\sigma(\cdot,l)\}_{l\in L_\sigma}$ either coincide only at the endpoints of the interval $[0,1]$, or are such that they coincide at the endpoints of the interval $[0,1]$ and intersect at some point $r \in (0,n)$. Finally, we show that if $\pi(0) = \pi(n) = 0$, then both of these possibilities are incompatible with the functions $\{u_\sigma(\cdot, l)\}_{l\in L_\sigma}$ having a constant-expectation.[6] Hence, we obtain a contradiction to the assumption that the collection includes more than one function, or the assumption that the strategy σ gives more than one number of likes.

We conclude this section with the observation that there are only n strategies that give a constant and fixed number of likes.[7] So the problem of identifying the principal-optimal impersonal and favored-first robust equilibrium strategy for a given environment can be solved numerically in a straightforward way, by comparing the principal's expected payoff in each one of the possible n robust equilibria.

5 Monotone Strategies

An impersonal, favored-first, strategy with a constant and fixed number of likes conveys no information about the number of favored agents. A natural question to ask is whether there exist impersonal, favored-first, equilibria in which the principal conveys such information to the agents.

The next example shows that such equilibria do indeed exist.

Example 2. Let $n = 7$ and suppose that at least one agent is always favored, and the prior distribution assigns the same probability to each number of favored agents $k \in \{1, \ldots, 7\}$. If $\beta \leq \frac{2}{65}$, then the following strategy $l_\sigma(k)$ is an equilibrium:

$$l_\sigma(k) = \begin{cases} 1 & k = 1, \\ 3 & k \in \{2, 3\} \\ 7 & k \in \{4, \ldots, 7\}. \end{cases}$$

□

Example 2 highlights the trade-off that exists between providing credible information about the total number of favored agents and their identities. When the number of favored agents is smaller, the principal is willing to concede as much in return for a higher credibility of the like she gives in this case, as measured by the posterior probability that an agent is favored conditional on having received a like.

[6]If $\pi(0) > 0$ and/or $\pi(n) > 0$ then there exist strategies, which rely on intricate tie-breaking rules for the principal when $k = 0$ or $k = n$, which are constant-expectation but not "constant-likes."

[7]Strategies that always give 0 likes and strategies that always give n likes are identical. Both are types of babbling strategies.

More generally, we say that a strategy is *monotone* if the number of likes that is given by the principal is increasing in the number of favored agents. Formally,

Definition. *An impersonal, favored-first strategy* $\{F_\sigma(k)\}_{k\in\{0,\ldots,n\}}$, *is* monotone *if:*

1. *For any two numbers of favored agents,* $k, k' \in \{0,\ldots,n\}$, $k' > k$ *implies that* $F_\sigma(k')$ *weakly first-order-dominates* $F_\sigma(k)$, *or* $F_\sigma(k')(\lambda) \leq F_\sigma(k)(\lambda)$ *for every* $\lambda \in \{0,\ldots,n\}$.
2. *There exist two numbers of favored agents* $k, k' \in \{0,\ldots,n\}$, $k' > k$, *such that* $F_\sigma(k')$ *strictly first-order-dominates* $F_\sigma(k)$, *or* $F_\sigma(k')(\lambda) < F_\sigma(k)(\lambda)$ *for at least one* $\lambda \in \{0,\ldots,n\}$.

Thus, in order to be monotone, a strategy needs to give at least two different number of likes. A strategy that gives a constant and fixed number of likes is not monotone.

The next theorem shows that the fact that in Example 2 the number of favored agents was assumed to always be positive is not coincidental. An impersonal, favored-first, and monotone strategy cannot be an equilibrium strategy if there is positive probability that none of the agents are favored.

Theorem 2. *Let* $\beta > 0$ *and* $\pi(0) > 0$. *Then, an impersonal, favored-first, and monotone strategy cannot be an equilibrium strategy, for any* $\beta \in (0,1)$.

The intuition for the proof of Theorem 2 is the following. When there are no favored agents ($k = 0$), the principal does not care about differentiating between agents (since none are favored), and is only interested in inducing the belief that the overall number of favored agents is high. It follows that in this case, the principal would send the message that induces the belief that the expected number of favored agents is highest, which precludes monotonicity.

Theorem 2 demonstrates that "one bad apple spoils the bunch" in the sense that a positive probability that the principal does not favor any agents precludes the straightforward communication embodied by a monotone liking strategy. For instance, it implies that a positive probability that a political candidate does not intend to follow through on any of her promises rules out an equilibrium where more promises made imply more promises kept. Furthermore, it can be shown that a sufficiently high probability that the principal does not favor any agents implies that only constant-expectation liking strategies can be sustained in equilibrium (regardless of robustness).

6 Conclusion

In this paper, we examine a cheap-talk communication game between a principal and n agents and demonstrate the principal's ability to transmit information to the agents in a robust equilibrium. We identify a novel channel that facilitates this information transmission, which is the differential preference that the principal holds towards favored agents.

Our analysis reveals a trade-off faced by the principal in conveying information regarding both the identities of favored agents and the total number of agents favored. In a robust equilibrium, the principal can only transmit credible information about the identities of favored individuals. The strategy that allows the principal to do this gives a constant and fixed number of likes, regardless of the number of genuinely favored individuals. As mentioned in the introduction, this strategy is similar to the policy implemented by the American Economic Association, allowing job candidates to indicate up to two "liked economic departments." This strategy also resembles the strategy recently implemented by the dating website Tinder, of allowing users to send one "super like" per day (and five super likes for premium members).[8] The use of these policies in these environments is consistent with our results. When agents face different principals, whom they do not know personally, communication norms need to be robust in order to be sustained in the long run. But, when agents are more familiar with the specific principal they are facing, robustness is a less important criterion. Accordingly, in the cases of the AEA and Tinder, we observe constant liking strategies, but not in Facebook, grading, or political communication.

[8] See S. Lee and Niederle (2015) for an experimental study of a similar idea.

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Appendix: Proofs

Proof of Theorem 1

The fact that agents respond to out-of-equilibrium messages in the same way they respond to a randomly generated equilibrium message implies that an impersonal and favored-first strategy that gives a constant and fixed number of likes is a robust equilibrium strategy.

The proof that an impersonal and favored-first robust equilibrium strategy gives a constant and fixed number of likes consists of three steps.

Step 1. Lemma 1 implies that that an impersonal and favored-first robust equilibrium strategy is a constant-expectation strategy.

Step 2. Lemmas 2 and 3 imply that if an impersonal and favored-first robust equilibrium strategy σ gives two different numbers of likes $0 \le l < l' \le n$, then $u_\sigma(r, l) = u_\sigma(r, l')$ at at most one point $r \in (0, n)$.

Step 3. We show that an impersonal and favored-first robust equilibrium strategy σ cannot give two different numbers of likes. Suppose that σ gives two different numbers of likes, $l \neq l' \in L_\sigma$. Suppose, without loss of generality, that σ gives l likes for at least two different numbers of favored agents. This involves no loss because giving a different numbers of likes for each number of favored agents is inconsistent with σ being a constant-expectation strategy (Lemma 1).

By Lemmas 2 and 3, there are two cases to consider. We show below that both cases imply a contradiction.

(1) The functions $u_\sigma(r, l)$ and $u_\sigma(r, l')$ do not intersect at any point $r \in (0, n)$. In this case, either $u_\sigma(r, l)$ lies entirely above $u_\sigma(r, l')$ or vice-versa. Suppose, without loss of generality, that $u_\sigma(r, l) > u_\sigma(r, l')$ for every $r \in (0, n)$. It follows that giving l' likes is dominated for any number $k \in \{1, \ldots, n-1\}$ of favored agents. A contradiction to σ being an equilibrium strategy.

(2) There exists some $r \in (0, n)$ such that $u_\sigma(r, l) > u_\sigma(r, l')$ on the interval $(0, r)$, and $u_\sigma(r, l') > u_\sigma(r, l)$ on the interval (r, n), or vice-versa. Suppose, without loss of generality, that the first case holds. The fact that σ is an equilibrium strategy implies that l likes can only be given when the number of favored agents is smaller than or equal to r, and l' likes can only be given when the number of favored agents is larger than or equal to r, and that either l or l' are given in more than just one number of favored agents. It follows that it cannot be that $\mathbb{E}[k|\sigma, l]$ and $\mathbb{E}[k|\sigma, l']$ are equal. A contradiction to Lemma 1.

Proof of Lemma 1

Suppose that a robust-equilibrium strategy σ is not a constant-expectation strategy. Let $l' = \text{argmin } \mathbb{E}[k|\sigma, l]$ and let l'' be such that $k'' \equiv \mathbb{E}[k|\sigma, l''] > \mathbb{E}[k|\sigma, l'] \equiv k'$. Let $k_{\min}$ be the smallest number of favored agents in which l likes are given with a positive probability. It follows that $0 \leq k_{\min} \leq k'$.

For any equilibrium strategy σ, by definition,

$$\mathbb{E}[k|\sigma, l] = \sum_{i=1}^{n} q_i(\sigma, l) \tag{3}$$

for any number of likes $l \in L_\sigma$.

Note that the principal-optimal way to compose the sum $k' = \mathbb{E}[k|\sigma, l']$ out of the posterior agents' beliefs q_i is to induce a posterior belief of 1 to each favored agent and to divide the remainder equally between all the non-favored agents. This, together with the assumption $\beta < 1$ implies,

$$u_\sigma(k_{\min}, l') \leq k_{\min} \cdot 1 + \beta(n - k_{\min}) \cdot \frac{k' - k_{\min}}{n - k_{\min}} = k_{\min} + \beta(k' - k_{\min}).$$

The fact that the worst way for the principal to compose the sum $k'' = \mathbb{E}[k|\sigma, l'']$ out of the posterior beliefs q_i of the agents is to induce identical posterior beliefs among all the agents implies that

$$u_\sigma(k_{\min}, l'') \geq k_{\min} \cdot \frac{k''}{n} + \beta(n - k_{\min}) \cdot \frac{k''}{n}.$$

If $u(k_{\min}, l'') > u(k_{\min}, l')$, then σ cannot be sustained as an equilibrium because when the number of favored agents is $k_{\min}$ the principal would strictly prefer to give l'' instead of l' likes.

Hence, if

$$k_{\min} \cdot \frac{k''}{n} + \beta(n - k_{\min}) \cdot \frac{k''}{n} > k_{\min} + \beta(k' - k_{\min}),$$

which holds if and only if,

$$\beta > \frac{k_{\min}(1 - \frac{k''}{n})}{k_{\min}(1 - \frac{k''}{n}) + k'' - k'}$$

then the strategy σ cannot be supported as an equilibrium.

Finally, the fact that $k'' \leq n$ and $k' < k''$ implies that the right-hand side of the previous inequality is strictly smaller than one, which implies that it is violated for all values of β close enough to 1. It follows that σ cannot be sustained as a robust equilibrium, a contradiction.

Proof of Lemma 2

Suppose that σ is an impersonal and favored-first equilibrium strategy. The definition of $u_{\sigma,l}(k)$ that is given in the text immediately implies that for every l, $u_\sigma(k,l)$ is piecewise linear and continuous in k: when $k \leq l$, it has the slope $(1-\beta)q^Y(\sigma,l)$, and when $l \leq k$, it has the slope $(1-\beta)q^N(\sigma,l)$. Additionally,

$$u_\sigma(0,l) = \beta\left(lq^Y(\sigma,l) + (n-l)q^N(\sigma,l)\right) = \beta E[k|\sigma,l]$$
$$u_\sigma(n,l) = lq^Y(\sigma,l) + (n-l)q^N(\sigma,l) = E[k|\sigma,l]$$

where in both cases the second equality follows from Eq. (3).

Finally, when $l \in \{0,n\}$, either $q_i = q^N$ for every agent, or $q_i = q^Y$ for every agent, respectively, and the argument follows in the same way as described above.

Proof of Lemma 3

Let σ be an impersonal, favored-first, equilibrium strategy, and let $l, l' \in L_\sigma$ be such that $0 < l < l' < n$. Because, by Lemmas 1 and 2, $u_\sigma(\cdot,l)$ and $u_\sigma(\cdot,l')$ are two increasing and concave functions that coincide at the endpoints of the interval $[0,n]$, they can intersect at most once within $[0,n]$.

We show that they cannot overlap either. Suppose that $u_\sigma(\cdot,l)$ and $u_\sigma(\cdot,l')$ overlap on their steeper line segments. By Lemma 2, it follows that $q^Y(\sigma,l) = q^Y(\sigma,l')$. By Lemma 1, $u_\sigma(\cdot,l)$ and $u_\sigma(\cdot,l')$ coincide at the ends points of the interval $[0,n]$. Lemma 2 again, and the fact that $l < l'$, implies that $u_\sigma(r,l') > u_\sigma(r,l)$ for any $r \in (l,n)$. Because σ is an equilibrium strategy, it follows that it cannot give l likes when the number of favored agents k is larger than l. Thus, σ gives l likes only when the number of favored agents k is smaller than or equal to l. This, in turn, implies that $q^N(l) = 0$. But then, $u_\sigma(n,l)$ cannot be equal to $u_\sigma(n,l')$. A contradiction.

A similar argument shows that $u_\sigma(\cdot,l)$ and $u_\sigma(\cdot,l')$ cannot overlap on their flatter line segments either.

Proof of Theorem 2

Let σ be a monotone impersonal and favored-first equilibrium strategy. Monotonicity and transitivity of first-order stochastic dominance imply that $F_\sigma(n^\circ) \succ_{FOSD} F_\sigma(0)$, where n° denotes the largest number of favored agents to which the prior assigns a positive probability. Let $l_\circ \in \{0,\ldots,n\}$ denote the smallest number of likes such that $F_\sigma(0)(l_\circ) > F_\sigma(n^\circ)(l_\circ)$. Then

$$F_\sigma(0)(l) = F_\sigma(j)(l) \quad \forall l < l_\circ, 0 \leq j \leq n^\circ \tag{4}$$

and

$$F_\sigma(0)(l_\circ) \geq F_\sigma(j)(l_\circ) \quad \forall 0 \leq j \leq n^\circ. \tag{5}$$

It follows that

$$\Pr(l = l_\circ | k = 0) \geq \Pr(l = l_\circ | k = 1) \geq \cdots \geq \Pr(l = l_\circ | k = n^\circ) \tag{6}$$

where at least one of these inequalities is strict. In particular:

$$\Pr(l = l_\circ | k = 0) > 0. \tag{7}$$

Let l° be the largest number of likes that is given by σ with a positive probability. By monotonicity:

$$\Pr(l = l^\circ | k = 0) \leq \Pr(l = l^\circ | k = 1) \leq \cdots \leq \Pr(l = l^\circ | k = n^\circ) \tag{8}$$

where at least one of these inequalities is strict. In particular, $\Pr(l = l^\circ | k = n^\circ) > 0$.

For every $i \in \{0,\ldots,n^\circ\}$, denote:

$$a_i = \Pr(l = l_\circ | k = i);\ b_i = \Pr(l = l^\circ | k = i);\ \pi_i = \pi(k = i)$$

For every $l \in \{0,\ldots,l^\circ\}$, let $G_\sigma(l)(\cdot)$ denote the posterior distribution of the number of favored agents conditional on l likes. Then, for every $0 \leq i \leq n^\circ$:

$$G_\sigma(l_\circ)(i) = \sum_{j=0}^{i} \Pr(k = j | l = l_\circ) = \sum_{j=0}^{i} \frac{\Pr(k = j)\Pr(l = l_\circ | k = j)}{\sum_{r=0}^{n^\circ} \Pr(k = r)\Pr(l = l_\circ | k = r)} = \frac{\sum_{j=0}^{i} \pi_j a_j}{\sum_{r=0}^{n^\circ} \pi_r a_r}$$

Similarly,

$$G_\sigma(l^\circ)(i) = \frac{\sum_{j=0}^{i} \pi_j b_j}{\sum_{r=0}^{n^\circ} \pi_r b_r}.$$

Equations (6) and (8), and the assumption that $\pi_0 = \Pr(k = 0) > 0$, imply that the distributions $G_\sigma(l_\circ)(\cdot)$ and $G_\sigma(l^\circ)(\cdot)$ satisfy the conditions of Lemma 4 below, hence $G_\sigma(l^\circ)(\cdot) \succ_{FOSD} G_\sigma(l_\circ)(\cdot)$, which implies $\mathbb{E}[k|\sigma, l^\circ] > \mathbb{E}[k|\sigma, l_\circ]$. But Equation (7) implies that $l_\circ$ likes are given with a positive probability when $k = 0$. But the principal's payoff when $k = 0$ and she gives l likes is given by $\beta\mathbb{E}[k|\sigma, l]$. Therefore, if $k = 0$, then l likes are optimal only if l maximizes $\mathbb{E}[k|\sigma, l]$, a contradiction to $l_\circ$ likes being given when $k = 0$.

Lemma 4. *Let $\{a_i\}_{i\in\{0,\dots,n\}}$, $\{b_i\}_{i\in\{0,\dots,n\}}$, $\{\pi_i\}_{i\in\{0,\dots,n\}}$ be three sequences of numbers in $[0,1]$ such that: $a_0 \geq \cdots \geq a_n$ with at least one strict inequality; $b_0 \leq \cdots \leq b_n$ with $b_n > 0$; $\pi_0 > 0$; and $\sum_{j=0}^{n} \pi_j = 1$. Define the functions $f(i) = \frac{\pi_i a_i}{\sum_{j=0}^{n} \pi_j a_j}$ and $F(i) = \sum_{j=0}^{i} f_j$, $g(i) = \frac{\pi_i b_i}{\sum_{j=0}^{n} p_j b_j}$ and $G(i) = \sum_{j=0}^{i} g_j$. Then, the functions F and G are cumulative distribution functions defined over the set $\{0,\dots,n\}$ with the density functions f and g, respectively. And, $G \succ_{FOSD} F$.*

Proof of Lemma 4

Define $\Pi(i) = \sum_{j=0}^{i} \pi_j$. We show that $F(0) > \Pi(0) \geq G(0)$ and that $F(i) \geq \Pi(i) \geq G(i)$ for every $i \in \{1,\dots,n\}$. Suppose that $F(0) \leq \Pi(0)$. Then $\frac{\pi_0 a_0}{\sum_{j=0}^{n} \pi_j a_j} \leq \pi_0$. Together with the assumptions that $\pi_0 > 0$ and $\sum_{j=0}^{n} \pi_j = 1$, this implies that $a_0 \sum_{j=0}^{n} \pi_j \leq \sum_{j=0}^{n} \pi_j a_j$. This is a contradiction to the assumption that $a_0 \geq a_i$ for every $i \in \{0,\dots,n\}$ with at least one strict inequality. A similar argument shows that $\Pi(0) \geq G(0)$.

Let $i \in \{1,\dots,n\}$. Note that $F(i) \geq \Pi(i)$ if and only if:

$$\frac{\sum_{k=0}^{i} \pi_k a_k}{\sum_{j=0}^{n} \pi_j a_j} \geq \sum_{r=0}^{i} \pi_r$$

if and only if

$$\frac{\sum_{k=0}^{i} \pi_k a_k}{\sum_{r=0}^{i} \pi_r} \geq \sum_{j=0}^{n} \pi_j a_j.$$

Suppose that A is a random variable that is supported on the values $\{a_i\}_{i\in\{0,\dots,n\}}$ and is distributed according to $\Pr(A = a_i) = \pi_i$. Then,

$$\frac{\sum_{k=0}^{i} \pi_k a_k}{\sum_{r=0}^{i} \pi_r} \geq \mathbb{E}[A|A \geq a_i] \geq \mathbb{E}[A] = \sum_{j=0}^{n} \pi_j a_j.$$

It follows that $F(i) \geq \Pi(i)$ for every $i \in \{1,\dots,n\}$. A similar argument shows that also $\Pi(i) \geq G(i)$ for every $i \in \{1,\dots,n\}$.