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LIES AND VAGUENESS**

By Marta Serra-Garcia, Eric van Damme and Jan Potters

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Hiding an Inconvenient Truth:
Lies and Vagueness

Marta Serra-Garcia[a,*], Eric van Damme[b] and Jan Potters[c]

[a]CentER, Tilburg University
[b]CentER and TILEC, Tilburg University
[c]CentER, Tiber, TILEC and Netspar, Tilburg University

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Abstract

When truth conflicts with efficiency, can verbal communication destroy efficiency? Or are lies or vagueness used to hide inconvenient truths? We consider a sequential 2-player public good game in which the leader has private information about the value of the public good. This value can be low, high, or intermediate, with the latter case giving rise to a prisoners' dilemma. Without verbal communication, efficiency is achieved, with contributions for high or intermediate values. When verbal communication is added, the leader has an incentive to hide the precise truth when the value is intermediate. We show experimentally that, when communication about the value must be precise, the leader frequently lies, preserving efficiency by exaggerating. When communication can be vague, the leader turns to vague messages when the value is intermediate, but not when it is high. Thus, she implicitly reveals all values. Interestingly, efficiency is still preserved, since the follower ignores messages altogether and does not seem to realize that vague messages hide inconvenient truths.

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*Corresponding author. Address: PO Box 90153, 5000 LE Tilburg, The Netherlands. Phone: +31 (0) 13 4662045; Fax:+31 (0) 13 4663042; E-mail:m.serragarcia@uvt.nl

The effective manager, in organizational terms, develops strategies to keep workers at their tasks (...) these managerial strategies included: lying to workers about opportunities for advancement, deceiving overburdened workers at their tasks (...)

Jackall (1980, p.158)

The rule of thumb here [in the communication between bosses and subordinates] seems to be that the more troublesome a problem, the more desiccate and vague the public language describing it should be.

Jackall (1988, p.136)

"No comment" is a comment.

Georg Carlin (comedian)

1   Introduction

A standard assumption in economic models is that players opportunistically misreport their private information when it is in their (material) interest to do so. Recent experimental studies, which are briefly reviewed below, have, however, shown that many individuals have some aversion to lying. In the present paper we examine how lying aversion interacts with the language that is available for communication. We compare, theoretically and experimentally, a setting in which only precise (single-valued) messages about the state of the world are allowed to one in which messages are allowed to be vague (set-valued).

We hypothesize that, all else equal, people prefer to be vague but truthful over being precise but untruthful. In case messages must be precise, inconvenient information can only be concealed by means of a lie. Whether senders will use such lies will depend on the strength of lying aversion. In case vague messages are available, these can be used to cover up inconvenient information, whilst lying is still avoided. To make this work, in equilibrium, the same vague messages must then be used when the information is convenient. Otherwise, the receiver can infer that vagueness means bad news and act accordingly.

Lies and vagueness are particularly important in the game we study because they can be efficiency-enhancing and even Pareto improving *ex ante* relative to truthtelling. This contrasts with most studies on lying aversion, which examine lies that, when believed, hurt others. In our game, when messages must be precise, a strong aversion to lying may hurt both the sender's and the receiver's material payoffs. Will this be sufficient to induce the sender to lie? If vague messages are available, will they be used to prevent lying? If so, will they be used consistently, that is, both when information is convenient and when it is inconvenient? Can senders resist the temptation to communicate convenient information precisely?

We address these questions in the context of a 2-player sequential move, public good game, in which only one player is informed about the exact value of the public good. The informed player (leader) decides whether to contribute first. The uninformed player (follower) observes the leader's contribution, makes inferences about the value, and then decides on his contribution. The public good has three equally likely values: low, intermediate or high. If the value is low, it is individually rational and (Pareto) efficient not to contribute. In contrast, if the value is high, contributing is both individually rational and efficient. In the intermediate case, the game is a prisoners'

dilemma: it is Pareto efficient to contribute, but each player has an incentive to free ride. The parameters are such that, given his prior beliefs, the follower's best action is not to contribute. However, if the follower knows that the value is equally likely to be intermediate or high, contributing becomes his best response. If the leader can only communicate through her actions ("leading by example", as in Hermalin (1998) and Vesterlund (2003)), then she will contribute if and only if the value is intermediate or high, since the follower will then imitate her contribution. Thus, the baseline game has a unique Nash equilibrium (both players contribute if and only if the value is intermediate or high), and this is efficient. Potters et al (2007) have shown that behavior in the laboratory conforms to this equilibrium, hence, a high efficiency level is obtained.

We introduce communication in this game by allowing the leader to send, alongside her contribution decision, a message about the value of the public good. In the case of precise communication (PC), three messages are available: 'the value is low', 'the value is intermediate' and 'the value is high'. In the treatment with vague communication (VC), we allow the leader to mention any combination of states, or to say nothing. Hence, in total eight messages are then available. In this case, precise messages are still available, but the leader can also say things like 'the value is intermediate or high' or 'the value is low, intermediate or high', or not say anything (send a blank message). We term a message vague if it is not available in PC.[1] Note that all these messages have a literal meaning. Throughout, we maintain the assumption that these literal meanings are understood and can be assumed to be understood. We say that a message is a lie whenever it is a statement which is not true.[2] Consequently, in PC, a message is a lie when the value stated in the message is different from the actual one. A vague message is truthful if it contains the actual value or is blank; otherwise it is a lie.

When communication must be precise, an efficient outcome can be reached only if the leader is willing to lie, at least if the follower is rational and maximizes his material payoff. If the leader were to reveal truthfully that the game is a prisoners' dilemma, the follower would free ride and then it is best for the leader to not contribute either. When the value is intermediate, there are thus three possibilities in PC: (i) lying about the value (saying it is high) and contributing, (ii) revealing the true value, anticipating the free riding of the follower and best responding to that, and (iii) revealing the true value, but nevertheless contributing and hoping that the follower will reciprocate. The last strategy seems rather risky; the second is costly in terms of payoffs and efficiency, while the first involves lying. All three options have their drawbacks: which one will be chosen?

Previous evidence leaves the answer to this question open. On the one hand, anecdotal evidence suggests that lying is common; compare our opening quote for the case of managers communicating to their workers. Similarly, Gneezy (2005) finds that individuals are willing to lie and that more individuals lie if the costs the lie inflicts on the receiver decrease. On the other hand, Erat and Gneezy (2009) find that several individuals (at least 39%) avoid Pareto white lies, despite their efficiency-enhancing nature.[3]

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[1] In the literature, vagueness has been defined in different ways. While we define a message as vague if it contains more than one value, others, for example, define vagueness as noise in the communication process (Blume and Board, 2009). We will turn to the differences in the next section.

[2] Although this may appear to be a rather trivial definition, in the philosophical literature there is quite some discussion about the appropriate definition of a lie, in particular on whether the intention to deceive is a necessary condition for a statement to be a lie (e.g. Bok, 1978). We do not have to enter into this discussion; our game is simple enough so that we can abstract from false statements made by mistake. Other studies in economics, with a focus on deception, rather than lying, highlight that by telling the truth one may also be deceiving others, see e.g. Sutter (2009).

[3] Erat and Gneezy (2009) define White Lies as lies that increase the receiver's payoff. They further

3

The dilemma about what to do in the intermediate state is somewhat less pronounced in the VC treatment. Here the leader does not need to lie to achieve the efficient outcome. If the value is intermediate, she can simply use a blank message, or say 'the value is intermediate or high'. An important condition for this to work is that the same message be then used also when the value is high; otherwise a rational and selfish follower will infer that the value is intermediate and not contribute in this case. However, if the leader has an aversion towards making vague statements, or if she naively communicates the state when it is high, a problem remains. Therefore, it is relevant to investigate whether there are differences in communication patterns and contribution decisions between PC and VC.

Our experiment reveals that, in PC, the leader frequently lies when the value is intermediate, by saying that it is high. In contrast, low or high values are revealed truthfully. In most cases, the leader contributes for intermediate and high values, and the follower reacts by mimicking the leader. Consequently, in PC, contributions are not significantly lower, as compared to a baseline treatment without communication (NC), and efficiency is preserved.

When the language is richer, as in VC, the frequency of lies in the intermediate state drops significantly; the leader instead often uses vague messages, such as a blank message, or by saying 'the value is intermediate or high'. Interestingly, these vague messages are used much less often when the value is high; in this case, most often the true state is simply revealed. In VC, we, hence, observe overcommunication (i.e., the leader's messages lead to a finer partition of states than in equilibrium), a phenomenon that earlier has been observed in Forsythe et al (1999), Blume et al (2001) and Cai and Wang (2006). The follower does not seem to realize that he should not trust vague messages; he neglects them, or interprets them literally, and contributes. Accordingly, contribution levels of both the leader and the follower remain at the same levels as without communication, and thus efficiency does not vary in this treatment either.

The communication pattern observed is thus consistent with players displaying some aversion to lying, although the "psychic cost" of lying does not seem to be too high. Furthermore, vague messages are risky since good information is revealed precisely. It is only as a consequence of the fact that the follower does not seem to realize such overcommunication in the good state that using vague messages is effective in the VC treatment.

Our results are in line with the anecdotal evidence reported by Jackall (1980, 1988), cited in the opening quotes, that effective managers resort to lying to motivate their workers when this is required. It is also in line with the suggestion that vague language will be used when the situation is somewhat "troublesome". It also points out an important consideration for studying communication in laboratory experiments. Using vague messages can be a way to costlessly avoid lying, and this might naturally be preferred by participants. A caveat is that this strategy only works if the uninformed side is somewhat naïve: as parties with good information tend to reveal their information, vagueness is often a veil to cover an inconvenient truth.

The remainder of the paper is organized as follows. Section 2 briefly relates our study to the literature. In Section 3, we outline the (stable) equilibria of the games without and with communication, where in the latter case we distinguish between the pure cheap talk case and the case where lying is associated with costs. In Section

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distinguish between Pareto White Lies, which increase both the sender and the receiver's payoffs, and Altruistic White Lies, which increase the receiver's payoffs but decrease the sender's. As our game shows, the classification of a statement along these lines can depend upon the point in time at which the statement is evaluated.

4, we list the hypotheses that follow from the theory. In Section 5, we describe the experimental design and the procedures. The experimental results are presented in Section 6. Section 7 concludes. All proofs are included in the Appendix.

2 Literature Overview

In the literature, two approaches have been taken to study cheap talk communication of private information or of intended actions. The first approach starts by assuming that messages have no a priori meaning and focuses on the evolution of their strategic meaning over time (among others, Blume, 1998). In this approach, the meaning of messages is thus endogenous to the game and derived from their use in equilibrium. Starting with Farrell (1985, 1993), there is a second approach that focuses on messages with an established, literal meaning. Blume et al (2001) compare these two approaches in sender-receiver games with partial common interest, showing that, with a priori meaning, communication is more likely to arise and does so more quickly. Our work is in the second tradition. The messages that are considered in this paper have a natural (or focal) meaning, and, although messages need not be believed, they will always be understood. Within this second approach, one can also meaningfully talk about lying; in effect, when the sender is averse to lying, this transforms the game from one with costless signaling to one with costly signaling.

Kartik, Ottaviani and Squintani (2007) and Kartik (2009) present models of strategic communication with lying costs and show that such costs may lead to "language inflation", whereby in equilibrium the literal meaning of messages is higher than the true state. We incorporate lying costs along the same lines and observe a similar effect. Closely related papers are Chen et al (2008), who present a refinement to select among cheap talk equilibria, with one of the motivations behind being related to lying costs, and Chen (2009) where a model with honesty and receiver naivite is developed. Demichelis and Weibull (2008) theoretically show, in a certain class of complete information coordination games, that lexicographically small lying cost may lead to the selection of the Pareto dominant Nash equilibrium.

Recently, several experimental studies have examined individuals' decision to lie in different games; among others, see Gneezy (2005), Sanchez-Pages and Vorsatz (2007), Hurkens and Kartik (2009), and Lundquist et al (2009). In these studies, the emphasis is on lying with the intention to deceive: subjects are presented with the choice of lying and increasing their payoff at the expense of others, or telling the truth and forgoing some monetary payoff. A frequent finding is a non-zero portion of individuals who are telling the truth, despite its monetary costs.

In our paper, we concentrate on lies which are (ex ante) Pareto-improving, that is, they can increase both the sender's as well as the receiver's payoff. Considering this ex-ante perspective, such lies could also be called Pareto White Lies, as is done in Erat and Gneezy (2009). However, from an ex-post perspective, if the leader contributes when the state is intermediate, lying is not beneficial for the follower, as he would earn a higher payoff if he would not contribute. The study by Erat and Gneezy (2009) does not display this difference between the ex-ante and the ex-post situation, because in their game the uninformed player has no information at all on the payoff consequences, whilst ours is a standard incomplete information game. Also, in their paper they only allow for precise messages. Therefore, the fact that, in natural language, vague messages offer a costless way to avoid lying or telling the precise truth has remained unexamined in previous experimental studies on lying aversion.

Although we use the term *vague* in line with the way it is used in everyday life, we

note that some other studies define the term in a different way. We assume messages have a literal meaning and, therefore, their interpretation with respect to the set of values of the public good is clear. In this context, we say a message is vague if it contains several values or none. Vagueness has been used and defined in a different way in Lipman (2009), Blume and Board (2009) and Agranov and Schotter (2009). Lipman (2009) discusses several definitions of vagueness and why it cannot be optimal under standard assumptions, and concludes arguing that a model of bounded rationality is necessary. Blume and Board (2009) formalize vagueness as noise in the communication process (see also Blume, Board and Kawamura, 2007). They find that vagueness can be efficiency-enhancing, as the noise mitigates the conflict between the sender and receiver. In our paper, vagueness can be efficiency-enhancing, since it allows a leader with a strong lying aversion to avoid lying and nevertheless elicit the follower's contribution. Agranov and Schotter (2009), on the other hand, define vagueness as lack of meaning (e.g., the words "x is high"), and compare it to ambiguity, which is defined as lack of a unique interpretation (e.g., the message "x is between 0 and 2"). They find experimentally that vague messages and ambiguous messages perform similarly, as long as the number of vague words available is small. If many vague words become available, efficiency decreases.

In addition to the aforementioned papers by Blume et al (2001) and Agranov and Schotter (2009), several experimental studies have compared the effect of different message sets (languages), but none has compared precise to vague communication. Forsythe et al (1999) study the impact of restricting communication to include the true state of nature, compared to unrestricted cheap talk. They find that efficiency increases when senders are forced to reveal the true state. Blume et al (1998) increase the message space from two to three messages. They find that, when the interests of senders and receivers conflict, this leads to a slight increase in pooling equilibria and, thus, less information is transmitted.[4]

Finally, in a related paper, we compare talking about actions, e.g. "I contribute", to speaking about private information, "the value is x" (Serra-Garcia et al., 2010). There, we consider the same public good setting, but with simultaneous moves. In that case, in the intermediate state, the informed player has an incentive to talk the other into contributing without contributing herself. We find that the leader does so when talk is about her private information, but that she significantly increases her contribution when she is forced to talk about that.

3 Theoretical Framework

3.1 Baseline Game

In our public good game G, there are two players, the leader and the follower. At the beginning of the game, Nature moves by picking the state of nature s from the set $S = \{a, b, c\}$, where $a \leq 0$, $0 < b < 1$, $c > 1$, and all values are equally likely. The payoff function of player i is

$$u_i = 1 - x_i + s(x_i + vx_j) \qquad i \in \{1, 2\}, j = 3 - i$$

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[4]Some experimental studies of sender receiver games allow senders to send imprecise messages, containing more than one state of nature (Dickhaut, McCabe and Mukherji, 1995, and Cai and Wang, 2006). Their focus is however on how much information is transmitted as interests of senders and receivers diverge.

where $v > 0$ measures the positive externality imposed by player j on player i. Throughout the paper, we assume that $b + c > 2$, $a + b + c < 3$, $a(1 - v) < 1$ and $b(1 + v) > 1$. Below, we indicate where these inequalities play a role.

If the state $s = a$ is common knowledge, it is both individually rational and socially optimal not to contribute. In fact, both players not contributing is the unique Pareto efficient outcome in that case. Instead, when $s = c$, it is a dominant strategy to contribute and both players contributing is the unique Pareto efficient outcome. Since $\frac{1}{1+v} < b < 1$, the intermediate state b corresponds to a prisoners' dilemma: it is individually rational not to contribute, but it is socially optimal to do so.

In our baseline game[5], s, however, is not common knowledge: *only* the leader is informed about the value of s and she chooses $x_1 \in \{0, 1\}$ first. The follower observes x_1 and chooses $x_2 \in \{0, 1\}$. The condition $a + b + c < 3$ implies that the follower will choose $x_2 = 0$, if he bases himself on his prior beliefs. On the other hand, the condition $b + c > 2$ implies that, if the follower knows that the state is either b or c, both with 50% probability, then he will choose $x_2 = 1$. These conditions imply different incentives for the players, from the case in which the state is common knowledge. For example, when $s = b$, the leader has an incentive to contribute, since this can induce the follower to contribute as well. We write a strategy of the leader in this baseline game as $\sigma = (\sigma_a, \sigma_b, \sigma_c)$, where σ_s denotes the probability of contributing in state s. A strategy of the follower will be specified as $\tau = (\tau_0, \tau_1)$ where τ_y denotes the probability that the follower contributes given that $x_1 = y$. The condition $a(1 - v) < 1$ guarantees that the leader has not contributing as a dominant action if $s = a$, and that the baseline game is dominance solvable, hence, has a unique Nash equilibrium.

Proposition 1 *The baseline game has a unique Nash Equilibrium, (σ^*, τ^*) with $\sigma^* = (0, 1, 1)$ and $\tau^* = (0, 1)$. This equilibrium is efficient, that is, the sum of the players' payoffs is maximized for all $s \in S$.*

Given full efficiency without communication, we next ask what will be the effect of adding verbal communication to the game. What communication strategies would the leader use if talk about the state of nature is costless? What will the equilibria be? We address these questions theoretically in the following subsections.

3.2 Allowing communication

We now add one-way communication from the leader to the follower. After the leader is informed about s, she sends the follower a message, $m \in M$, where M contains at least two messages. At the same time, she chooses x_1. The follower observes m and x_1 and chooses x_2. The payoff function of each player remains as above, hence, the additional communication is costless ('cheap talk'). We write $G(M)$ for the resulting game. We first consider the pure cheap talk case with a general message set M, and then move to the language sets in the case of PC and VC, together with lying costs. We will show that, in the general case, although allowing communication leads to additional and inefficient Nash equilibria, only the efficient equilibrium from Proposition 1 is stable.

As a result of the messages being costless, game $G(M)$ allows multiple equilibria. Part of this multiplicity is 'inessential' (payoff irrelevant) and only concerns the messages. For example, one equilibrium has players contributing according to the strategy

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[5]This baseline game is a general version of the game used in Potters et al. (2007). In their setting, $a = 0, b = 0.75, c = 1.5$ and $v = 1$. Our theoretical results are more general; in our experiment, we use the same values for a, b, c, but set $v = 2$. We choose $v = 2$ in order to increase the efficiency gains from contributing when $s = b$ and $s = c$.

pair (σ^*, τ^*) from Proposition 1, but the leader announcing m' for any $s \in S$ whereas another equilibrium has the same contributions, with the leader always announcing a different message m''. Clearly, such multiplicity is not very interesting. However, there are also other, quite different, equilibria, with inefficient contribution levels, and such equilibria are even sequential. For example, suppose that the leader chooses $(m', 0)$ in state $s = a$, and chooses $(m'', 0)$ if $s = b, c$. Also, suppose that the follower responds to $(m'', 0)$ with $x_2 = 1$ and to all other combinations of messages and actions with $x_2 = 0$. Further, the follower stubbornly believes that any action of the leader different from $(m', 0)$ or $(m'', 0)$ signals that the state is $s = a$, while after $(m', 0)$ and $(m'', 0)$ his beliefs satisfy Bayes' rule. Given this behavior of the follower, the best response of the leader is to follow the strategy as indicated, and we have obtained a Nash (even Sequential) Equilibrium in which only the follower contributes, and then only when the state is intermediate or high: the efficiency of this equilibrium is substantially lower than that of the Nash Equilibrium from Proposition 1.

The inefficient Sequential Equilibrium from the previous paragraph does not survive the Intuitive Criterion (Cho and Kreps, 1987). Suppose the leader deviates from her equilibrium strategy and chooses $(m'', 1)$. Then, under the Intuitive Criterion, the follower must infer that the state is $s = c$, since only in this state can the deviation possibly yield the leader a payoff higher than in the current equilibrium. But, given such beliefs, it is a best response for the follower to choose $x_2 = 1$ after the deviation, upsetting the equilibrium.

Although the intuitive criterion suffices to eliminate this specific inefficient equilibrium, we need to apply a refinement which is a little stronger to eliminate the multiplicity in contributions in general.[6] Formally, we rely on the 'equilibrium dominance' criterion, which is implied by stability as in Kohlberg and Mertens (1986). We show that all stable equilibria of the cheap talk game $G(M)$ lead to the same contribution levels as those obtained in Proposition 1.

To state this result formally, we introduce some notation. Let σ denote a strategy of the leader in the game $G(M)$ with communication language M and let τ be a strategy of the follower. Then $\sigma = (\sigma_a, \sigma_b, \sigma_c)$ where $\sigma_s : M \times \{0, 1\} \to [0, 1]$, and $\sigma_s(m, x_1)$ denotes the probability that a message-contribution pair is chosen by the leader in state s. If the strategy is pure, that is, does not involve any randomization, we simplify notation by writing $\sigma_s = (m, x_1)$. Similarly τ specifies the probability $\tau(m, x_1)$ that the follower will contribute for any message-contribution pair (m, x_1) that the leader may choose. We write $M_s(\sigma)$ for the set of messages in M that occur with positive probability when the state is s and σ is played. Similarly $X_s(\sigma)$ denotes the probability that the leader contributes when the state is s and σ is played. Finally, $E(s \mid m, x_1; \sigma)$ denotes the expected value of s given (m, x_1) and strategy σ.

Proposition 2 *In any stable equilibrium of the game $G(M)$ we have:*

(1) $(X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 1, 1)$
(2) $E(s \mid m, 1; \sigma) \geq 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$
(3) $\tau(m, 0) = 0$ for all $m \in M_a(\sigma)$, while $\tau(m, 1) = 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$

Condition (1) states that, in a stable equilibrium, the leader contributes unless $s = a$. Condition (2) states that for any message that is sent with positive probability

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[6]Equilibria exist in which the leader randomizes between different messages when $s = a$, including also the message, say m'', used when $s = \{b, c\}$. In neither state does the leader contribute. The randomization is such that the follower is indifferent between contributing or not after m''. In such an equilibrium, the leader also has an incentive to deviate to contributing when $s = b$. The intuitive criterion is not powerful enough to eliminate mixed equilibria of this type.

when $s = b$ or $s = c$, the follower's conditional expected value of s is at least 1. This condition is necessary and sufficient for the best reply of the follower to be to contribute. Condition (2) is satisfied if types b and c of the leader follow the same strategy ($\sigma_b = \sigma_c$), with this being different from the strategy of type a ($\sigma_a \neq \sigma_b$); more generally, it requires that σ_b and σ_c are not too different. Condition (3) states that the follower mimics the contributions of the leader.

Proposition 2 implies that, with communication, and irrespective of the language that is available, the (stable) equilibrium *contributions* are the same as in the equilibrium without communication. Note, however, that, if speaking is costless, equilibrium does not determine the *messages* that will be used: as long as the messages used in states b and c are sent with a similar frequency, a stable equilibrium results. By using messages with a literal meaning, and assuming that players are averse to lying, we can, to a great extent, eliminate this indeterminacy. In fact, when messages have to be precise, the indeterminacy is eliminated. We turn to this in the next subsection.

3.3 Messages with literal meaning and lying costs

We now focus on the case where messages have a literal meaning. We allow the leader to talk about the state and consider two different languages. In the first, the leader is forced to communicate precisely: she has to communicate a state, hence, messages correspond to states. We refer to this game as $G(PC)$. The messages available are $M_{PC} = \{a, b, c\}$. In the second case, $G(VC)$, also vague communication is allowed: the leader communicates a set of states. This means, $M_{VC} = \{a,\ b,\ c,\ 'a\ \text{or}\ b',\ 'a\ \text{or}\ c',\ 'b\ \text{or}\ c',\ 'a,b\ \text{or}\ c',\ 'blank'\}$. The second language is richer than the first; all messages that are available in the first case are also available in the second.

In both cases, the leader can lie if she wants, but we assume that she has an aversion to do that: if in state s the message m is a lie, then the leader incurs a disutility of ε; for the rest the payoffs remain as specified at the beginning of Section 3.1. We refer to the resulting games as $G_\varepsilon(PC)$ and $G_\varepsilon(VC)$. Note that our assumption implies that the leader does not value being precise, hence, she does not mind using vague messages. At the end of this subsection, we will argue that, if the leader would prefer to be precise, vague messages would lose their attraction; we would essentially be back in the game with precise communication.

Proposition 3 *In any stable equilibrium of the game $G_\varepsilon(PC)$ with precise communication and positive cost of lying, we have:*

- *If $\varepsilon < b(1+v) - 1 : \sigma_a = (a,0)$, $\sigma_b = \sigma_c = (c,1)$, and $\tau(a,0) = 0$, $\tau(c,1) = 1$;*
- *If $\varepsilon > b(1+v) - 1 : \sigma_a = (a,0)$, $\sigma_b = (b,0)$, $\sigma_c = (c,1)$, and*
$$\tau(a,0) = \tau(b,0) = 0,\ \tau(c,1) = 1$$

Proposition 3 shows that, if lying costs are small, the contribution levels remain as in the game without verbal communication. The leader contributes if and only if the state is b or c, and the follower mimics the leader's contribution. Furthermore, the assumption of lying costs leads to a precise prediction about which messages will be used: the leader lies when $s = b$ by saying that it is c, and is truthful in the states a and c. However, if lying costs are larger, the leader truthfully reveals each state, so that neither player contributes in state b, with a drop in efficiency as its consequence.

Note that, in any stable equilibrium of $G_\varepsilon(PC)$, the leader always obtains his best possible payoff, both when the state is a as when it is c. In contrast, if $s = b$, the leader can improve: if ε is small, she incurs lying costs, while for large ε the contributions are

9

not at the efficient level. These negative aspects can be avoided when vague messages can be used, as in the game $G_\varepsilon(VC)$. We have:

Proposition 4 *The game $G_\varepsilon(VC)$ with vague communication and positive cost of lying has multiple stable equilibria. First of all, any stable equilibrium of the game $G_\varepsilon(PC)$ remains stable in $G_\varepsilon(VC)$. Next to that, there are stable equilibria in which the leader, while being truthful, uses a vague message when $s = b, c$, hence:*

- *$\sigma_a=(m_a,0)$ where m_a is a message that is truthful when $s = a$, and $\tau(m_a,0)=0$*
- *$\sigma_b = \sigma_c =(m,1)$ where m is a vague message that is truthful both when $s = b$ and $s = c$, and $\tau(m,1)=1$*

Note that, when $s = a$ or $s = c$, both players are indifferent about which of the equilibria from Proposition 4 is played. In contrast, when $s = b$, the leader strictly prefers an equilibrium with vague communication. Consequently, from the ex ante point of view, the leader prefers vague communication. When lying costs are small, this preference is not very strong, but the larger these costs are, the more the leader prefers to communicate vaguely. Furthermore, for large lying costs, also the follower strictly prefers an equilibrium with vague communication. On the basis of these attractive payoff properties, we predict players to coordinate on such an equilibrium (see Hypothesis 3 in the next section).

To conclude this Section, let us briefly discuss the case where the leader does not just dislike lying, but where she also dislikes being vague. If we assume that vagueness is disliked equally much as lying (hence, vague messages are associated with the same cost of ε), then we are essentially back to the context of Proposition 3. A slight adaptation of the proof of that Proposition shows that when $s = a$ or $s = c$ the leader will be precise and truthful, hence, this modified game, $G'_\varepsilon(VC)$, has a unique stable equilibrium outcome, which is as in Proposition 3.

4 Hypotheses

If lying costs are absent, as in the standard game theoretic approach, or sufficiently small, we obtain the result that the stable equilibria of the game with (precise or vague) communication lead to the same contribution levels and, hence, efficiency, as the game without communication (Propositions 1-4). This forms our main hypothesis.

H1: The addition of communication has no effect on contributions, payoffs and efficiency.

Taking into account the literal meaning of messages, and assuming small lying costs, we can also hypothesize which messages will be used by the leader in each state. If communication must be precise ($G_\varepsilon(PC)$), and lying costs are small, the leader will send message a when $s = a$, while she will send message c when the state is b or c. This leads to Hypothesis 2.

H2: When communication must be precise, the leader reveals states a and c truthfully and precisely. But, she lies when the state is b, by saying that it is c.

However, if lying costs are large, Hypothesis 2 does not hold. In consequence, Hypothesis 1 would also be rejected. In particular, from Proposition 3, we know that,

if lying costs are large, the leader prefers to reveal that the state is b and to not contribute in that state. This, in turn, implies that, if $s = b$, the follower does not contribute either, and that efficiency falls.

In contrast, when communication can be vague (as in $G_\varepsilon(VC)$), the leader prefers sending vague and truthful messages, such as the state is 'b or c', 'a, b, or c', or 'blank', when the state is b or c. This leads to Hypothesis 3.

H3: When communication can be vague, the leader sends a truthful message in state a. When the state is b or c, the leader uses the same vague and truthful message.

Lastly, the follower, who is assumed to be rational and self-interested, reacts optimally to the information revealed by the leader. Therefore, in the PC treatment, he contributes after observing a contribution of the leader accompanied by message c. In treatment VC, he contributes after observing a contribution of the leader accompanied by a message that is truthful when the state is c. This leads to Hypothesis 4.

H4: The follower's contribution decision is optimal given the information revealed by the leader's contribution and message, if available. Consequently,
(i) In NC, the follower imitates the leader;
(ii) In PC, he contributes after observing a contribution of the leader together with message c;
(iii) In VC, he contributes after observing a contribution of the leader together with a message that is truthful in state c.

5 Experimental Design and Procedures

In the experiment, the payoff function of our game was given by $u_i = 40[1 - x_i + s(x_i + vx_j)]$, where $i = \{1, 2\}, j = 3 - i, s = \{0, 0.75, 1.5\}$ and $v = 2$. In the experiment, s was labeled as the earnings table number (1, 2 or 3) corresponding to the values of s, 0, 0.75 or 1.5, respectively. Subjects were asked to choose between A (equivalent to $x_i = 0$) and B (equivalent to $x_i = 1$) in each round. Payoffs (in points) are summarized below for each s. These tables were shown to subjects both in the instructions as well as on the computer screens.[7]

		$s = 0$ Other person's choice		$s = 0.75$ Other person's choice		$s = 1.5$ Other person's choice	
		A	B	A	B	A	B
Your choice	A	40	40	40	100	40	160
	B	0	0	30	90	60	180

Table 1: Payoff matrices

In each round, the leader was informed about s first and then could make her choice, A or B, on the same screen. If the treatment allowed communication, the leader, at the same time, was asked to select a message from a list of possible messages. The follower was informed about the leader's choice (and message, when relevant) and was asked to choose between A or B. The roles of leader and follower were randomly determined within each pair in each round.

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[7]The instructions are included in Appendix B.

We ran three treatments. The No communication (NC) treatment, serves as a baseline. Under Precise Communication (PC), only precise messages regarding s could be chosen, corresponding to language M_{PC}. With Vague Communication (VC), vague messages were available, corresponding to language M_{VC}.

Both players had a history table at the bottom of their screens, displaying for each of the previous periods: the state (s), the role of the player, her decision (including the message sent if applicable), that of her partner in that round, and the earnings of both the player and that partner. From this information, players could not identify the players with whom they had previously played.

For each of the three treatments we had two sessions with 16 subjects each. Since we had two independent matching groups of 8 subjects in each session, we obtained 4 independent observations per treatment. Subjects were re-paired every period with another subject in their matching group and roles were randomly assigned. To have enough learning possibilities for each earnings table, subjects played the game for 21 periods. Since there were 8 subjects in each matching group, each subject met the same person 3 times. We ensured that the same pair did not meet twice in a row. Overall, 84 pairings were obtained per matching group (4 pairs x 21 periods): 25 faced Earnings Table 1, 30 Earnings Table 2 and 29 Earnings Table 3.[8] The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007)[9]. Players were paid their accumulated earnings in cash and in private at the end of the experiment.

The experiment was conducted in CentERlab at Tilburg University during the second week of April, 2008. It lasted between 50 and 80 minutes and subjects earned 13.55 EUR on average. Most of the subjects were students in Economics (40%) and Business (40%).

6   Results

In this section, we report the experimental results. We first analyze the impact of communication on efficiency, and on the contributions of the leader and the follower. Then, we turn to the leader's use of messages and the follower's reactions to these. Throughout we take into account all periods of the experiment. Unless explicitly specified otherwise, the results do not change when taking the first half, or the second half of the experiment. The unit of observation is taken to be each matching group in the experiment.

6.1   The impact of communication on efficiency

Efficiency, defined as the sum of leaders' and followers' payoffs, divided by the maximum sum of payoffs attainable, is displayed in Table 2. Columns (1) to (3) display efficiency by state, while column (4) displays overall efficiency. The table shows that the addition of communication has no effect on efficiency. Overall efficiency is around 85% in all treatments, with little variation. At the bottom of each column, we display Mann-Whitney tests, comparing efficiency in NC and PC, and in NC and VC, respectively. There are no significant differences across treatments. Efficiency is lowest when $s = 0.75$ and communication is precise (75.7%).

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[8] The matching schemes, roles and states of nature for each period and pair were randomly drawn before the experiment. This allowed us to have the same patterns across different matching groups.

[9] The z-tree program files and the raw data files can be downloaded at http://center.uvt.nl/phd_stud/garcia/liesandvagueness.rar. This file also includes all the files used to generate the paper's results.

	Efficiency[a]			
Treatment	s=0	s=0.75	s=1.5	Overall
	(1)	(2)	(3)	(4)
NC	91.0%	80.1%	90.3%	87.3%
	(6.2)	(6.3)	(2.3)	(2.4)
PC	94.0%	**75.7%**	89.3%	85.7%
	(3.7)	(3.7)	(10.8)	(6.4)
VC	92.5%	81.5%	89.6%	87.5%
	(4.4)	(9.1)	(13.9)	(10.1)
Mann-Whitney tests, p-values				
NC vs PC	0.4678	0.3094	0.7702	0.7728
NC vs VC	0.6592	0.8845	0.2454	0.5637

Note:[a] Efficiency$=\frac{\text{sum of follower and leader payoff}}{\text{maximum sum of payoffs}}$;

Standard deviations in parentheses.

Table 2: Efficiency by state s and treatment

Examining contributions in somewhat more detail, we see that communication did not alter significantly the contribution of either leader or follower. Hence, also individual payoffs do not differ. Figure 1 displays average contributions of the leader and the follower per state and treatment, and shows that these do not change significantly across treatments. When s=0 (the three leftmost bars in Figures 1a and 1b), average contributions are close to 0%, while, when s=1.5 (the three rightmost bars), they are above 90% for player 1 and around 80% for player 2. When s=0.75, the average contribution lies between 50% and 70%, with that in PC being lowest for both players. Contributions in NC are similar to those observed in Potters et al (2007). For s=0.75, if we compare the leader's contributions in NC (68%) with those in PC (60%), the Mann-Whitney test yields a p-value of 0.3065. The leader's contribution frequency in VC is 68%, which is not significantly different to that in NC either (MW test, p-value of 0.6612). Similarly, comparing the follower's contributions in NC vs. PC yields a p-value of 0.4624 and NC vs. VC yields a p-value of 0.7702.[10] Consequently, we do not reject Hypothesis 1, as summarized in Result 1.

Result 1: The addition of communication, whether restricted to be precise or not, does not significantly affect contributions of either player, payoffs or efficiency. Therefore, we do not reject Hypothesis 1.

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[10]If we compare treatments PC and VC, the Mann-Whitney test yields a p-value of 0.6631 for the difference in the leader's contributions and 0.1059 for that in the follower's contributions.
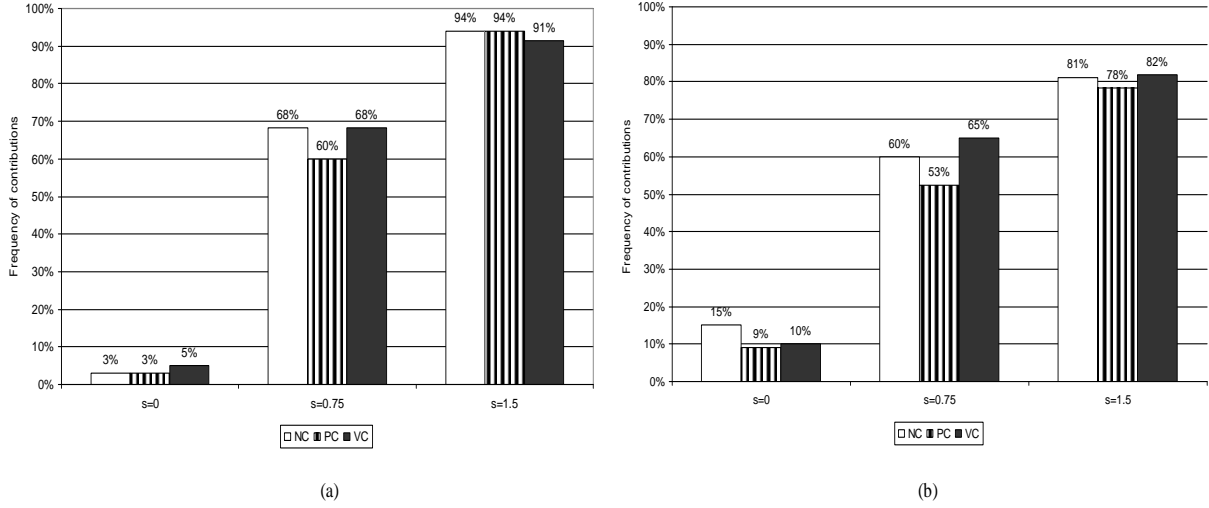
Figure 1: Average contributions of leaders (Figure 1a) and followers (Figure 1b) per state s and treatment

6.2 The leader's communication

Table 3 displays the frequencies with which a message is sent (in %), depending on state s and the leader's contribution decision. The upper panel displays the results for the precise communication (PC) treatment, while the bottom panel gives the data for the vague communication (VC) treatment.

Under PC, in state 0, the leader is most frequently truthful and does not contribute (82%). In state 1.5, the leader is also frequently truthful, but with contribution (86.2%). In contrast, when the state is intermediate ($s = 0.75$), the leader lies in more than 70% of the cases. The truthful message, '0.75', is used in only 28.3% of the cases; in 13.3% it is paired with no contribution, and in 15% with a contribution. When $s = 0.75$, most frequently, the leader sends message '1.5' and contributes (43.3%). In each state the modal response is in line with hypothesis 2, and therefore in line with the stable equilibrium outcome with no or small lying costs.

Although message '1.5' together with $x_1 = 1$ is observed more frequently in state 1.5 than in state 0.75, the difference is only marginally significant with a Wilcoxon signed ranks test (WSR-test, p-value=0.068) if we take all periods of the experiment into account, and it becomes insignificant in the second half, after period 10 (WSR-test, p-value=0.144). Consequently, with experience, the leader lies and contributes more often.

14

Treatment	State	Contribution	'0'	'0.75'	'1.5'	'0.75 _or_ 1.5'	'_blank_'	other vague messages	Total
									Message
PC	s=0	x_1=0	82.0%	6.0%	2.0%				90.0%
		x_1=1	0.0%	1.0%	9.0%				10.0%
	s=0.75	x_1=0	6.7%	13.3%	20.0%				40.0%
		x_1=1	1.7%	15.0%	**43.3%**				60.0%
	s=1.5	x_1=0	0.9%	0.9%	4.3%				6.0%
		x_1=1	0.9%	6.9%	86.2%				94.0%
VC	s=0	x_1=0	61.0%	3.0%	2.0%	5.0%	17.0%	7.0%	95.0%
		x_1=1	0.0%	0.0%	1.0%	3.0%	0.0%	1.0%	5.0%
	s=0.75	x_1=0	2.5%	4.2%	9.2%	3.3%	7.5%	5.0%	31.7%
		x_1=1	1.7%	24.2%	**18.3%**	8.3%	10.8%	5.0%	68.3%
	s=1.5	x_1=0	0.9%	0.0%	1.7%	3.4%	0.9%	1.7%	8.6%
		x_1=1	0.9%	1.7%	**75.9%**	1.7%	7.8%	3.4%	91.4%

Table 3: Frequency with which each combination of contribution and message decision is observed, by state and treatment

Result 2: In the PC treatment, the leader lies in more than 70% of the cases when the state is 0.75, most often by saying it is 1.5. She reveals the state truthfully when it is 0 and 1.5. Therefore, we do not reject Hypothesis 2.

In the VC treatment, when $s = 0.75$ vague messages are used frequently. Messages '0.75 or 1.5' and 'blank' are used in 11.7% (3.3%+8.3%) and 18.3% (7.5%+10.8%) of the cases, respectively. The leader contributes and sends message '1.5' only 18.5% of the time, a frequency which is significantly lower than in treatment PC, 43.3% (Mann-Whitney (MW) test, p=0.020). This is consistent with leaders having moderate lying costs.

However, equilibrium requires that the leader chooses the same contribution and message when $s = 1.5$ as when $s = 0.75$. In fact, given that the leader contributes, the frequency with which message '1.5' is used in state 0.75 (18.3%) is significantly lower than the frequency of that message in state 1.5, 75.9% (WSR-test, p-value=0.068). This result does not change in the second half of the experiment. This is the first indication that Hypothesis 3 is not supported. It suggests that, in the VC treatment, leaders are overcommunicating, a phenomenon earlier observed in Forsythe et al (1997), Blume et al (2001) and Cai and Wang (2006).

To investigate in more detail whether such overcommunication is taking place, we now analyze the information revealed by the leader's messages. Below, we focus on the cases in which the leader contributes and we compare the probability that the state is 0, 0.75 and 1.5 across the different available messages. This posterior probability is displayed in Table 4. It is calculated by taking the message use of all leaders in each state and by using Bayes' Rule. We also display the expected payoff difference from contributing compared to not contributing, from the follower's perspective, i.e. $E(\pi(x_2 = 1) - \pi(x_2 = 0)|m, x_1 = 1)$. This payoff difference is simply equal to $E(s|x_1 = 1, m) - 1$, that is, the conditional expected value of the state, minus 1. If this difference is positive, $E(s|1, m) - 1 > 0$, the follower's best response is to contribute; otherwise, not contributing is optimal.

Treatment	Message (m)	Prob(s=0|x_1=1,m)	Prob(s=0.75|x_1=1,m)	Prob(s=1.5|x_1=1,m)	$E(s\|1,m)-1$
NC	-	0.02	0.42	0.56	0.16
PC	'0'	0.00	0.75	0.25	-0.06
	'0.75'	0.02	0.77	0.22	-0.10
	'1.5'	0.01	0.34	0.64	0.22
VC	'0'	0.00	0.50	0.50	0.13
	'0.75'	0.00	**0.88**	0.13	-0.16
	'1.5'	0.01	0.20	**0.79**	**0.33**
	'0.75 or 1.5'	0.54	0.39	0.07	**-0.60**
	'blank'	0.00	0.63	0.37	0.02

Table 4: Probabilities that the state s is 0, 0.75 and 1.5 conditional on each message given that the leader contributed

Without verbal communication, in treatment NC, a contribution by the leader reveals that the probability that the state is 0.75 (0.42) is relatively close to that of the state being 1.5 (0.56). Also, $E(s|1,m) - 1 = 0.16 > 0$. Thus, the follower has an incentive to contribute.

In treatment PC, we see that sending message '1.5' and contributing leads to a similar result: the conditional probability that the state is 1.5 is 0.64, which is enough to incentivize the follower to contribute as well. In contrast, if the leader sends message '0' or '0.75' and contributes, the follower has no incentive to contribute ($E(s|1,m) - 1$ is -0.06 and -0.10, respectively).

In treatment VC, we see that a precise message, '0.75' or '1.5', is essentially revealing the corresponding state.[11] Consequently, the follower has no incentive to contribute when the message sent is '0.75'. After a vague message (message '0.75 or 1.5' or a blank message), there is a much higher probability that the state is 0.75 than that the state is 1.5. In particular, after message '0.75 or 1.5' the probability that the state is high is only 0.07, and the best response is not to contribute.[12] Thus, when vague messages are used, in particular the message 'the value is 0.75 or 1.5', the leader is essentially saying that the state is not good, and that the best response is not to contribute; the leader is overcommunicating.

Result 3: In the VC treatment, when $s = 0.75$, the leader lies significantly less than in PC. Instead, she frequently uses vague messages, such as 'the value is 0.75 or 1.5', or 'blank'. As the leader reveals the good value ($s = 1.5$) precisely in more than 75% of the cases, this leads to overcommunication. Therefore, we reject Hypothesis 3.

6.3 The follower's reactions

In the absence of communication (treatment NC), the follower matches the leader's contribution. He contributes when the leader does (in 84.5% of the cases), and he does not if the leader does not contribute (88% of the cases). Consequently, we do not reject Hypothesis 4(i).

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[11]Note that, if the leader sends message 0 and contributes, $E(s) - 1$ is positive, 0.13. This result is driven by the fact that this message is sent rarely and only in two of the four matching groups.

[12]The probability that s=0 is high (0.54) after message '0.75 or 1.5' because it is rarely used in some matching groups. In particular, in two of the four matching groups this message is only used once and only in state 0. In another matching group, it is used 6 times only when s=0.75, and in the final matching group it is used once when s=0, four times when s=0.75 and twice when s=1.5.

We examine the follower's reactions to messages and contributions of the leader in PC and VC in Table 5 below. This table displays the reaction of the follower (fraction of x_2=1) to each message of the leader, conditional on her contribution decision. As in Table 3, the upper panel presents results for treatment PC and the bottom one for treatment VC.

Treatment			'0'	'0.75'	'1.5'	'0.75 or 1.5'	'blank'
				Leader's message[a]			
PC	If $x_1 = 1$	Percentage of $x_2 = 1$	0.0%	**32.5%**	**83.9%**		
		Frequency[b]	0.9%	8.0%	45.8%		
	If $x_1 = 0$	Percentage of $x_2 = 1$	4.5%	11.7%	33.5%		
		Frequency	27.1 %	6.8%	11.3%		
VC	If $x_1 = 1$	Percentage of $x_2 = 1$	75.0%	**74.2%**	86.9%	70.8%	79.2%
		Frequency	0.9%	9.2%	33.0%	4.5%	6.5%
	If $x_1 = 0$	Percentage of $x_2 = 1$	1.0%	38.9%	41.0%	7.4%	26.7%
		Frequency	19.3%	2.4%	4.5%	3.9%	8.0%

[a] In Table 5 we report the follower's reaction to vague messages which were used in more than 5% of the cases in at least one treatment.

[b] Frequency (in %) refers to the number of times a combination of message m and x_1 was observed over the total number of times the public good game was played within a treatment.

Table 5: Follower's contributions for a given message and contribution of the leader

We first consider the follower's reaction to messages in Treatment PC. In this treatment, the follower reacts to both the contribution and the message of the leader. Given that the leader contributes, in 83.9% of the cases, the follower responds to message '1.5' with a contribution. In contrast, if the leader sends message '0.75', but still contributes, the follower often free-rides on the leader's contribution. He contributes in 32.5% of the cases, significantly less than when the message is '1.5' (WSR-test, p-value=0.068)[13]. Thus, the follower reacts optimally to these messages, contributing only after 1.5 as it is only in this case it is optimal. These reactions are in line with Hypothesis 4(ii).

When vague messages are allowed, if the leader contributes, the follower no longer reacts differently to the message sent by the leader. Given $x_1 = 1$, the contribution rate of the follower after message '0.75' is of 0.742, while it is 0.869 after message '1.5'. The difference is not significant (WSR-test, p=0.465). Similar response rates are observed for vague messages (0.75 or 1.5) and for blank messages, and differences are insignificant. In this treatment, after a contribution of the leader, the follower is not behaving optimally. As we saw in the previous section, the leader often overcommunicates. She sends vague messages when s =0.75, but reveals the state precisely when s =1.5. Thus, the follower has no incentive to contribute after message '0.75' or message '0.75 or 1.5', based on the information conveyed by these messages. Nevertheless, he still frequently does contribute. This is against Hypothesis 4(iii), but is in line with Blume et al (2001), who find that receivers do not fully take advantage of the sender's overcommunication.

[13] The difference in contributions of the follower between messages 0.75 or 1.5, conditional on the leader contributing, is significant at the 10% level when taking all periods together, as reported, and taking periods 11 to 21 (WSR-test, p=0.068). But it is not significant from periods 1 to 10 (WSR-test, p=0.353).

The reactions of the follower are confirmed when regressing the follower's contribution on the leader's contribution and messages. In Table 6, the regression results are presented.

	(1)	(2)
	PC	VC
	x_2	x_2
x_1	1.354***	1.609***
	[0.191]	[0.394]
$m=0$	-1.647***	-1.529***
	[0.302]	[0.073]
$m=0.75$	-0.888***	-0.297
	[0.239]	[0.414]
vague message		-0.242
		[0.167]
Period	0.009	-0.021***
	[0.014]	[0.006]
Constant	-1.10	-1.194
	[1.161]	[1.808]
Observations	336	319
Log-likehood	-126.9	-121.5
Pseudo - R2	0.455	0.445

Note: Probit regression results. The follower's contribution x_2 is the dependent variable; x_1 is the contribution of the leader; $m=0$ is a dummy variable which is 1 if the message is 'the value is 0', similarly for $m=0.75$; vague messages include 'the value is 0.75 or 1.5' and blank; other vague messages are excluded; the omitted message is thus 'the value is 1.5'. Several individual characteristics are included as controls: age, gender, field and level of studies, nationality and previous experience in experiments. These are not reported here for brevity. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in brackets.

Table 6: Follower reactions to the leader's contribution and messages

We first note that a contribution by the leader always increases the probability of the follower's contribution significantly, as we see from the significant coefficients of x_1 in the first row. The reaction to messages varies across treatments. In column (1) for the PC treatment, we observe that both messages '0' and '0.75' have a significant negative effect on the follower's probability to contribute, compared to message '1.5' (the omitted message). In contrast, considering the VC treatment, in column (2), we find that message '0.75' and vague messages have no significant effect on follower's contributions, compared to message '1.5'. This confirms the conclusions drawn from Table 5, that the follower does not react differently to the messages '1.5', '0.75' or to vague messages in the VC treatment.

These results are summarized in Result 4.

Result 4: In the NC and PC treatments, the follower most often optimally reacts to the information conveyed by the contribution and, in PC, messages of the leader, and we do not reject Hypotheses 4(i) and (ii). In contrast, in the VC treatment, the follower often does not react optimally. He contributes with equal frequency after messages

'1.5', '0.75', '0.75 or 1.5' and blank, although message '0.75' and vague messages are indirectly revealing that the state is 0.75. Therefore, we reject Hypothesis 4(iii).

In the VC treatment, the leader is not hurt by her overcommunication. Since the follower does not react to the information contained in vague messages or in the message '0.75', the leader's overcommunication is not 'punished'. An interesting question is why the follower does not react to the leader's overcommunication in VC. It could be driven by the fact the follower has less experience with messages in the VC treatment, where more messages are available compared to the PC treatment. However, the follower has slightly more experience with message '0.75' in the VC treatment, where its frequency is 9.2%, than in the PC treatment, where its frequency is 8%. Alternatively, it might also be that followers just pay less attention to messages in this treatment, where more messages are available.

7 Conclusion

The assumption of positive but moderate lying cost organizes the data from our experiment reasonably well. When communication must be precise, the leader lies frequently to avoid revealing the state and to prevent the ensuing free riding behavior. With only precise language available, the follower is attentive to both the messages that the leader uses and the leader's actions and he generally responds optimally.

The situation is different when vague messages are available as well. Equilibrium requires that the leader uses the same message when the value is high as when it is intermediate. Empirically, the leader's communication behavior is different: she reports the state precisely when it is high, but communicates vaguely when it is intermediate. Hence, there is overcommunication. Although this could clearly hurt the leader, as well as efficiency, the leader is saved by the fact that, with the richer language, the follower pays less attention to the messages, or finds them more difficult to interpret; in any case, when vague messages are available, the follower predominantly reads to what the leader does, not to what she says. As a result, contribution levels, payoffs and efficiency are not much different in the case when communication is possible, as compared to when it is not, and material payoffs do not depend much on the language that is available for communicating.

Some of the management literature recommends that managers use lies or vague language to motivate workers to work hard and invest. Lying conflicts with general ethics, and being vague would seem to be self-destroying over time, if workers accumulate additional information. Our experiment shows that ethics are not very strong, and that learning may take considerable time. In such circumstances, such behavior may indeed be meaningful and beneficial.

Finally, recall the quote at the beginning of this paper: "'no comment' is a comment". The phrase 'no comment' is typically used to conceal an inconvenient truth. Such concealment should not be effective when convenient truths are revealed precisely and truthfully. Then 'no comment' is a comment indeed. The most frequently used vague message in our experiment is 'blank', which may be seen as the equivalent of 'no comment'. Somewhat surprisingly, followers do not seem to pick up the fact that it is usually only used when the truth is inconvenient indeed. Hence, in the experiment, it is an effective message to hide private information. Perhaps this may explain why it still such a popular expression among public figures. As Winston Churchill was once quoted saying: "'No comment' is a splendid expression. I am using it again and again" (Muller, 1999, p.20).

Appendix

A. Proofs

Proposition 1

The baseline game has a unique Nash Equilibrium, (σ^*, τ^*) with $\sigma^* = (0, 1, 1)$ and $\tau^* = (0, 1)$. This equilibrium is efficient, that is, the sum of the players' payoffs is maximized for all $s \in S$.

Proof of Proposition 1.

We will prove the stronger result that strategy profile (σ^*, τ^*) is the only one that survives iterated elimination of strictly dominated strategies.

Since $a(1-v) < 1$ the leader has $x_1 = 0$ as a strictly dominant action for $s = a$: the worst payoff resulting from not contributing is $1 + av$, while choosing $x_1 = 1$ yields at most a. The condition $a + b + c < 3$ then implies that the follower will respond to $x_1 = 0$ by not contributing either: seeing $x_1 = 0$ makes him less optimistic that the state is intermediate or high. Since $c > 1$, this implies that the leader has $x_1 = 1$ as her dominant action when $s = c$. Since $b + c > 2$, this in turn implies that the follower will contribute after a contribution of the leader. Having established that, for the follower, only $\tau^* = (0, 1)$ survives the elimination of dominated strategies, it easily follows that $\sigma_b = 1$, hence, that $\sigma^* = (0, 1, 1)$ is the unique surviving strategy for the leader.

Proposition 2

In any stable equilibrium of the game $G(M)$ we have:
(1) $(X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 1, 1)$
(2) $E(s \mid m, 1; \sigma) \geq 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$
(3) $\tau(m, 0) = 0$ for all $m \in M_a(\sigma)$, while $\tau(m, 1) = 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$

Proof of Proposition 2.

First of all, we note that, since $a(1 - v) < 1$, any action with $x_1 = 1$ is strictly dominated for $s = a$. Consequently, type $s = a$ of the leader will not contribute. In the remainder of the proof, we can thus focus on the types b and c.

The second important observation is that, with respect to these types b and c, a single crossing condition is satisfied. Formally, denote by p the probability that the follower will contribute in response to some $(m, 0)$ and let q be the probability that he contributes in response to some $(m', 1)$. Then a simple calculation shows that, if type b of the leader weakly prefers $(m', 1)$ to $(m, 0)$, then any type c strictly prefers $(m', 1)$ to $(m, 0)$.

From this it follows that, in equilibrium, type $s = c$ of the leader cannot randomize her contribution. Assume she would. Then she would be indifferent between some $(m, 0)$ and some $(m', 1)$. But this implies that type $s = b$ would strictly prefer $(m, 0)$ to $(m', 1)$. Consequently, when seeing $(m', 1)$, the best response of the follower would be to contribute with probability 1, contradicting the indifference for type $s = c$ that was assumed.

Next, assume that there is an equilibrium in which type $s = c$ does not contribute. The single crossing property implies that also type $s = b$ does not contribute. Let $m^* \in M$ be a message such that type c chooses $(m^*, 0)$ with positive probability in equilibrium and write p^* for the probability that the follower contributes after $(m^*, 0)$. Obviously, type c will only choose messages for which p^* is maximal, and a similar remark holds for type b. It follows that the equilibrium utility of type s $(s = b, c)$ is given by $u_s^* = 1 + svp^*$, and that in order for type s not to deviate to some action $(m, 1)$, we must have

$$u_s^* = 1 + svp^* \geq s(1 + vq) \qquad (*)$$

where q is the probability that the follower contributes after $(m, 1)$. The single crossing condition implies that, in (*), only the constraint for type $s = c$ is binding. Consequently, the equilibrium can be stable (in the sense of Kohlberg and Mertens, 1986), only if it survives if the follower interprets the message-action pair $(m, 1)$ as coming from type c and then plays a best response. Given this interpretation, the best response, however, is $q = 1$, and this violates (*) for $s = c$. This shows that an equilibrium in which $s = c$ does not contribute is not stable; hence, in any stable equilibrium, we must have $X_c(\sigma) = 1$.

Finally, let m be a message used by $s = c$ in equilibrium. Then $\tau(m, 1)$ must be constant over all such messages m. In fact, $\tau(m, 1) = 1$ for all such m, since $(m, 1)$ is strictly dominated for type $s = a$. If type b chooses not to contribute, her payoff is 1, as in that case the follower will infer that the state is a or b. On the other hand, if $s = b$ chooses $(m, 1)$, then her payoff will be $b(1 + v)$. It follows that type $s = b$ will mimic type $s = c$. This established the proof of (1). The conditions (2) and (3) simply follow since, in any equilibrium, the follower must play a best response against all actions of the leader that occur with positive probability.

Proposition 3

In any stable equilibrium of the game $G_\varepsilon(PC)$ with precise communication and positive cost of lying, we have:
- If $\varepsilon < b(1 + v) - 1 : \sigma_a = (a, 0)$, $\sigma_b = \sigma_c = (c, 1)$, and $\tau(a, 0) = 0$, $\tau(c, 1) = 1$
- If $\varepsilon > b(1 + v) - 1 : \sigma_a = (a, 0)$, $\sigma_b = (b, 0)$, $\sigma_c = (c, 1)$, and
$$\tau(a, 0) = \tau(b, 0) = 0, \ \tau(c, 1) = 1$$

Proof of Proposition 3

Since $a(1 - v) < 1$ and lying costs are strictly positive, $(a, 0)$ is a strictly dominant strategy for type a. Consequently, in any Nash equilibrium, we will have $\sigma_a = (a, 0)$. As in Proposition 2, we can therefore focus on the types b and c.

Let us first focus on type c. We first show that, in any stable equilibrium, type c must choose $(c, 1)$ with positive probability. Assume not, then it follows that also type b chooses $(c, 1)$ with zero probability. (If b would choose $(c, 1)$ with positive probability, the follower would respond to $(c, 1)$ with $x_2 = 0$, yielding type b the payoff $b - \varepsilon$, which is less than the payoff 1 that type b can at least guarantee by chosing $(b, 0)$.) Consequently, consider an equilibrium in which $(c, 1)$ is not chosen at all in equilibrium. An argument as in the proof of Proposition 2 shows that c is more likely to deviate to $(c, 1)$ than b is, hence, that the follower should respond with $\tau(c, 1) = 1$, upsetting the equilibrium. We have, therefore, shown that $\sigma_c(c, 1) > 0$ in any stable equilibrium.

Note that if the follower responds with $\tau(c, 1) = 1$, then type c will not chose any other action, and the proof is complete, at least for type c. So assume $\tau(c, 1) < 1$. Given $\sigma_c(c, 1) > 0$, this choice of the follower can only be optimal if $\sigma_c(c, 1) < 1$. Assume $m \neq c$ is such that $\sigma_c(m, 1) > 0$. Then c must be indifferent between the two messages, hence, because of the lying cost $\tau(m, 1) > \tau(c, 1)$. But then type b strictly prefers $(m, 1)$ to $(c, 1)$, so that $\sigma_b(c, 1) = 0$, hence, $\tau(c, 1) = 1$, a contradiction. A similar argument leads to a contradiction in case some $(m, 0)$ would be chosen with positive probability by type c. This establishes that $\sigma_c(c, 1) = 1$, which, in turn, leads to the conclusion that $\tau(c, 1) = 1$.

Now, consider type b. The only possibility for this type to elicit a contribution from the follower is by choosing $(c, 1)$. This will yield payoff $b(1 + v) - \varepsilon$. Alternatively, by choosing $(b, 0)$, the guaranteed payoff is 1. If follows that b will choose $(c, 1)$ if $b(1 + v) - \varepsilon > 1$, and will choose $(b, 0)$ if the reverse inequality is satisfied.

Given that we have uniquely determined the strategy of the leader, it easily follows that the follower's strategy must be as written in Proposition 3. Hence, in any stable equilibrium,

the leader and the follower contribute when the state is c, and, when lying costs are small, also if the state is b.

Proposition 4

The game $G_\varepsilon(VC)$ with vague communication and positive cost of lying has multiple stable equilibria. First of all, any stable equilibrium of the game $G_\varepsilon(PC)$ remains stable in $G_\varepsilon(VC)$. Next to that, there are stable equilibria in which the leader, while being truthful, uses a vague message when $s = b, c$, hence:

- $\sigma_a=(m_a,0)$ where m_a is a message that is truthful when $s = a$, and $\tau(m_a,0)=0$
- $\sigma_b = \sigma_c =(m,1)$ where m is a vague message that is truthful both when $s = b$ and $s = c$, and $\tau(m,1)=1$

Proof of Proposition 4

That a stable equilibrium outcome of the game $G_\varepsilon(PC)$ remains stable in the extended game $G_\varepsilon(VC)$ (formally: that such an outcome cannot be upset by applying the equilibrium dominance criterion) follows from the fact that both type a and type c obtain their highest possible payoff in such an equilibrium; unexpected messages of the leader should, therefore, be attributed to type b, however, type b clearly has no incentive to deviate from the equilibrium either.

The strategy pairs described in Proposition 4 in which vague messages are used are clearly Nash equilibria: each player best reponds to the other. As also in these equilibria both type a and type c obtain their best possible payoff, a similar argument as above implies that also such equilibria cannot be upset by applying the equilibrium dominance criterion.

B. Instructions

The text in [ ], indicates treatment variations, while the text in { } was not included in the written instructions but read aloud by the experimenter.

{Experimenter announces: "We're now ready to begin the experiment. Thank you all for coming. You should all have a set of instructions. I am going to begin by reading through the instructions aloud"}

<div align="center">Instructions</div>

Introduction

This is an experiment about decision making. You are not allowed to talk to the other participants during the experiment. If, at any stage, you have any questions raise your hand and a monitor will come to where you are sitting to answer them.

The experiment will consist of twenty-one rounds. In each round you will be randomly paired with another participant. At the end of the experiment you will be paid in private and in cash, based upon your accumulated earnings from all twenty-one rounds. Your earnings will be converted into EUR according to the following rate: 100 points = 0.70 EUR.

Choices and earnings

In each round you have to choose between two options, A and B. The other person in your pair also has to choose between option A and option B.

Your earnings and the earnings of the other person in your pair will depend on your choice, the choice of the other person and the earnings table selected randomly by the computer.

One of three possible earnings tables is randomly selected by the computer at the beginning of each round, and may vary from round to round. In any round the earnings table is equally likely to be earnings table 1, earnings table 2 or earnings table 3. This earnings table is the same for you and the person with whom you are paired in a round. The earnings table may be different for different pairs of participants.

For each earnings table, your earnings are displayed below. These earnings depend on your choice and that of the other person in your pair. If you want to know your earnings for a particular earnings table and a choice made by you and the other person in your pair, first move to that particular earnings table. Then, select your choice and that of the other person. Your earnings are stated in points. From these tables you can also calculate the earnings of the other person in your pair, by switching the terms 'your choice' and 'other person's choice'.

{Experimenter announces: In the next page you see three tables. Your earnings are displayed depending on the earnings table selected by the computer, your choice and the choice of the other person}.

If the earnings table is 1,

Earnings Table 1

		Other person's choice	
		A	B
Your choice	A	40	40
	B	0	0

If the earnings table is 2,

Earnings Table 2

		Other person's choice	
		A	B
Your choice	A	40	100
	B	30	90

If the earnings table is 3,

Earnings Table 3

		Other person's choice	
		A	B
Your choice	A	40	160
	B	60	180

Procedure and information

At the beginning of each round you will be randomly paired with another participant. This will be done in such a way that you will not be paired with the same person two rounds in a row. Nor will you be paired with the same person more than three times throughout the experiment. You will never know the identity of the other person in your pair, nor will that person know your identity.

In each round, one participant in each pair is randomly chosen to be the first mover and the other the second mover. At the beginning of each round you will be informed about your role (first mover or second mover) in the pair for that round.

The first mover will be informed about the exact earnings table selected by the computer (earnings table 1, earnings table 2 or earnings table 3) before making his or

her choice, but the second mover will not be informed about the earnings table before making his or her choice.

[PC and VC: In each round, the first mover will choose a message he or she wishes to send to the second mover. first movers may choose among the following messages:]

[PC:

- "The earnings table selected by the computer is 1"
- "The earnings table selected by the computer is 2"
- "The earnings table selected by the computer is 3".

Please note that it is costless for the first mover to send a message.]

[VC:

- "The earnings table selected by the computer is 1"
- "The earnings table selected by the computer is 2"
- "The earnings table selected by the computer is 3"
- "The earnings table selected by the computer is 1 or 2"
- "The earnings table selected by the computer is 1 or 3"
- "The earnings table selected by the computer is 2 or 3"
- "The earnings table selected by the computer is 1, 2 or 3"
- "The earnings table selected by the computer is – (blank)".

Please note that it is costless for the first mover to send a message.]

[NC: In each round,] [PC and VC: Also,] the first mover will enter a choice (A or B). Then, the second mover will enter a choice (A or B). Before making his or her choice the second mover will be informed about the first mover's [PC and VC: message and] choice.

When all the second movers have made their choices, the result of the round will be shown on your screen. The screen will list the earnings table that was selected by the computer, [PC and VC: the message that was sent by the first mover,] the choices made by you and the other person in your pair, the amounts earned by you and the other person in your pair, and your accumulated earnings until that round.

Quiz

To make sure everyone understands how earnings are calculated, we are going to ask you to complete a short quiz. Once everyone has completed the quiz correctly we will continue with the instructions. If you finish the quiz early, please be patient. For each question you have to calculate earnings in a round for you and the other person in your pair.

{Experimenter announces: "Now please answer the questions in the quiz by filling in the blanks. In five minutes I'll check each person's answers. If you have a question at any time, just raise your hand."}

Complete the following table

[NC:

Earnings table selected by the computer	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	B	B	__	__
1	B	B	__	__
3	A	B	__	__
1	A	B	__	__
3	A	A	__	__
3	B	A	__	__

24

[PC: Earnings table selected by the computer	Message sent by first mover 'The earnings table selected by the computer is:	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	1'	B	B	__	__
1	1'	B	B	__	__
3	3'	A	B	__	__
1	2'	A	B	__	__
3	3'	A	A	__	__
3	1'	B	A	__	__]

[VC: Earnings table selected by the computer	Message sent by first mover 'The earnings table selected by the computer is:	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	1 or 2'	B	B	__	__
1	-(blank)'	B	B	__	__
3	2 or 3'	A	B	__	__
1	2'	A	B	__	__
3	1,2 or 3'	A	A	__	__
3	3'	B	A	__	__]

{When all subjects have completed quiz correctly, experimenter announces: "Everyone has completed the quiz so I'll continue with the instructions at the top of the fourth page where it says "summary"."}

Summary

Before we start the experiment let us summarize the rules. The sequence of each round is as follows:

1. Two participants are randomly paired; one is randomly chosen to be the first mover and the other the second mover.

2. The earnings table is selected by the computer: the earnings table is equally likely to be earnings table 1, earnings table 2 or earnings table 3.

3. The first mover is informed about the earnings table selected by the computer.

4. [PC and VC: The first mover choose which message he or she wishes to send to the second mover]

5. The first mover chooses between A and B.

6. The second mover is informed about the first mover's [PC and VC: message and] choice, but not the earnings table, and chooses between A and B.

7. Both the first mover and the second mover are informed about the results of the round.

After round 21 the experiment ends and each participant is paid his or her accumulated earnings, in private and in cash. Recall that accumulated earnings will be converted to EUR according to the following rate: 100 points = 0.70 EUR.

{Experimenter announces: "We will now start the experiment. At various times you will have to wait for others to make their decisions. When that happens please be patient. On the top right corner of your screen you will see a time display labeled "remaining time (sec)". This time display is not binding, you may take as much time as you need to reach your decision. If you have a question at any time, just raise your hand."}

Acknowledgments

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