

Mediating Conflict in the Lab

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Abstract

According to the theory of mechanism design, the presence of a mediator can strictly improve the chances for peace between two contestants. What is striking is that the result follows even when the mediator is less informed than the two parties and has no enforcement power. We test the theory in a lab experiment where two subjects negotiate how to share a resource. In case of conflict, the subjects' privately known strength determines their payoff. The subjects send cheap talk messages about their strength to one another (in the treatment with direct communication) or to the mediator (in the mediation treatment), before making their demands or receiving the mediator's recommendations. We find that, in line with the theory, messages are significantly more sincere when sent to the mediator. However, contrary to the theory, peaceful resolution is not more frequent, even when the mediator is a computer implementing the optimal mediation program. While the theoretical result refers to the best (i.e. most peaceful) equilibrium under mediation, multiple equilibria exist, and the best equilibrium is particularly vulnerable to small deviations from full truthfulness. Subjects are not erratic and their deviations induce only small losses in payoff, but translate into significant increases in conflict.

1 Introduction

Consider two parties fighting over a contested resource. Can an impartial third party help resolve conflict? Probably, if that party can distribute additional resources to the warring factions, or if it has superior information about their preferences and strengths, and enforcement power to lend teeth to its recommendations. But if that is not the case? From family disputes to labor relations to international conflict, mediation continues to attract sustained and indeed increasing attention, from psychologists, lawyers and judges, international organizations, and corporate agents specializing in its craft.¹ Concentrating attention to international conflict, widely quoted surveys conclude, for

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¹See for example a recent *Financial Times* article: "Industry of peacemakers capitalizes on global conflict" (Oct. 22, 2019).

example, that "half of all interstate wars and one third of all international crises since World War I have involved mediation" (Beardsley, 2011, p.3); in international crises, the recourse to mediation increases to almost two thirds in 1990-96 (Wilkenfeld et al. 2003, p 286). There can be many reasons for mediation's potential usefulness. But with self-interested and rational parties, in the absence of transfers, information, or power, through which mechanism can we hope for mediation to be helpful?

The surprising answer, proposed by Myerson in a particularly beautiful application of mechanism design, is that indeed, under these constraints, mediation can still increase the chances of peace (Myerson, 1991, ch.6). The essence is the confidentiality of the communication between the contestants and the mediator. It is possible for the mediator to induce the parties to the dispute to reveal their actual strength, and yet issue recommendations that leave them uncertain about the strength of their opponent, and thus willing, because of this uncertainty, to accept the recommendation rather than engage in open conflict. The final result is a higher frequency of peaceful resolutions than the two sides can obtain by communicating directly, a higher frequency fully engineered by the mediator's subtle modulation of incentives in the recommendations issued. As Myerson phrases it, the key is the *obfuscation* the mediator can employ—the possibility of not fully revealing the opponent's message—obfuscation that the parties cannot achieve by direct communication.

Myerson's insight is exploited by Hörner, Morelli and Squintani (2015) in an elegant model that confirms the superior role of mediation, relative to the best equilibrium under direct communication.² Narrowly defined, the present paper presents an experimental test of Hörner et al's model. More broadly, it studies the robustness of optimal mechanisms to multiple equilibria and noise.

The set-up is simple. Two subjects negotiate how to share a resource. In case of conflict, the subjects' privately known strength determines their payoffs. The subjects send cheap talk messages about their strength either to one another, in the direct communication treatment, or to the mediator, in the mediation treatment, before making their demands or receiving the mediator's recommended allocation. The mediator is a neutral third party whose goal is to maximize the probability of a peaceful resolution, but who has no information about the opponents' levels of strength (beyond a common prior) and no enforcement power. Upon seeing the subjects' messages, the mediator can issue a recommendation or refuse to mediate. Peace prevails if the mediator accepts to mediate and if the recommendation is individually accepted by both subjects. In line with Myerson's lesson, Hörner et

²Hörner et al. reach a particularly strong result: in their model a mediator with no enforcement power is just as effective in avoiding conflict as an arbitrator who can force the two factions to accept the arbitration resolutions (but cannot force them to enter into the arbitration process).

al. show that if the mediator can commit to refuse mediation under some conditions, then the ex ante probability of peace can be strictly higher, for some parameter values, than what the two opponents can achieve without a third party.

The streamlined game lends itself well to experimental testing. We take it to the lab, with minimal departures from the theoretical model. At the center of our experiment is the comparison between a treatment with direct communication and a mediation treatment where the mediator is a computer, known to enact the theoretical optimal mediation mechanism identified by Hörner et al..³ We find that mediation does indeed increase sincerity, something that theory predicts in our setting: in particular, the possibility to send confidential messages is associated with higher willingness to admit weakness. However, mediation does not increase the frequency of peace.

We find that there are several reasons. First, keeping constant the mediation program, there is a multiplicity of equilibria which vary greatly both in the messages' truthfulness and in the frequency of peace. This is a well-known problem in mechanism design,⁴ and not too surprisingly the lab makes it salient. Second, and more closely tied to the specific mechanism studied here, when the equilibrium with highest peace requires obfuscation, the locus of equilibria is discontinuous in the probability of peace in the neighborhood of full truthfulness. Any deviation from full truthfulness, no matter how small, must trigger non-compliance with the mediator's recommendations and a discrete upward jump in the probability of conflict. The fragility of obfuscation matters because according to the theory it is exactly the possibility of obfuscation that makes mediation superior to direct negotiations. In the data, the extent of non-compliance is less than the equilibrium analysis predicts, but is large enough to make the frequency of peace under mediation and under direct communication fully comparable.

However, the fragility of obfuscation is not the only source of our experimental results. There is no discontinuity in the absence of obfuscation, and yet in our data when the optimal mediation program does not involve obfuscation, the frequency of peace is comparable to that achieved with direct communication. Again, part of the reason can be found in the multiplicity of equilibria, given the mediation program, but we also see experimental subjects deviating from equilibria. And still, even with such a complex game, subjects' decisions are not erratic. For both messages and acceptance strategies we very strongly reject the hypothesis that subjects act randomly. In the lab, observed actions are not always best responses to the choices of others, but the deviations come consistently

³The optimal mechanism—the precise mapping from the pair of messages received and the mediator's recommendations—is publicly announced and known to the experimental subjects.

⁴See, for example, Palfrey (1990).

with small payoff effects. This is true for all subjects, but the intentionality of the choices is particularly clear for subjects of lesser strength: two thirds of such subjects suffer losses of not more than 5 percent; if subjects played randomly, the fraction suffering such small losses would be between one tenth and one fifth, depending on treatment. This then is the third reason we see for our results. Optimal mediation is fragile not only because of multiple equilibria, not only because of the instability of obfuscation to small deviations from full truthfulness, but more broadly because a large set of strategies induces both small individual losses and high conflict.

Our study can be read under two alternative perspectives. It is an analysis of the effectiveness of mediation, and thus contributes to the literature on mechanisms for bargaining and dispute resolution. Economic theorists continue to debate the extent to which the form of mediation we study in this paper—without superior information, transfers, or enforcement power—can improve outcomes in two-player conflict relative to direct communication. Not surprisingly, the answer is sensitive to the details of the game: how long the direct communication can last; whether it is only verbal or can take other forms; whether, after the communication stage, the bargaining is one-shot or dynamic; whether the asymmetry of information is one or two-sided.⁵ From an applied perspective, the mediator’s lack of enforcement power makes the model particularly well-suited to conflict between sovereign states. Even with this specific application in mind, the theoretical result is very sensitive to the precise assumptions: in a model very similar to Hörner et al., Fey and Ramsay (2010) find that mediation cannot improve over direct communication if the asymmetry of information concerns a private value—the cost of going to war—as opposed to an interdependent value as in Hörner et al.—the strength of each party, and hence the probability of victory in case of conflict. We follow Hörner et al. but in the lab simplify the direct communication protocol to a one-round exchange of cheap talk messages, without the support of any correlation device. Although the theoretical superiority of mediation becomes less surprising, the discrepancy between such theoretical superiority and the empirical performance we see in the lab delivers a sharper, if negative, result.⁶

Our paper can also be approached by a second direction, opening the road to more constructive

⁵For seminal papers on the question, see Forges (1986) and Aumann and Hart (2003). The limits of verbal v/s richer communication are discussed in Forges (1990) and Krishna (2007); Fanning (2019) summarizes the current state of the art on mediation in dynamic bargaining; Goltsman et al. (2009) study the same questions asked by Hörner et al. in a sender-receiver model where the asymmetry of information is one-sided.

⁶In Political Science, the theoretical literature on mediation in international conflicts usually grants the mediator more tools than confidentiality alone. Typically the mediator has access to independent information, as opposed to having to elicit it from the parties; often the question concerns whether such information can be conveyed accurately and believed, when the mediator is more or less biased towards one of the parties or towards peace (Kidd, 2003; Kidd, 2006; Rauchhaus, 2006; Smith and Stam, 2003).

suggestions. To the best of our knowledge, most existing experiments on mediation simulate historical world crises and observe the impact of a mediator, trained to follow different protocols (see for example Wilkenfeld et al., 2003). A noticeable exception is the recent work by Blume et al. (2019) who compare mediation and direct communication in a sender-receiver game with one-sided asymmetric information.⁷ Our work focuses on conflict mediation with two-sided asymmetric information, as in classic experiments in political science, but, like Blume et al., follows closely the methodology of game theory experiments, with a simple but very precise abstract model, a fully controlled environment, and a detailed formal theory that pins down the expected effects of the different treatments. It belongs to the tradition of experiments in mechanism design, a tradition with a successful record of melding theory and practice. Where mechanism design has been particularly influential (in planning matching mechanisms, for example, or designing spectrum auctions), the theory has been complemented by experimental studies that have tested and fine-tuned the final format: "The lab as a "wind-tunnel" for mechanisms", as phrased by Chen and Ledyard (2006).⁸ In this perspective, our study reaches two main conclusions. First, we find that the theoretical properties of optimal mediation are weakened by the multiplicity of equilibria. Scholars interested in applications would benefit from engineering a reduction in the number of equilibria. In our data, some experimental sessions deliver equilibrium outcomes, but nevertheless fall short of the frequency of peace that corresponds to the best equilibrium, i.e. the equilibrium with maximal peace. The problem is different, but the lesson is similar to the results of Cason et al. (2006), highlighting, as we do, the potential of multiple equilibria to hamper implementation of a desirable social choice. Second, theoretical predictions on outcomes must be robust to small noise in behavior. This is where the fragility of the mediation mechanism we observe in the lab becomes problematic. Again the problem is different but the broad question as well as the conclusion echo Aghion et al. (2018), confronting subgame perfect implementation with behavioral biases in the lab. The observation can matter for applications. For example, Meiorowitz et al. (2019), again working with the Hörner et al. model, single out exactly the mediation mechanism with obfuscation as being the one dispute resolution institution that would not lead to increased

⁷Blume et al. (2019) find that while there are some deviations from equilibrium that prevent the full gains from mediation, mediation does increase truthful revelation and leads to moderate payoff improvements. Schroeter and Vyrastekova (2003) test whether agreement is encouraged or delayed by information on the opponent's payoff. There is no mediator in the experiment, but in one treatment subjects can agree to make all payoffs mutually known (which the authors identify as agreeing to mediation).

⁸For FCC auctions, see, for example, Banks et al., 2003, and Brunner et al., 2010; Milgrom, 2004, offers a thrilling account of the collaboration between theorists, FCC officers, and experimentalists in fine-tuning the first spectrum auction in July 1994 under severe time constraints. For matching mechanisms, see, among many others, Chen and Somnez, 2006; Roth, 2002 and 2016. For other examples, see for example Attiyeh et al., 2000; Chen and Plott, 1996, and Chen, 2008 for VCG mechanisms for public good provision.

militarization and eventually increased conflict. We observe in the lab that the mechanism with obfuscation is particularly fragile, a fragility that calls for caution.

The paper proceeds as follows. The next section describes the model and its main theoretical properties, comparing optimal mediation, direct communication, and mediation in the absence of commitment power; Section 3 describes the experimental design; Section 4 reports the results; Section 5 discusses possible reasons why the optimal mediation mechanism is not more successful than direct communication in averting conflict in the lab. Section 6 reports equilibria for the direct communication treatment, as well as for the experimental treatment that implements mediation without commitment, a "human mediator" treatment, where the mediator was played by a third subject. Finally, Section 7 concludes. Additional material, in particular but not exclusively the derivation of the theoretical equilibria, is collected in two Appendices.

2 The Model

The mediation game we took to the lab follows closely the model in Hörner, Morelli and Squintani (2015) (HMS), with a few modifications that streamline the experimental design. Two risk-neutral players, 1 and 2, compete for a resource of size 1. Each player is of type $T \in \{H, L\}$. Types are drawn independently for the two players and are private information, but it is commonly known that each player is of type H with probability q , and of type L with probability $1 - q$. If 1 and 2 agree on sharing the resource peacefully, each receives the agreed share. If not, they go to war, the resource shrinks to $\theta < 1$ and is divided according to the two players' types: if the two players' types are equal, each receives $\theta/2$; if one player is H and the other is L , H receives the full amount θ and L receives 0. From an efficiency standpoint, distribution is irrelevant: maximizing ex ante efficiency corresponds to maximizing the probability of peaceful resolution.

An equal split $(1/2, 1/2)$ is always preferable to conflict for an L type; in the absence of other information, $(1/2, 1/2)$ is also acceptable to an H type if $1/2 \geq (1 - q)\theta + q\theta/2$. To highlight the role of information, HMS (and we) assume $1/2 < (1 - q)\theta + q\theta/2$, or $q < (2\theta - 1)/\theta$. In addition, we constrain $\theta/2 > 1 - \theta$ to ensure that the H type prefers to fight rather than accepting the smaller share when facing another H type.

The core of the analysis is the procedure through which the two players can reach an agreement.

We consider two such procedures: unmediated (or direct) communication and mediation.⁹ In both cases, the players take actions in two consecutive stages: a message stage, and an allocation stage.

Under unmediated communication, after learning one's own type, at the message stage each player sends to the other player a cheap talk message $m(T)$. The message can be blank, or report a type as the player's own, but the report need not be truthful. Using lower case letters to indicate reported types, and s for the option to remain silent, $m \in \{s, h, l\}$. The two players send messages simultaneously. After messages are sent and received, the game moves to the allocation stage. At this stage, the two players, again moving simultaneously, express a demand $d(m, m', T)$, where m' stands for the opponent's message. Demand may consist of the refusal to negotiate, or indicate the demanded share of the resource. We constrain d to take one of four values: $d \in \{1 - \theta, 1/2, \theta, w\}$, where w stands for "walking out", as we phrase it in the lab. If neither player chooses w and the two demands are compatible ($d_1 + d_2 \leq 1$), then each player receives what the player demanded, and peace prevails. If either player chooses w , or if $d_1 + d_2 > 1$, then no agreement is reached and war follows: the resource shrinks to θ and is divided according to the players' types.¹⁰

Under mediation, a third party enters the game, the mediator, whose objective is to maximize the probability of peace. The mediator shares the common prior q but has no information on the realizations of the players' types and has no enforcement power. At the message stage, each player sends the mediator a confidential message, where, as before, $m \in \{s, h, l\}$. On the basis of the messages received, the mediator recommends a division of the resource between the two players, or alternatively refuses to mediate. Denoting by r the mediator's recommendation, and indicating the share recommended to player 1 and then to player 2, in order, we constrain $r(m, m')$ to one of the following values $r \in \{\{1 - \theta, \theta\}, \{1/2, 1/2\}, \{\theta, 1 - \theta\}, w\}$ where as before w stands for "walking out", or the mediator's refusal to mediate. If the mediator has made a recommendation, then, at the allocation stage, each player has the option of accepting the recommendation or rejecting it. The recommendation is implemented if both players accept it. If the mediator has refused to mediate, or if either player rejects the recommendation, then war follows, the resource shrinks to θ and is divided according to the players' types.

The mediator's ability to commit to war by refusing to mediate is essential to inducing players to be truthful in their messages. It is also key to the following result:

⁹HMS also consider arbitration, i.e. mediation with enforcement power.

¹⁰If $d_1 + d_2 < 1$, a third agent acquires what is left of the resource. In the lab, it will be the experimenter.

Proposition HMS. *If $(2\theta - 1) < q < (2\theta - 1)/\theta$, mediation can achieve a strictly higher probability of peace than any equilibrium of the unmediated communication game.*

By the revelation principle, the optimal mediation program must result in a weakly higher frequency of peace than unmediated communication. But HMS' result is stronger: for parameters in the specified range, mediation can achieve a *strictly* higher probability.¹¹

Under the optimal mediation program, there exists an equilibrium where all messages to the mediator reveal the player's type sincerely, and all mediator's recommendations are always accepted by the players. The two binding constraints are L 's incentive compatibility constraint (L 's incentive to be truthful), and H 's ex post participation constraint (H 's acceptance of the mediator's recommendation). The optimal mediation program has two crucial ingredients. First, the mediator refuses to mediate with positive probability following an h message (thus keeping L sincere)—the mediator is able to *commit*. Second, if $q > (2\theta - 1)$, the mediator's optimal recommendation does not reveal the opponent's type (thus limiting H 's recourse to war when matched with an L)—although all messages are sincere, the opponent's type is *obfuscated*.

The mediator's ability to obfuscate explains the superiority of the optimal mediation equilibrium relative to what can be achieved under unmediated communication, where the direct messages prevent conditioning strategies on true types and yet having players uncertain about their opponent.¹² Effective obfuscation however requires a sufficiently high frequency of H types, high enough that an H player, uncertain about the type of the opponent, is still willing to accept an equal share of the resource. The equilibrium with obfuscation cannot be sustained if $q < (2\theta - 1)$. And in the absence of obfuscation, there exists an equilibrium of the direct communication game that replicates what mediation can accomplish.

As HMS show, the optimal equilibrium of the direct communication game is a correlated equilibrium that exploits a publicly observed randomization device. In our experimental design, there is no explicit public correlation device. In its absence, achieving the correlated equilibrium through the randomization of individual messages is very difficult in principle¹³, and, we believe, impossible

¹¹Our adaption differs slightly from HMS' original model because we allow for silence and constrain both demands and the mediator's recommendations to lie in a restricted set. However, Proposition HMS continues to hold in our set-up because both under mediation and under direct communication the HMS equilibria remain optimal. Under mediation, the option of remaining silent can be ignored (again by the revelation principle), and under both mediation and direct communication, if the HMS equilibria are optimal in the absence of restrictions, they must be optimal over the smaller set of programs that satisfy the restrictions.

¹²As noted in the Introduction, the superiority of mediation also depends on the interdependent nature of the variable subject to private information (see Fey and Ramsay, 2010).

¹³Mixed strategy profiles cannot typically result in correlated randomness (Forges (1986)). HMS make the same

in practice. Since lack of correlation is achievable in the HMS unmediated communication game but is not part of the optimal program, the highest achievable frequency of peace must be weakly lower when excluding correlated equilibria. For emphasis, we state this observation as a separate Remark:

Remark: *In the uncorrelated equilibria of the unmediated communication game played in the lab, the probability of peace must be weakly lower than in the optimal correlated equilibrium. Hence it must be lower than in the optimal mediation equilibrium, and strictly lower if $(2\theta - 1) < q < (2\theta - 1)/\theta$.*

In addition to introducing coordination, the public correlation device exploited in the best correlated equilibrium of the direct communication game induces war with a positive probability in response to specific pairs of messages. The possibility of war plays a disciplining role in equilibrium that mimics the commitment demanded from the mediator. In studying unmediated communication equilibria in our experimental setting, we ignore correlated equilibria, but the subjects' option to *walk-out* ($d = w$) can in principle introduce commitment to war and induce sincerity. For example, there always exists a truthful equilibrium where all messages are sincere, all L types demand $1/2$, and all H types walk-out. In fact, as the next proposition shows, in the absence of correlation and for the range of θ values that are relevant for the experiment ($\theta/2 > 1 - \theta$), full revelation in the unmediated communication game can *only* occur in equilibria where the option to walk-out is chosen with positive probability.

We focus, in the proposition below as in the rest of our analysis, on equilibria that are symmetric for players of given type. Then:

Proposition 1. *Consider any uncorrelated equilibrium of the unmediated communication game in which $d = w$ is never played. Then at least one type of player must be lying with strictly positive probability.*

Proof. Suppose to the contrary that a fully revealing equilibrium exists where $d = w$ is never played. Consider the players' demand strategies, conditional on their type and their opponent's (fully revealed) type. Consider first a player of type T facing an opponent of the same type. With $\theta/2 > 1 - \theta$, war against an opponent of the same type yields more than $(1 - \theta)$; hence demanding $1 - \theta$ is strictly dominated.¹⁴ Thus in any symmetric equilibrium with full revelation, in a match between two players of equal type, either both demand $1/2$, or both demand θ , or both mix between $1/2$ and θ . Now

observation and document that, in the UC game, the optimal equilibria with mixed strategies at the message stage lead to a probability of war that under some parameters must be strictly higher than in the optimal correlated equilibrium with full truthfulness.

¹⁴The strategy is strictly dominated under the restriction that the opponent never plays $d = w$ (otherwise, the player's own demand could be irrelevant). The strategy is always weakly dominated.

consider a match between an H and an L . In such a match, the H player can always guarantee itself θ by asking for it, and the pair of demands $(\theta, 1 - \theta)$ is the unique pair of mutual best responses. Consider then an L who reveals her type truthfully. If matched with an L , the highest possible realized share is $1/2$; if matched with an H it is $(1 - \theta)$. But then an L type has an incentive to deviate: declare type h , be believed, and best respond to the opponent's strategies. The L type masquerading as an H can demand and obtain θ against an L opponent, and at least $(1 - \theta)$ against an H opponent. The deviation is strictly profitable. Hence a fully revealing equilibrium cannot exist. \square

In the absence of repetition or commitment, $d = w$ is always weakly dominated by $d = \theta$, for any type and for any message sent and received. In the lab, random rematching induces lack of repetition, and in what follows we concentrate on uncorrelated, symmetric equilibria in weakly undominated strategies, where $d = w$ is never chosen. We refer to them in short as "equilibria".¹⁵

In the experiment, optimal mediation is implemented by a computer algorithm, but we also investigated a more exploratory question: whether untrained experimental subjects could be effective mediators. The experimental design has anonymity and random rematching across rounds, with the result that mediators cannot build reputation and lack incentives to walk out of mediation. It is well-known that the absence of commitment power hinders the effectiveness of mediation. The following proposition, proved in the Appendix, makes the case for the present model.

Proposition 2. *Assume $q < (2\theta - 1)/\theta$. If the mediator cannot commit to refuse mediation, a truthful equilibrium exists if and only if $q \geq (2\theta - 1)$. If $q > (2\theta - 1)$ the probability of peace is strictly lower than can be achieved by a mediator with commitment power.*

In a later part of the paper (Section 6) we describe and test non-correlated equilibria of the direct communication game, as well as equilibria of the subject-mediator game. However, Proposition HMS, Proposition 1, and Proposition 2 are sufficient to establish the hypotheses at the heart of our experiment: the optimal mediation program is expected to yield both higher peace and higher sincerity than either the unmediated communication game or the subject-mediator game played in the lab.

The comparison of mediation with and without commitment is complicated by the fact that, in the absence of commitment, the revelation principle does not apply (Beste and Strausz, 2000

¹⁵Focussing on equilibria in undominated strategies eliminates trivial equilibria where, regardless of messages, all players' demand equals w under unmediated communication, or all players reject the mediator's recommendation under mediation. (In the lab, the frequency of subjects choosing $d = w$ in the direct communication treatment is always less than 5 percent).

and 2001).¹⁶ Thus we consider possible lessons from the subject-mediator treatment more tentative. The main focus of the experiment is the relative performance of the optimal mediation program to unmediated communication.

3 Experimental parametrization and design

Throughout the experiment we fixed $\theta = 0.7$. We studied two different parametrizations of the ex ante frequency of H types: $q = 1/2$ (Par1) and $q = 1/3$ (Par0). The optimal program follows directly from Lemma 3 in HMS. The mediator's recommendations are the following:¹⁷

Par1: $q = 1/2$. $r(l, l) = (0.5, 0.5)$; $r(h, l) = \{(0.7, 0.3) \text{ with probability } 5/8, (0.5, 0.5) \text{ otherwise}\}$; $r(h, h) = \{(0.5, 0.5) \text{ with probability } 1/2, w \text{ otherwise}\}$. The probability of peace is $7/8 = 0.875$

Par0: $q = 1/3$. $r(l, l) = (0.5, 0.5)$; $r(h, l) = \{(0.7, 0.3) \text{ with probability } 3/4, w \text{ otherwise}\}$; $r(h, h) = w$. The probability of peace is $7/9 = 0.778$.

Note that when q is low, L 's temptation to lie is particularly strong because of the high probability of being matched to an L type and benefiting from the mediator's asymmetric recommendation in favor of an h message. Hence the mediator must refuse to mediate more often at lower q , with the counterintuitive conclusion that the probability of peace under optimal mediation is lower at lower q .

With $q = 1/2$, $q > 2\theta - 1$, and the optimal mediation program includes obfuscation: an H type who sent message h and receives recommendation $(0.5, 0.5)$ does not know whether the opponent sent message h or message l . Under sincerity, acceptance is preferable in the former case, and war in the latter; given the mediator's program, the H type is just indifferent and in equilibrium accepts. With $q = 1/3$, on the other hand, $q < 2\theta - 1$, and in the sincere equilibrium the mediation program reveals the opponent's type: following message h , either the mediator refuses to mediate, or recommends $(0.7, 0.3)$, making clear that the opponent is L .

Experimentally, the difference makes the two parametrizations interesting. Theory tells us that it is the possibility of obfuscation that renders the mediator indispensable; but obfuscation also complicates subjects' problem. Collecting data under both $q = 1/2$ and $q = 1/3$ allows us to study how subjects react to the optimal mediation programs in the two cases.

¹⁶We cannot rule out that other, non-truthful equilibria, may lead to lower peace. HMS compare mediation without commitment and unmediated communication in their online appendix, and conclude that the two are equivalent if we restrict attention to standard truthful revelation mechanisms.

¹⁷The program depends on the pair of messages only: (h, l) is treated symmetrically to (l, h) .

There are other possible but less compelling reasons for the two parametrizations. The optimal program under $q = 1/3$ corresponds to the optimal correlated equilibrium of the unmediated communication game. If such an equilibrium had predictive power in the lab, theory would predict a larger difference in the frequency of peace between optimal mediation and direct communication under Par1 than under Par0. In practice, however, with subjects limited to uncorrelated equilibria, this difference between the two parametrizations need not follow. Similarly, Proposition 2 predicts that in the subject-mediator treatment, in the absence of commitment, truthful equilibria exist if $q = 1/2$ but not if $q = 1/3$. Thus there exist equilibria such that the difference in sincerity between optimal mediation and subject-mediation is larger under Par0 than under Par1. However, the multiplicity of equilibria means that the difference need not hold in the lab.¹⁸

We ran the experiment at Columbia’s Experimental Lab for the Social Sciences (CELSS) with subjects recruited through the lab’s ORSEE recruitment system (Greiner, 2015). Most subjects were undergraduate students at Columbia University and Barnard College. The experiment lasted about 90 minutes and earnings ranged from \$16 to \$37, with an average of \$28 (including a \$10 show-up fee) Experimental procedures were standard and are described in detail in the Appendix, where the instructions for one of the treatments are also reproduced.¹⁹

Subjects in each experimental session were exposed to a single parametrization, either $q = 1/2$ or $q = 1/3$, but to four different treatments, varying the communication and mediation protocol. Each treatment was presented as a separate part of an experimental session, consisting of multiple rounds, and instructions for each part were read just before that part began. To avoid decimals, the size of the resource was set to 100. We implemented the following design.

No-communication (NC)

In the no-communication treatment (NC) there was no message stage. Subjects were matched in pairs, randomly and anonymously, and independently assigned types by the computer according to q . After learning their type, each player expressed one of the feasible demands $d \in \{30, 50, 70, w\}$. If the two demands were compatible, they were satisfied; if not, the resource shrank and was shared according to the players’ types. Each subject was informed of the opponent’s demand, and of the final outcome (and thus learnt the opponent’s type). Across rounds, types were reassigned and pairs

¹⁸The equilibria characterized in Section 6 make the ambiguity transparent. In the direct communication equilibria, the difference in the ex ante probability of peace relative to optimal mediation can be larger or smaller in Par1 relative to Par0, depending on the equilibrium. In the subject-mediator equilibria, players may be more or less truthful in Par1 relative to Par0, depending on the equilibrium.

¹⁹The experiment was programmed in ZTree (Fischbacher, 2007).

rematched. We began all sessions with ten rounds of the NC treatment because their relative simplicity helped the subjects understand the game. Although those rounds were rewarded, we consider them akin to practice rounds.

Unmediated communication (UC)

The UC treatment corresponds exactly to the unmediated communication game described in the previous section. After being randomly matched in pairs and assigned a type according to q , all subjects sent their partner a message, chosen among $\{h, l, s\}$. After messages were exchanged, demands were chosen, again within the set $\{30, 50, 70, w\}$; demands were satisfied if compatible, if not, the resource shrank and was allocated according to players' types. As in the NC treatment, each subject was informed of the opponent's demand, and of the final outcome (and thus learnt the opponent's type). In each session, we played 20 rounds of the UC treatment, but changed the order of the treatment.

Computer mediator (CM)

In the computer mediation treatment, we introduced the mediator, delegating the mediator's role to the computer and implementing the optimal mediation program. After having been randomly matched in pairs and assigned types, each subject sent to the computer-mediator a private message chosen among $\{h, l, s\}$. The computer then either accepted to mediate and recommended a division of the resource, or refused to mediate: $r \in \{\{30, 70\}, \{50, 50\}, \{70, 30\}, w\}$. The decision was a function of the two messages, according to the optimal HMS program. The mediator's program relevant to the parametrization used in the session was projected on the lab screen during instructions and remained on the screen throughout all rounds of the treatment (Figure 1).

The instructions (and the screen) also told the subjects that the computer would interpret silence according to the prior. Unless the computer chose w , the recommendation was conveyed to each subject who then chose, separately, either to accept it or reject. If the computer issued a recommended allocation, it was implemented only if accepted by both players. If not, or if the computer chose w , the resource shrank and was allocated according to players' types.

Players were told their payoff from the round, and thus always learnt their opponent's type in case of war, but not if a peaceful division was agreed upon. If the computer mediator proposed a peaceful division, subjects always learnt the opponent's message when $q = 1/3$, but not necessarily when $q = 1/2$. Each session included 20 rounds of the CM treatment, again varying the order of the treatment, as described below.

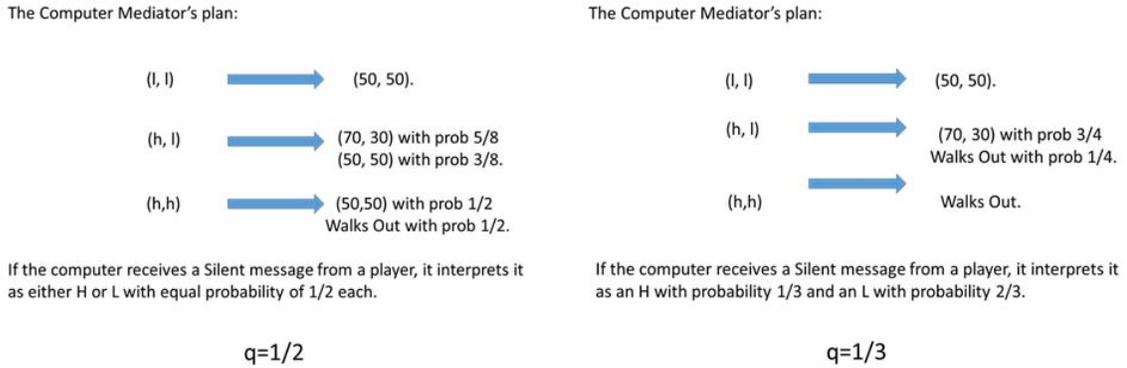


Figure 1: The Computer Mediator program

Human mediator (HM)

In the HM treatment, in each round subjects were randomly matched in groups of three; two players and one mediator. The round proceeded following the mediation game rules, but without constraining the mediator to any specific program and without communicating any such program to the players. After privately learning their type, players 1 and 2 each sent a confidential message $m \in \{h, l, s\}$ to the mediator. The mediator knew q , but had no additional information. Upon receiving the messages, the mediator issued a recommendation $r \in \{\{30, 70\}, \{50, 50\}, \{70, 30\}, w\}$. Unless $r = w$, each of the two players, independently, could either accept the recommendation or reject it. If both accepted, the recommendation was implemented; if not or if $r = w$, conflict followed, the resource shrank to 70 and was allocated according to the player's types. All subjects learnt the outcome of the game—whether the recommendation was made and accepted, and in all cases their payoffs; but they did not learn the opponent's message and, unless there was conflict, the opponent's type.

We rewarded the mediator according to the following schedule: the mediator earned 60 if a recommendation was made and accepted, 20 if the recommendation was made but was rejected, and 40 if the mediator refused to mediate. Thus the mediator's incentive to refuse to mediate was stronger when mediation was more likely to fail; if rejection is most probable when the two players have both reported message h , the indirect effect is to discipline the L 's type by checking its temptation to send message h . The numerical values for the mediator's payoffs were kept constant across the two parametrizations.

As under all previous treatments, players always learnt the opponent's type in case of conflict, but

not if a peaceful division was achieved. In addition, since the mediator’s program was not announced to the players and most probably was not consistent across mediators, they could not deduce the opponent’s message from the mediator’s recommendation with any confidence.

At each round, the three players were matched randomly, but under the constraint that all subjects played the role of mediator for an equal number of rounds. In each session, subjects played 30 rounds of the HM treatment, 10 rounds as mediator and 20 as players.

Because our main focus is on the comparison between the UC and the CM treatments, we varied the order of treatments so as to treat UC and CM symmetrically. We ran 12 experimental sessions, each with 12 subjects, with the following experimental design:

Parametrization and order of treatments

Sessions	q	Order
s1-s3	1/2	1: NC, UC, HM, CM
s4-s6	1/3	1: NC, UC, HM, CM
s7-s9	1/2	2: NC, CM, HM, UC
s10-s12	1/3	2: NC, CM, HM, UC

Number of subjects, groups and rounds per session

Order	# Subjects	# Groups per Treatment	# Rounds	Groups x Rounds
1: NC, UC, HM, CM	12x3	6,6,4,6	10,20,30,20	60,120,120,120
2: NC, CM, HM, UC	12x3	6,6,4,6	10,20,30,20	60,120,120,120

Because we always ordered NC first and, as mentioned, treated it as a practice treatment, we do not compare its results to the other treatments and do not discuss it in the text. For completeness, we describe the NC data as well as the equilibria of the NC game in the online Appendix.

4 Experimental Results

When comparing unmediated communication and mediation, the theory makes two broad qualitative predictions. The optimal mediation program can lead to: (1) more sincerity, and to (2) more frequent agreement. The CM treatment implements the program that can support the best equilibrium, but whether the results are observed in the lab depends on the predictive power of such an equilibrium.

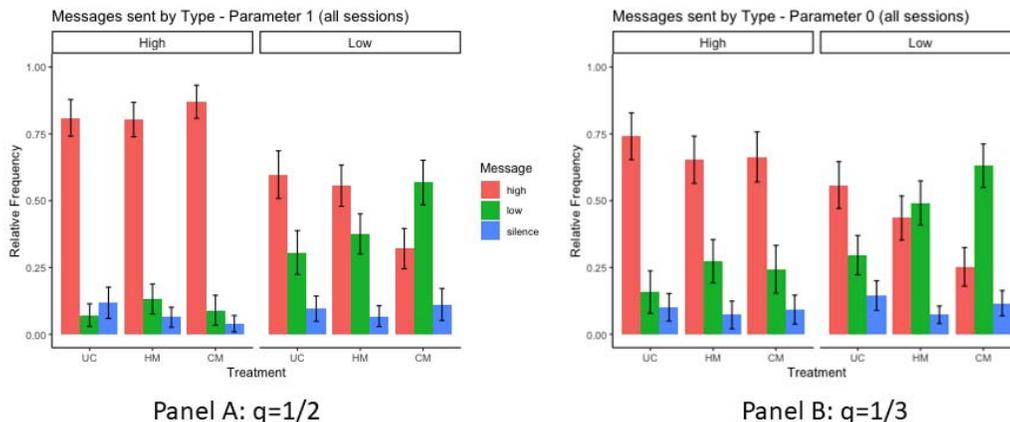


Figure 2: Messages by type and treatment

Whether the predictions extend to the human mediator treatment, with inexperienced mediators and inexperienced players, is an interesting but still more speculative question.

We begin by reporting our results on sincerity.

4.1 Sincerity

The two panels of Figure 2 report the frequencies of different messages in the two parametrizations, $q = 1/2$ and $q = 1/3$, for the three treatments, UC, HM and CM. In each panel, the H type's messages are reported on the left, and the L type's messages on the right. The data are aggregated over all sessions and both orders of treatments. Confidence intervals are calculated from standard errors clustered at the individual level.

The figure makes clear a number of regularities. First, although we never see full sincerity, H types send message h with high frequency in all treatments and for both parametrizations. In all treatments more than 80 percent of all H types send message h when $q = 1/2$; more than 65 percent do so when $q = 1/3$. There is no detectable treatment effect. Second, there is less sincerity but a clear treatment effect for L types: the frequency of l messages from L subjects goes from 31 percent in UC to 57 percent in CM if $q = 1/2$, and from 30 to 64 percent if $q = 1/3$. The difference is significant both quantitatively and statistically. The HM treatment too sees higher frequency of sincere l messages, relative to UC: 38 percent with $q = 1/2$ and 49 with $q = 1/3$. Third, the option of sending a silent

message is used relatively little: it is always less than 15 percent of messages sent by either type.²⁰

As shown in the first column of Table 1, a linear probability model confirms what the figures show.²¹

L types are less sincere than H types, and for L types treatment effects are present and significant: sincerity is lowest under UC, intermediate under HM and highest under CM. In addition, H types, but not L types, are more sincere when $q = 1/2$, and both types learn to become more sincere with experience in the session, but the effect is very small.

The data show the extent to which subjects assigned different types report their type sincerely in the different experimental treatments. However, sincerity does not map directly into the information conveyed: how much information a message transmits depends on the use of that same message by the opposite type. To take an extreme example, suppose H types are fully sincere and always send message h ; yet, if L types always lie, no information is conveyed by an h message because *all* types always send message h .²² How much a message moves the posterior probability of a given type relative to the prior depends on the use of the message by both types.

The Kullback Leibler (KL) measure of dispersion provides an answer to exactly that question.²³ Figure 3 reports, for the three treatments and the two parametrizations, the corresponding KL measures for messages l and h , expressed as fractions of the maximum value for each parametrization and averaged over the relevant sessions.

²⁰Using data from Order 1 and Order 2, our design allows us to compare the UC and CM treatment between subjects, when the two treatments are run in rounds 11-30 in a session, and thus on subjects with identical experience. Figure 13 in the online Appendix replicates Figure 2 and shows the same regularities.

²¹Results are unchanged under a probit model. We report all regression results in the paper as estimated from a linear probability model; in all cases we have verified that qualitative results are unchanged under probit.

²²This is clearly the case whenever all types send the same message with equal frequency.

²³For the two messages h and l , the respective KL measures are:

$$KL(h) = \Pr(H|h) \log \left(\frac{\Pr(H|h)}{\Pr(H)} \right) + \Pr(L|h) \log \left(\frac{\Pr(L|h)}{\Pr(L)} \right)$$

$$KL(l) = \Pr(H|l) \log \left(\frac{\Pr(H|l)}{\Pr(H)} \right) + \Pr(L|l) \log \left(\frac{\Pr(L|l)}{\Pr(L)} \right)$$

KL measures are always non-negative and equal 0 when the posterior equals the prior (no information has been conveyed). In our setting, maximal values are $-\log(q)$ for $KL(h)$ and $-\log(1-q)$ for $KL(l)$.

	<i>Dependent variable:</i>	
	Honesty (1)	Silence (2)
TreatmentHM	-0.039 (0.028)	-0.042** (0.020)
TreatmentCM	0.005 (0.034)	-0.049** (0.021)
Order2	0.009 (0.040)	-0.069*** (0.025)
Parameter1	0.142*** (0.042)	-0.015 (0.026)
TypeLow	-0.354*** (0.082)	-0.029 (0.039)
Period	0.002*** (0.001)	-0.001*** (0.0004)
TreatmentHM>TypeLow	0.181*** (0.042)	-0.012 (0.021)
TreatmentCM>TypeLow	0.298*** (0.055)	0.038 (0.028)
Order2>TypeLow	-0.025 (0.062)	0.018 (0.021)
Parameter1>TypeLow	-0.198*** (0.063)	-0.005 (0.022)
TypeLow:Period	-0.0002 (0.001)	0.001 (0.001)
Constant	0.611*** (0.057)	0.212*** (0.041)
		Observations
Observations	8,640	8,640
R ²	0.158	0.024
Adjusted R ²	0.157	0.022
Residual Std. Error (df = 8628)	0.453	0.288

Note: *p<0.1; **p<0.05; ***p<0.01

The excluded category in the regression is H in treatment UC with q=1/3 under Order 1. Standard errors are clustered at the individual level.

Table 1: Sincerity and Silence

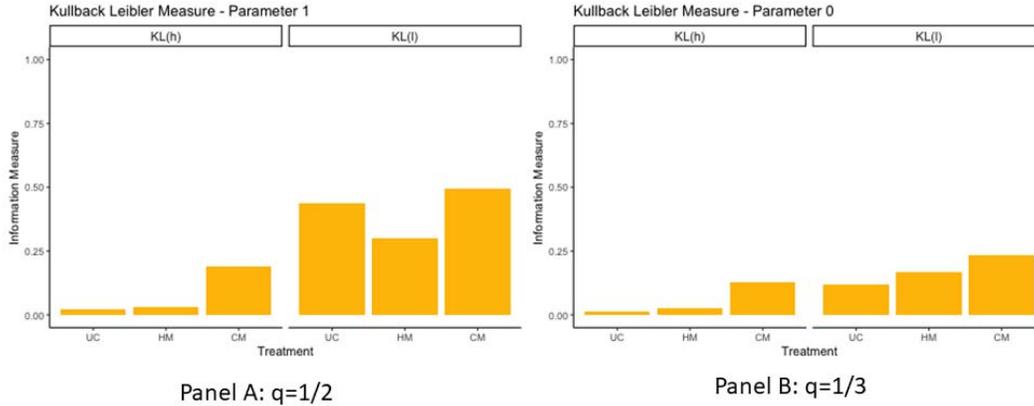


Figure 3: KL measures

Although it remains true that the treatment conveying most information is CM, the lesson from the KL measures is more nuanced than the previous figures suggest. The high sincerity of the H types does not translate into high information from the h message, since the same message is also used by the L types. Message l on the other hand, is more informative even though sincerity is less common among L 's because few are the H types who send message l . The importance of the interaction in the use of the messages between the two types becomes very clear when comparing the two parametrizations. Even though L 's tend to be more sincere with $q = 1/3$, the more common use of message l by H types severely reduces the information transmitted by the messages, relative to the $q = 1/2$ parametrization.

Finally, our experimental design allows subjects to send a silent message. As figure 2 shows, silent messages are used sparingly—the highest frequency is 14 percent by L types in UC, with $q = 1/2$. Estimation of a linear probability model shows that silence is used more frequently in UC, when communicating directly, and its frequency declines with experience (Table 1, column 2). The reduced use of silence under Order 2 is probably due to the early experience with the mediation treatments (recall that UC is the last treatment under Order 2).

4.2 Peace

Figure 4 reports the frequency of peace across treatments, for the two parametrizations, as well as 95 percent confidence intervals (with standard errors clustered at the session level). Whether $q = 1/2$ or $q = 1/3$, there is no significant difference across treatments. In both cases, treatment HM results in

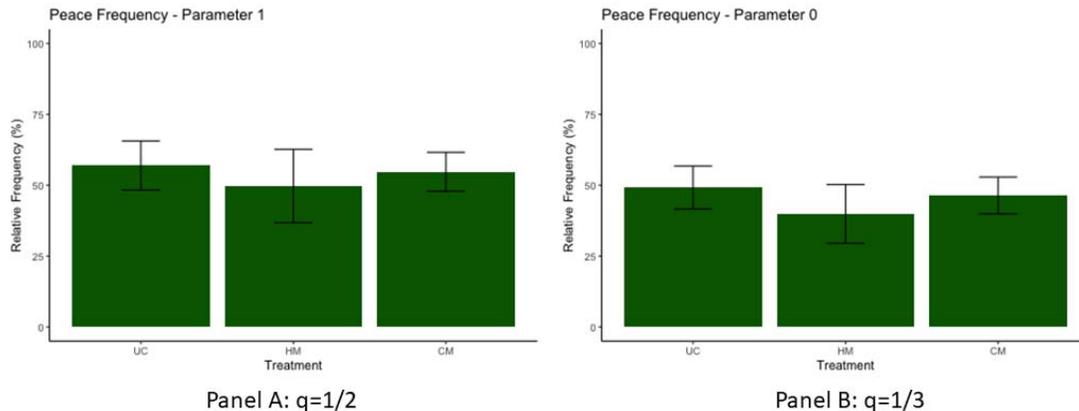


Figure 4: Frequency of peace.

least frequent peace and UC in most frequent peace, but the effects are small.²⁴ In both cases, the highest theoretical frequency under CM (87 percent with $q = 1/2$, and 78 percent with $q = 1/3$) is not within the confidence interval. The difference between the two parametrization is in the direction the theory predicts, with higher peace in all treatments under $q = 1/2$, but none of the differences are statistically significant.

The estimation of a simple linear model of the frequency of peace, isolating treatment, order and parameter effects, qualifies the results slightly but does not change the main message. We report the results below, where we also add the round number, to control for learning, and the pair types. (The default treatment is UC, Order 1, Par0, and when looking at different pair types, the default pair is HH . Standard errors are clustered by pairs.) As expected, peace is highest between $L - L$ pairs, and lowest between $H - H$ pairs, it is higher under $q = 1/2$, and increases significantly but very little over time. Across treatments, UC and CM are comparable, while peace is significantly lower under HM .²⁵

²⁴Ordering the numbers as $\{UC, HM, CM\}$, the frequencies of peace in the data are: $\{0.57, 0.50, 0.55\}$ if $q = 1/2$, and $\{0.49, 0.40, 0.46\}$ if $q = 1/3$.

²⁵In the online Appendix, Figure ?? reports the frequency of peace in CM and UC between subjects, when both treatments are played second in the session (the conclusion is identical). We also report in the online Appendix the regression results with the full set of interaction terms. We find that the low performance of the HM treatment is driven by the unusually low frequency of agreement when one or, especially, when both players are of type L .

	<i>Dependent variable:</i>	
	IsPeace	
	(1)	(2)
TreatmentHM	-0.082*** (0.020)	-0.085*** (0.018)
TreatmentCM	-0.025 (0.020)	-0.019 (0.018)
Order2	0.005 (0.018)	0.012 (0.016)
Parameter1	0.087*** (0.018)	0.186*** (0.016)
PairTypeHigh-Low		0.293*** (0.018)
PairTypeLow-Low		0.606*** (0.018)
Round	0.001*** (0.0004)	0.001*** (0.0003)
Constant	0.435*** (0.026)	0.042 (0.026)
Observations	4,320	4,320
R ²	0.015	0.191
Adjusted R ²	0.013	0.190
Residual Std. Error	0.497 (df = 4314)	0.450 (df = 4312)

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2: Peace

5 Optimal Mediation Induces More Sincerity but not More Peace. Why?

Theory gives us precise hypotheses for two of the treatments, UC and CM. What can we learn from comparing the experimental results to the theoretical predictions in these two cases? The lesson from the data is unambiguous: because of the messages by L types, sincerity is higher, and the messages more informative, under CM. But peace is not. We can represent both observations in a single graph. Call τ_T the frequency with which a type T player sends a truthful message, and σ_T the frequency with which the player is silent. Recall that in CM the computer interprets silent messages according to the prior. Thus $\hat{\tau}_L = \tau_L + (1 - q)\sigma_L$ is the frequency of all messages sent by L subjects that are read as l by the computer, and $\hat{\tau}_H = \tau_H + q\sigma_H$ is the frequency of all messages sent by H subjects that are read as h by the computer.

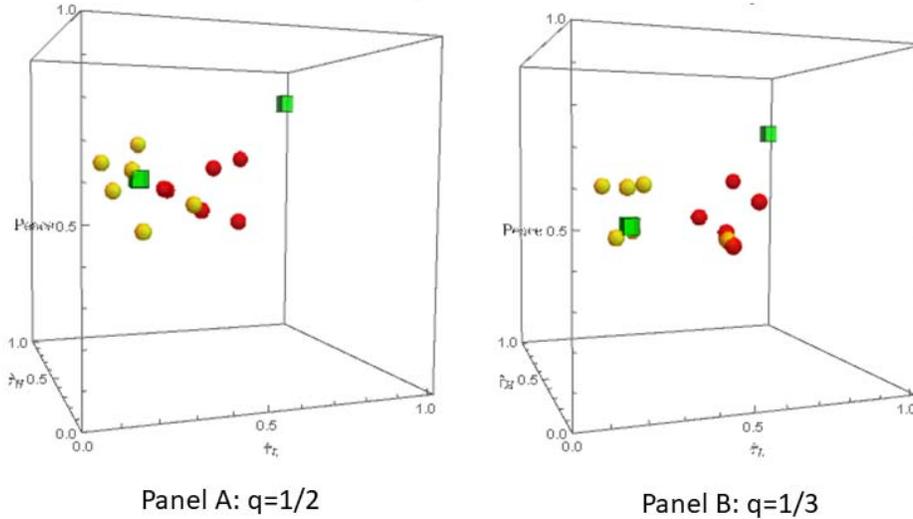


Figure 5: Sincerity and peace in UC (yellow) and CM (red) sessions. The green cubes are theoretical equilibria.

We construct descriptive figures of the data by imputing the same interpretation of silence in UC, i.e. by supposing that subjects too interpret silence according to the prior.²⁶

For each experimental session, Figure 5 reports $\hat{\tau}_L$ on the horizontal x-axis, $\hat{\tau}_H$ on the depth axis y, and the frequency of peace on the vertical z-axis. Panel A refers to $q = 1/2$, panel B to $q = 1/3$. Each sphere corresponds to a session; yellow spheres report results for UC treatments, and red spheres for CM treatments. The two green cubes correspond to the theoretical equilibria with highest peace in the two treatments²⁷ (the green cube centered among the yellow spheres refers to UC; the green cube corresponding to $\hat{\tau}_L = 1$, $\hat{\tau}_H = 1$ represents the HMS equilibrium in CM). As shown earlier, the two treatments on average yield similar values for $\hat{\tau}_H$. Here, yellow and red spheres align similarly along the y-axis (not easily readable in the figure), but are clearly differentiated along the x-axis, and the orientation of the figures highlights the two clusters, almost fully distinct, with lower $\hat{\tau}_L$ values for UC, and higher $\hat{\tau}_L$ values for CM. However, the spheres are not organized by color on the vertical axis—the frequency of peace. There is no systematic variation between the two treatments.

Why wasn't the promise of optimal mediation realized in the data? Figure 6 gives some indications

²⁶Recall that the frequency of silence is low and comparable across the two treatments in both parametrizations (Figure 2).

²⁷For UC, the green cube corresponds to the equilibrium with highest peace among the equilibria characterized in Section 6.2.

of where the problems lie. The figure plots, for each parametrization, the causes of war under CM in the data. The yellow column corresponds to the computer’s refusals to mediate in the data; the orange column to mediator’s refusals if all subject had been sincere; green columns indicate rejections of the computer’s offer by H types, and blue columns by L types, organized according to the offer.²⁸ In the optimal mediation equilibrium, all messages are sincere, all offers are accepted, and war only follows from the mediator’s refusal to mediate. In the data, not all messages are sincere and not all recommendations are accepted, and the figure reflects both types of deviations.

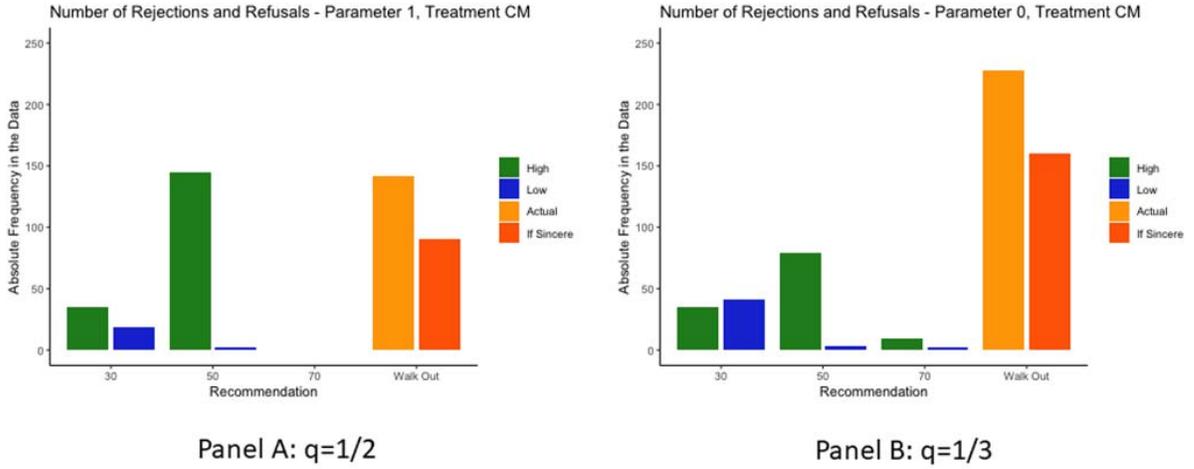


Figure 6: Causes of war

With both parametrizations, dominated actions (L rejecting 50, either type rejecting 70) are rare. When $q = 1/2$, excess war has two main causes. The first is the lack of full sincerity of L types, reflected in the higher frequency of refusals to mediate. The second, more striking, is the high number of rejections of offers of 50 by H types: sincere H types rejected more than one third of all 50 offers they received. The subtlety of the obfuscation appears not to work in the lab.

When $q = 1/3$, all (h, h) messages and 1/4 of (h, l) messages result in refusals to mediate. Although L 's are more sincere than under $q = 1/2$, L 's reporting of h messages is punished harshly: there are 228 instances of refusals to mediate in the data; there would have been less than half, 107, if all L 's had been sincere (keeping H 's messages unchanged). Offers are also sometimes rejected, especially by

²⁸The figures report individual rejections of offers. Because a single rejection is sufficient to trigger war, there can be some double counting: two individual rejections can amount to a single offer being turned down.

H types masquerading as l 's and receiving offers of 30 or 50, but the total number of rejections is less than half the computer's refusals to mediate.²⁹

The lack of full sincerity in the lab is hardly surprising; what is surprising is the fragility of mediation in achieving peace. One possible explanation is that the CM treatment has multiple equilibria. The HMS equilibrium is the equilibrium with highest peace, but, given the mediation program, how sensitive are the other equilibria to less than full truthfulness?

5.1 Multiple equilibria under computer mediation

Keeping fixed the mediator's program, we study the equilibria of the CM treatment in undominated strategies.³⁰ We concentrate on equilibria where, regardless of message: (i) all players accept 70; (ii) L players always accept 50; (iii) H players always reject 30. Denoting by Tm a player of type T who sent message m , what remains to be determined are the acceptance strategies of Hh and Hl players offered 50, and of Ll players offered 30, as well as the first stage message strategies for both types. We simplify notation by denoting by α_m the probability of an Hm type accepting 50, and by β the probability of an Ll type accepting 30 (the offer of 30 can only follow an l message). As before, we denote by $\hat{\tau}_T$ the probability that type $T \in \{H, L\}$ is truthful (corrected for silence).

We report the full set of equilibria in the Appendix; here we concentrate on equilibria that do not contradict grossly the experimental data. In particular, in the data, having sent message l , L types accept 30 more than 89 percent of the times if $q = 1/2$, and 80 percent of the times if $q = 1/3$. In line with this observation, we focus here on equilibria with $\beta = 1$. By selecting such equilibria, we also rule out equilibria where $\hat{\tau}_H < \hat{\tau}_L$, in clear contradiction to our data. The equilibria are reported in the following table:

²⁹By sending message l , untruthful H types do reduce the frequency of mediators' refusals. However, by then rejecting the offer of 50, the positive impact on peace is fully undone: keeping L 's messages constant, H 's lack of sincerity reduces the refusals to mediate from 294 to 228, but 79 subsequent offers of 50 are then rejected.

³⁰Because our focus is understanding the experimental results, we characterize the equilibria for the specific parameter values used in the experiment. The analysis generalizes to arbitrary θ and q , keeping in mind that Par1 corresponds to $q > (2\theta - 1)$ and Par0 to $q < (2\theta - 1)$, the mediation program corresponds to Lemma 3 in HMS, and we maintain the assumptions $q < (2\theta - 1)/\theta$ and $\theta/2 > (1 - \theta)$.

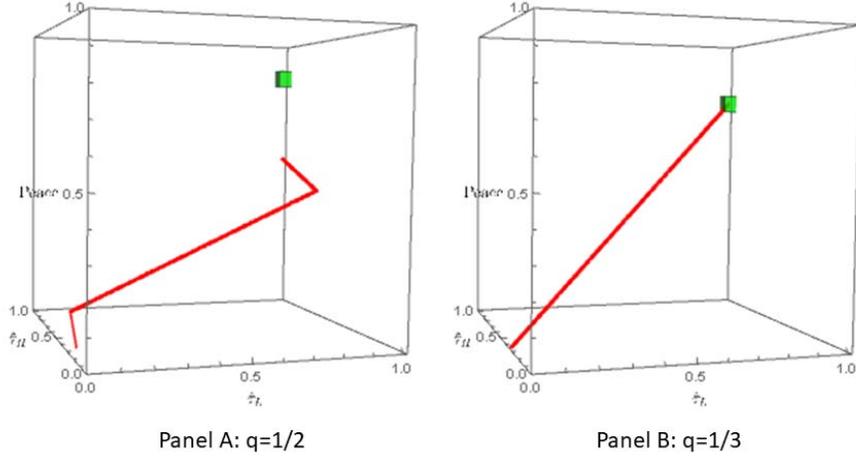


Figure 7: Equilibria under CM

$q = 1/2$	$q = 1/3$
$\alpha_h = 1, \beta = 1, \hat{\tau}_L = 1, \hat{\tau}_H = 1$	$\beta = 1, \hat{\tau}_L = 1, \hat{\tau}_H = 1$
$\alpha_h = 0, \beta = 1, \hat{\tau}_L = 1, \hat{\tau}_H = 1$	$\alpha_l = 0, \beta = 1, \hat{\tau}_L \in (0, 1), \hat{\tau}_H = 1/3 + (2/3)\hat{\tau}_L$
$\alpha_l = 0, \alpha_h = 0, \hat{\tau}_L = 0, \hat{\tau}_H \leq 4/15$	$\alpha_l = 0, \hat{\tau}_L = 0, \hat{\tau}_H \leq 1/3$
$\alpha_l = 0, \alpha_h = 0, \beta = 1, \hat{\tau}_L \in (0, 1), \hat{\tau}_H = 4/15 + (6/15)\hat{\tau}_L$	
$\alpha_l = 0, \alpha_h = 0, \beta = 1, \hat{\tau}_L = 1, \hat{\tau}_H \in [2/3, 1)$	

Table 4. Equilibria under CM

and represented graphically in Figure 7. The x axis is $\hat{\tau}_L$, the y-axis is $\hat{\tau}_H$, and the ex ante probability of peace is on the vertical z-axis.

For both parametrizations, the first equilibrium in Table 4 is the HMS equilibrium, identified by the green cubes in Figure 7; the other equilibria correspond to the red lines. For both $q = 1/2$ and $q = 1/3$, there are equilibria supporting any frequency of peace, between 0 and the highest frequency, corresponding to the HMS equilibrium ($7/8$ with $q = 1/2$, and $7/9$ with $q = 1/3$). Similarly, for both values of q , there are equilibria spanning any frequency of truthfulness, from 0 to 1, for L 's and almost as large a range for H 's. This then is our first observation: keeping fixed the mediator's program, equilibrium behavior under CM is compatible with a large range of messages and outcomes.

Beyond depicting such wide variation, the most striking feature of the figure is the discontinuity

in the locus of equilibria under $q = 1/2$. The mediation program uses obfuscation, and the HMS equilibrium entails $\alpha_h = 1$: sincere H types accept the (50, 50) offer with probability 1. The figure shows that the equilibrium is fragile: if there is *any* deviation in the messages from full sincerity by either type, including any use of the silent message, the peace probability falls discontinuously.

The discontinuity does not depend on the specific parameters used in the experiment but applies over the whole parameter region for which obfuscation is part of the optimal mediation program. And because it is obfuscation that makes the HMS equilibrium superior to any equilibrium of the direct communication game, the observation is of interest beyond the specific experiment.³¹ We phrase it in the following proposition for generic parameter values in the appropriate range. In line with the HMS' model, Proposition 3 ignores the option of silent messages. We include the possibility of silence in the Appendix, where the result in the proposition is part of the equilibria characterization, specialized to the experimental design and parameters.³²

The relevant restrictions are $(2\theta - 1) < q < (2\theta - 1)/\theta$. Following Lemma 3 in HMS, the optimal mediation program is then the following: $r(l, l) = (1/2, 1/2)$; $r(h, l) = \{(1/2, 1/2)$ with probability q_M and $(\theta, 1 - \theta)$ otherwise}; $r(h, h) = \{(1/2, 1/2)$ with probability q_H and w otherwise} where:

$$\begin{aligned} q_M &= \left(\frac{1 - \theta}{2\theta - 1} \right) \left(\frac{1 + q - 2\theta}{\theta - q} \right) \\ q_H &= \left(\frac{1 - q}{q} \right) \left(\frac{1 + q - 2\theta}{\theta - q} \right) \end{aligned} \tag{1}$$

As above, we use α_h (α_l) to denote the probability that type Hh (Hl) accepts 1/2. The following proposition holds:

Proposition 3. *Suppose $(2\theta - 1) < q < (2\theta - 1)/\theta$. Then: (i) $\alpha_h = 1 \implies \{\tau_H = 1, \tau_L = 1\}$. (ii) If $\tau_H < 1$ or $\tau_L < 1$, then $\alpha_h = 0$. (iii) $\{\tau_H = 1, \tau_L = 1\} \not\Rightarrow \alpha_h = 1$.*

Proof. Call $\Delta_{Hh}(1/2)$ the expected differential gain from accepting rather than rejecting 1/2 for player i , an H player who sent message h . Player i 's opponent is indexed by j . Since all L types

³¹Obfuscation is also at the core of Meirowitz et al. (2019), showing that the prospect of mediation with obfuscation reduces the incentives for militarization.

³²HMS allow for some probability $p < 1/2$ that L prevails in case of conflict. Since we have set $p = 0$ throughout, we do not reintroduce it here, but we have verified that the discontinuity is robust to the generalization.

always accept 1/2, it is not difficult to see that:

$$\begin{aligned} \Delta_{Hh}(1/2) &= (1/2 - \theta/2)[\Pr(j \text{ is } H \text{ and } h_j | (1/2, 1/2), h_i)\alpha_h + \Pr(j \text{ is } H \text{ and } l_j | (1/2, 1/2), h_i)\alpha_l] + \\ &\quad + (1/2 - \theta)\Pr(j \text{ is } L | (1/2, 1/2), h_i) \end{aligned}$$

Solving the probabilities:

$$\begin{aligned} \Pr(j \text{ is } H \text{ and } h_j | (1/2, 1/2), h_i) &= \frac{\Pr(j \text{ is } H \text{ and } h_j \text{ and } (1/2, 1/2) | h_i)}{\Pr((1/2, 1/2) | h_i)} = \\ &= \frac{q_H \tau_H q}{q_H[\tau_H q + (1 - \tau_L)(1 - q)] + q_M[(1 - \tau_H)q + \tau_L(1 - q)]} \end{aligned}$$

$$\Pr(j \text{ is } H \text{ and } l_j | (1/2, 1/2), h_i) = \frac{q_M(1 - \tau_H)q}{q_H[\tau_H q + (1 - \tau_L)(1 - q)] + q_M[(1 - \tau_H)q + \tau_L(1 - q)]}$$

and:

$$\Pr(j \text{ is } L | (1/2, 1/2), h_i) = \frac{q_M \tau_L (1 - q) + q_H (1 - \tau_L)(1 - q)}{q_H[\tau_H q + (1 - \tau_L)(1 - q)] + q_M[(1 - \tau_H)q + \tau_L(1 - q)]}.$$

Substituting (1) and simplifying, $\alpha_h > 0 \iff \Delta_{Hh}(1/2) \geq 0$ or:

$$(1 - q)\tau_H\alpha_h + \frac{(1 - \theta)q}{(2\theta - 1)}(1 - \tau_H)\alpha_l \geq (1 - q)\tau_L + \frac{(2\theta - 1)(1 - q)^2}{(1 - \theta)q}(1 - \tau_L) \quad (2)$$

The left-hand side of (2) is always weakly increasing in α_h and α_l , and maximal at $\alpha_h = \alpha_l = 1$ and $\tau_H = 1$, while the right-hand side is minimal at $\tau_L = 1$. Hence the condition is mostly likely to be satisfied at these values, at which it simplifies to $(1 - q) = (1 - q)$, holding with equality. Thus if $\alpha_h > 0$, then $\alpha_h = 1$, $\tau_H = 1$, $\tau_L = 1$. If either $\tau_H < 1$ or $\tau_L < 1$, then $\alpha_h = 0$. In addition, even at $\tau_H = 1$, $\tau_L = 1$, a second equilibrium exists with $\alpha_h = 0$: full sincerity is necessary but not sufficient for $\alpha_h = 1$. \square

Keeping the mediation program constant, any expected deviation from full sincerity by others induces the Hh type to *always* reject $1/2 - \alpha_h = 0$. In fact, even with full sincerity a second equilibrium exists where $\alpha_h = 0$. The intuition is straightforward: when offered 1/2, H 's best option is to accept if the opponent is H and reject if the opponent is L , conditional on the opponent accepting. If other H 's are expected to reject, always rejecting is a best response, even if all are sincere. And even if other H 's are expected to accept, rejecting is a best response if the posterior probability that the opponent is L , conditional on the mediator's recommendation, is high enough—and simple calculations show this

must indeed be the case for any deviation from full truthfulness by either type.

Proposition 3 is very relevant for a lab experiment and possibly for actual applications of mediation plans: expecting some lying with positive probability seems inevitable. The proposition tells us that, for the relevant range of parameter values, no peace probability in the neighborhood of the HMS equilibrium can then be expected. Under the optimal mediation program, the ex-post participation constraint of an H type offered $1/2$ is binding; any deviation leads to the violation of the constraint.³³ Yet, what is interesting is that the discrete jump in the expected frequency of peace is limited to the mediation program that exploits obfuscation. As shown in Figure 7, panel B, in the absence of obfuscation under $q = 1/3$ there is no discontinuity in the locus of equilibria around the full sincerity point: a small probability of untruthful messages leads to a lower probability of peace, but the equilibrium analysis shows that compliance of sincere types with the mediator's recommendations is not affected. This is true if $q = 1/3$, or more broadly $q < (2\theta - 1)$, and the optimal mediation program does not include obfuscation, but is also true if $q > (2\theta - 1)$ and the mediation program is optimized under the constraint of no obfuscation. The reason is that in the absence of obfuscation the ex post participation constraints for a sincere H type offered $1/2$ and a sincere L type offered $(1 - \theta)$ are slack, and remain slack in the presence of lies; the ex post participation constraints for a sincere H type offered θ is binding under full sincerity and remains binding along the equilibrium locus in the presence of lies.³⁴

5.2 Sincerity and peace: data v/s equilibrium predictions

Do the multiple equilibria explain the relatively poor performance of mediation in the CM treatment?

The figure below superimposes the data, aggregated by session, to the equilibria in Figure 7. As

³³Interestingly, the obfuscation equilibrium with $q = 1/2$ is trembling-hand perfect. Perfection arises because of the latitude left to the specification of the error processes. As long as the probability of trembles in L 's acceptance strategies is high enough, relative to the probability of the other trembles, the equilibrium is perfect. (See the discussion in the Appendix).

³⁴Without obfuscation, subjects learn their opponent's message from the mediator's recommendations. Hence for example $\Delta_{Hh}(1/2)$ becomes:

$$\begin{aligned} \Delta_{Hh}(1/2) &= (1/2 - \theta/2) \frac{\tau_H q}{\tau_H q + (1 - \tau_L)(1 - q)} \alpha_h + \\ &\quad + (1/2 - \theta) \frac{(1 - \tau_L)(1 - q)}{\tau_H q + (1 - \tau_L)(1 - q)} \end{aligned}$$

Thus, $\Delta_{Hh}(1/2) \geq 0$ if:

$$(1 - \theta)\tau_H q \alpha_h \geq (2\theta - 1)(1 - \tau_L)(1 - q)$$

Whether $q > (2\theta - 1)$ or $q < (2\theta - 1)$, there always are $\underline{\tau}_L < 1$ and $\underline{\tau}_H < 1$ such that accepting $1/2$ is superior to rejecting it if $\alpha_h = 1$, $\tau_L \in (\underline{\tau}_L, 1)$, and $\tau_H \in (\underline{\tau}_H, 1)$. With $q = 1/2$ and $\theta = 0.7$, the optimal mediation program in the absence of obfuscation corresponds to: $r(l, l) = (1/2, 1/2)$; $r(h, l) = (0.7, 0.3)$; $r(h, h) = (1/2, 1/2)$ with probability $1/5$, and w otherwise. The expected frequency of peace is 0.8 (v/s 0.875 with obfuscation).

before, the horizontal axes measures $\hat{\tau}_L$ and $\hat{\tau}_H$, (sincerity, corrected for silence), and the vertical axis the frequency of peace (or the ex ante probability in the theoretical model). The equilibria correspond to the red lines, with the equilibrium with highest expected peace—the HMS equilibrium—denoted by the green cube. The data are represented by red spheres.

The 3D figures allow us to represent directly the three variables at the heart of the mechanism, sincerity by either type and peace. As we already know, in both parametrizations and all sessions, all three variables fall short of the HMS equilibrium. But relative to the other equilibria, the deviations go in opposite directions: with $q = 1/2$, holding $\hat{\tau}_L$ fixed to the experimental values, the data have more frequent peace and more sincere H types than the theory predict; with $q = 1/3$, two sessions sit almost exactly on the equilibrium line, but for the remaining four the opposite is true: holding $\hat{\tau}_L$ fixed, the data have less peace and less sincerity from H types than the corresponding theoretical equilibria.

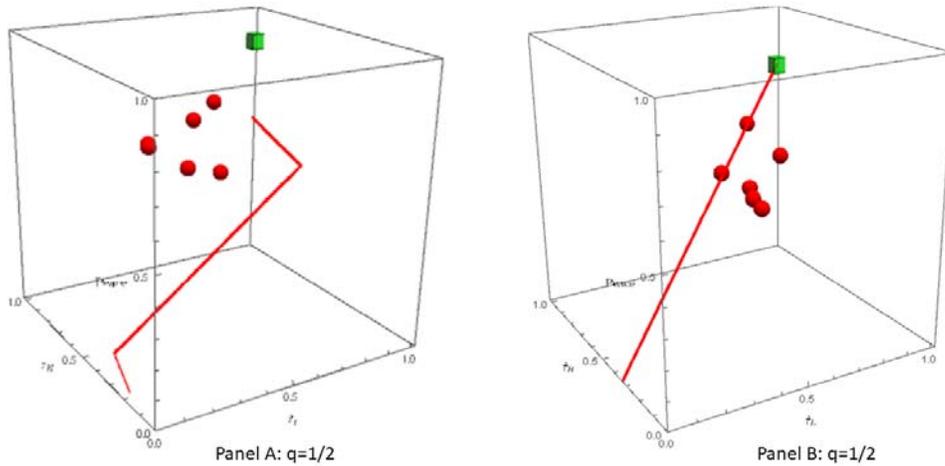


Figure 8: CM. Data and equilibria.

With $q = 1/3$, untruthful messages by H 's are followed by recommendations of either (50, 50) or (30, 70), which are then rejected.³⁵ Had those messages been sincere, some would have been followed by recommendations of (70, 30), which could have resulted in peace. But note that peace was only

³⁵Both types HL and Hs reject 50 more than 80 percent of the times, and reject 30 100 percent of the times.

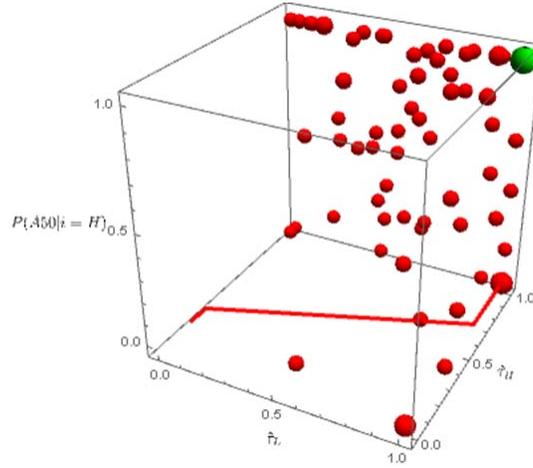


Figure 9: Individual subjects. Frequency of accepting 50 when H ; $q = 1/2$.

likely if the opponent was an L ,³⁶ in which case accepting the mediator's recommendation or going to war is equivalent for the H player. The loss of efficiency comes at very little cost to the H player, a point to which we will return below.

With $q = 1/2$, peace is instead higher than equilibrium predicts. In all equilibria with less than perfect truthfulness H types never accept 50—in the data, aggregating over all sessions, the frequency of acceptances is just below 60 percent, with high dispersion across subjects. Figure 9 shows the disparity in individual strategies. The vertical axis is the frequency of acceptance of 50 by an H type; the x and y-axes are $\hat{\tau}_L$ and $\hat{\tau}_H$, and the red line at the bottom is the equilibrium line.³⁷ There are 72 subjects in all, and each is represented in the figure by the subject's frequency of truthfulness (as an H and as an L), and acceptance of 50 when H ; the volume of each sphere is proportional to the number of individual subjects the sphere represents. The green sphere corresponds to the 5 subjects who always played (1,1,1)—the HMS equilibrium strategies. There are 4 subjects at (1,1,0) (also an equilibrium point); the overwhelming majority of the rest are individual subjects. The figure shows clearly that only few subjects reject the offer consistently.

Why are H types accepting 50, against the theory's predictions? Two explanations seem plausible. First, subjects could be risk averse. The optimal mediation program would differ under risk aversion,

³⁶Recall that the computer mediator always walks out after messages (h, h) .

³⁷The figure does not distinguish on the basis of the subject's message, but close to 90 percent of all messages were h .

but we can still ask how risk averse subjects would respond to the program implemented by the computer mediator. Rejecting the mediator’s recommendation increases risk, and indeed risk aversion can induce a sincere H type to accept 50. Proposition 3 does not hold under risk aversion.³⁸

We did not explicitly elicit measures of risk aversion, but we can deduce them from subjects’ behavior in other treatments of the experiment—a methodology with the advantage of not disturbing the experiment or creating experimenter demand effects. Recall that we started each session with 10 rounds of direct demands without communication (NC). In the NC treatment, demanding 30 is dominated for an H (and we observe it only once, out of 356 demands) but is not dominated and is the minimum risk strategy for an L . Under $q = 1/2$, L types demand 30 30 percent of the times; for reference, the unique equilibrium of the NC game under risk neutrality has L types demanding 30 with more than 70 percent probability (see the Appendix). Across subjects, the correlation between the frequency of accepting 50 when Hh in CM and demanding 30 when L in NC is, if anything, negative: $\hat{\rho} = -0.39$ (with 95 percent $CI = [-0.58, -0.17]$). In the HM treatment, recall that refusing to mediate guarantees the mediator a riskless payoff of 40—we expect risk averse mediators to walk out with high frequency. Under $q = 1/2$, following messages (h, h) , human mediators walk out 36 percent of the times; as we describe in Section 6.1, the HM game has many equilibria, but in the equilibrium we found that best explains the data, the corresponding frequency under risk neutrality is in fact higher (0.535). Across subjects, we find no correlation between the frequency of accepting 50 when Hh in CM and walking out after (h, h) in HM: $\hat{\rho} = -0.13$ (with $CI = [-0.36, 0.11]$). All together, these numbers do not make a case for risk aversion.

A second possible explanation for the behavior we observe is that the actions chosen by the subjects come at little cost. Given the behavior of others, how far are subjects from best responding? We address this question in the next section.

³⁸Under the CM program,

$$\begin{aligned} \Delta_{Hh}(50) &= [u(50) - u(35)][4\tau_H\alpha_h + 3(1 - \tau_H)\alpha_l] + \\ &\quad + [u(50) - u(70)](4 - \tau_L) \end{aligned}$$

It is not difficult to verify that the constraint now has slack at full sincerity and $\Delta_{Hh}(50) \geq 0$ is possible under some lying. Note however that the truthful equilibrium where H types always reject 50 ($\alpha_h = 0, \alpha_l = 0, \tau_H = 1, \tau_L = 1$) continues to exist.

5.3 Neighborhood of best responses

Dominated actions are rare in the data. If we ignore them, each player of given type faces two decisions: the message, $\hat{\tau}_H$ if H and $\hat{\tau}_L$ if L , and the acceptance of 50 if H , α , and of 30 if L , β .³⁹ For each session, we calculated the average strategies played by others in a session. We then calculated the expected payoff of an H type as function of $\hat{\tau}_H$ and α , and correspondingly of an L type as function of $\hat{\tau}_L$ and β . Given type, the differences across subjects and sessions were minor, and our findings can be summarized in the figures below, drawn for a representative subject of each type, H and L , playing against the average strategies in each of the two parametrizations (averaged over all sessions). Figures 10 and 11 are contour plots reproducing the loss from not best responding, as percentage of the maximum possible payoff. Figure 10 refers to $q = 1/2$ and Figure 11 to $q = 1/3$; in both cases the left panel refers to an H type, and the right panel to an L type. The horizontal axes in the two panels correspond to the message choices, $\hat{\tau}_H$ and $\hat{\tau}_L$; the vertical axis to the acceptance decisions, α and β . The shades of the different contours indicate the expected loss, from below 2.5 percent for the lightest shade, to above 25 percent for the darkest. The circles superimposed on the plots correspond to individual subject observations, with the size of the circle proportional to the number of subjects with choices at the specific point in the plot.⁴⁰

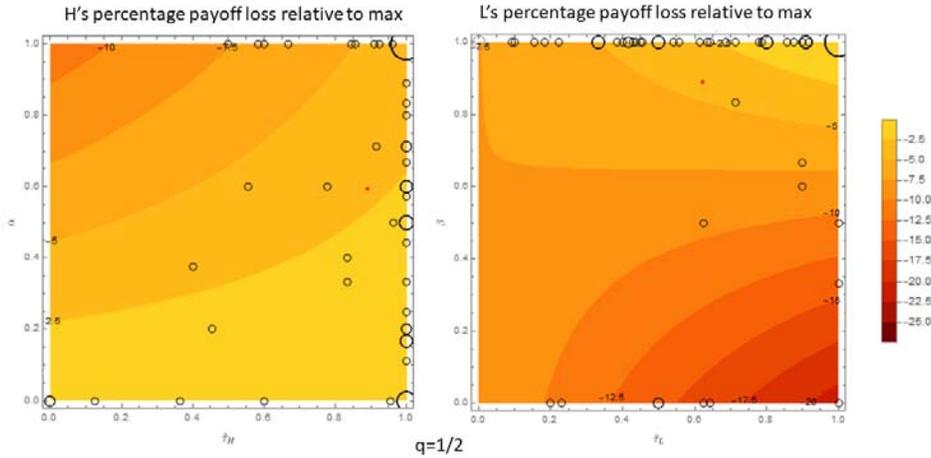


Figure 10: Losses relative to best responding, $q = 1/2$.

In Parameter 1 sessions ($q = 1/2$), there is clear asymmetry in the range of possible losses between

³⁹ Again conflating α_l and α_h if $q = 1/2$.

⁴⁰ In each panel, the small red dot reports the average strategy for players of the corresponding type.

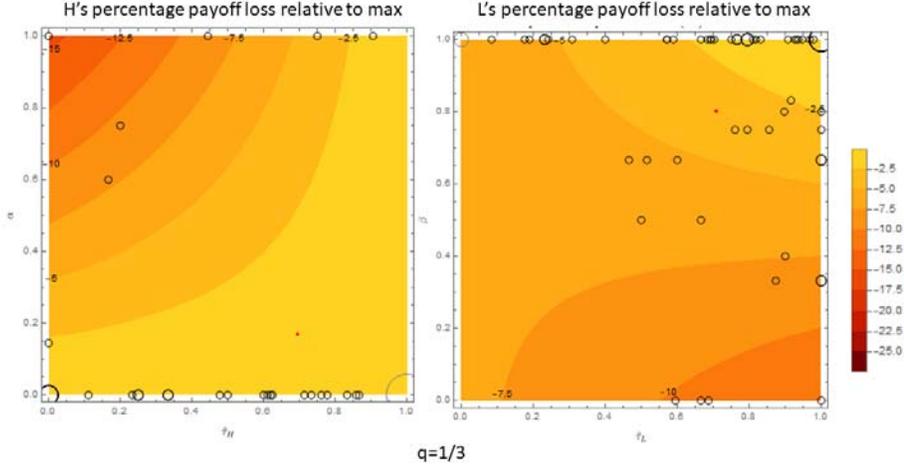


Figure 11: Losses relative to best responding. $q = 1/3$

H and L types: at most 10 percent of maximum payoff for H 's, more than 25 percent for L types. For an H type, losses depend primarily on α ; as $\hat{\tau}_H$ increases, the frequency of offers of 50 declines and so does the sensitivity of expected losses to α (hence the upward sloping contours). For L types, losses can be significant if high sincerity, high $\hat{\tau}_L$, is matched with low compliance, low β . Note that full sincerity ($\hat{\tau}_L = 1$) and full compliance with the mediator ($\beta = 1$) are best response strategies in the data, given the behavior of others. But this is not true for H types: a sincere H type does better by rejecting 50, as the equilibrium analysis suggested. The loss however is small.

In Parameter 0 sessions ($q = 1/3$), there is no asymmetry in potential losses between H 's and L 's. H types are never offered 50 if sincere; hence the value of α makes little difference at high $\hat{\tau}_H$. As sincerity declines, accepting 50 is increasingly costly, with potential losses reaching 15 percent at $\hat{\tau}_H = 0$ and $\alpha = 1$. L types are only offered 30 if sincere; thus β has no impact on expected losses at low $\hat{\tau}_L$. At higher sincerity, however, accepting 30 becomes a preferable choice, and at $\hat{\tau}_L = 1$ losses are monotonically declining in β . With $q = 1/3$, for both types full sincerity and compliance with the mediator's recommendations are the payoff maximizing choices in the lab. In the absence of obfuscation, as is the case for the mediator program with $q = 1/3$, lack of full sincerity by others does not affect the optimal strategies. Some robustness is built into the mediation mechanism.

It is also true, however, that in the lab we did not see full sincerity and compliance with the mediator under either $q = 1/2$ or $q = 1/3$. One possible reason is that under both parametrizations, deviations from best responding had little cost. With $q = 1/2$, 93 percent of H subjects and just

below two thirds (64 percent) of L subjects lost less than 5 percent from their failure to best respond to the empirical frequency of their opponents' play. With $q = 1/3$, the corresponding fractions are 92 percent for H subjects, and again 64 percent for L subjects.

The observation raises a question: are losses low because the range of possible losses in the game is limited, or because subjects choose strategies that limit their losses? How badly would subjects have fared if they had acted randomly?

We tested the null hypothesis of random play by running Kolmogorov-Smirnov tests, corrected for discreteness, comparing random messages to the distribution of observed messages, and random acceptance decisions to the distribution of observed acceptances, by player's type and by parametrization.⁴¹ All eight resulting tests strongly reject the hypothesis that subjects' choices were random ($p < 0.001$ in all cases).

Figure 12 compares CDF's of losses, in the data (in blue), and under random decision-making (in orange) for each player's type and the two parametrizations.

The figure shows clearly the higher frequency of small losses in the data. With the exception of H players in parameter 1, where, as shown by the contourplots, potential losses are always limited, experimental subjects are experiencing much lower losses than erratic play would induce. If subjects were playing randomly, the fractions of L players experiencing losses of not more than 5 percent would be less than 10 percent when $q = 1/2$ and less than 20 percent when $q = 1/3$. Experimental subjects are playing strategies that although not best responses are not far from them, in payoff space.

6 The HM and UC treatments

The focus of the experiment was the CM treatment, but evaluating the effectiveness of the optimal mediation program requires the comparison to other treatments. Propositions HMS, 1, and 2 yield our main theoretical predictions. Beyond the broad results in the propositions, we have studied equilibria of the UC and HM games played in the lab. For both treatments, the main challenge is the large number of possible equilibria. In this section, we report briefly on some such equilibria and discuss how

⁴¹Ignoring silence, both messages and acceptances are binary variables—each individual observation is either 0 or 1—and because of randomness, the data show different numbers of realizations for different subjects. For each choice $c = m, a$ we thus have a sample of $n(c, t, q)$ individuals, with k_i realizations for each individual i . We construct a corresponding random data set by drawing a sample of n subjects, each with k_i realizations equally likely to be 0 or 1. We compare the empirical distribution to the random distribution via a KS test. We repeat the procedure 1,000 times. The p-value we report is the fraction of KS tests reporting a probability higher than 5 percent that the samples are drawn from the same population.

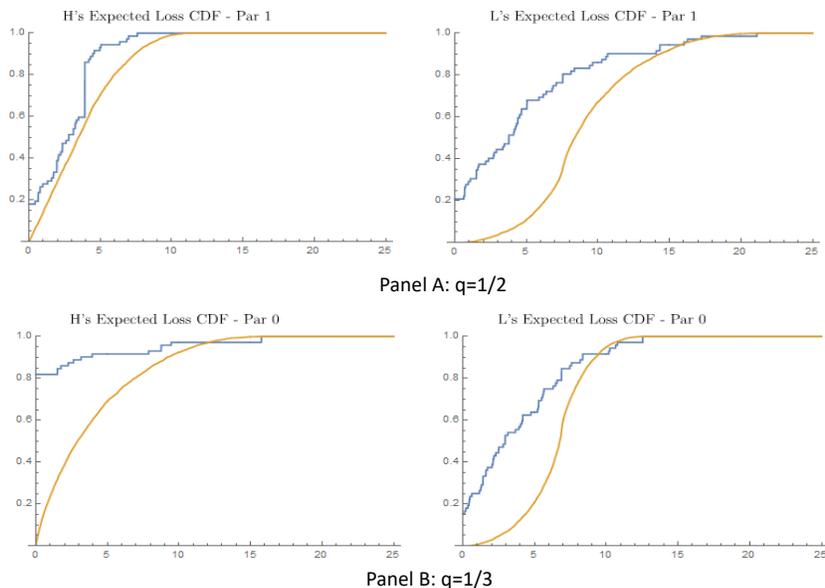


Figure 12: CDF's of losses, given observed play by others - data (blue) versus random decision-making (orange)

they fare, relative to the experimental data. All details of the derivations are in the online Appendix.

6.1 Human Mediation

The HM treatment was exploratory—without a known mediation program, without repeated interactions or mediator's commitment, the problem for the subjects is very difficult. It is interesting to see how subjects were able to use mediation under these conditions. Figures 2 and 4 as well as Tables 1 and 2 provide some answers to this question: relative to CM, sincerity is lower under HM, especially for L subjects, and so is peace, especially under $q = 1/3$. Is the lack of commitment the origin of those results?

We begin by comparing the mediation program we observe under HM to the corresponding program and behavior under CM. Table 5 summarizes the two mediation programs.⁴²

⁴²Silence is rare in both treatments. Under CM it is translated automatically into either h or l according to the prior; we make the same assumption under HM. In the (h, l) row, under HM we only count $(70, 30)$ if 70 is offered to the h player; as a result the (h, l) rows under HM sum to slightly less than 1.

$q = 1/2$	<i>HM</i>			<i>CM</i>		
	(50, 50)	(70, 30)	w	(50, 50)	(70, 30)	w
(l, l)	0.78	0.06	0.16	1	0	0
(h, l)	0.25	0.59	0.14	0.375	0.625	0
(h, h)	0.62	0.03	0.35	0.5	0	0.5

$q = 1/3$	<i>HM</i>			<i>CM</i>		
	(50, 50)	(70, 30)	w	(50, 50)	(70, 30)	w
(l, l)	0.77	0.01	0.21	1	0	0
(h, l)	0.28	0.43	0.26	0	0.75	0.25
(h, h)	0.48	0.03	0.50	0	0	1

Table 5: The HM and CM mediation programs

The two programs are qualitatively similar. In particular, note HM’s more frequent refusals to mediate at lower q , in line with the optimal program. We do not see a tendency towards refusals to mediate (w), minimizing concerns about distortions due to risk aversion. On the contrary, we see HM’s bias towards peace in the effort to mediate after (h, h) messages, even under $q = 1/3$.

Table 6 reports the players’ strategies in the lab in the two mediation treatments, as well as the realized peace frequencies. For both values of q , the players’ strategies are similar, but for two systematic differences (bolded in the table): in HM, L is less sincere and H is more willing to accept 50 (especially after message l).

		$q = 1/2$						
		$\hat{\tau}_H$	$\hat{\tau}_L$	α_h	α_l	β_l	β_h	P
<i>HM</i>		0.84	0.41	0.68	0.52	0.88	0.67	0.50
<i>CM</i>		0.89	0.62	0.64	0.28	0.89	–	0.55

		$q = 1/3$						
		$\hat{\tau}_H$	$\hat{\tau}_L$	α_h	α_l	β_l	β_h	P
<i>HM</i>		0.68	0.54	0.54	0.50	0.69	0.58	0.40
<i>CM</i>		0.69	0.71	–	0.17	0.80	–	0.46

Table 6. Observed players’ strategies and outcomes, HM and CM

The obvious question then is whether these regularities reflect equilibrium behavior in the HM game—for example, we know from Proposition 2 that supporting full sincerity in the absence of commitment is impossible under $q = 1/3$, and we do observe less sincerity under $q = 1/3$. The game has many equilibria; we focus here on two types of equilibria in which dominant acceptance strategies are followed (both players accept 70, L accepts 50, and H rejects 30), and, in line with the data, $r(l, l) = (50, 50)$ and H players are sincere ($\tau_H = 1$).⁴³ The first type of equilibria exists for both parametrizations; the second exists only for $q = 1/2$. (The precise characterization is in the online Appendix).

Equilibria 1. Par1 and Par0: $q = 1/2$ and $q = 1/3$. *The mediator recommendations are: $r(l, l) = (50, 50)$, $r(h, l) = (70, 30)$, $r(h, h) = w$, and, when a recommendation is made, it is always accepted. H types are fully sincere ($\tau_H = 1$). With $q = 1/2$, L types are fully sincere as well ($\tau_L = 1$), and $P = 3/4$. With $q = 1/3$, $\tau_L = 2/3$, and $P = 56/81 = 0.69$.*

With $q = 1/2$, this is the full sincerity and full compliance equilibrium of Proposition 2. As stated in the Proposition, full sincerity and full compliance cannot be sustained with $q = 1/3$; however an equilibrium exists where the mediator's recommendations, conditional on messages, are unchanged, and the players always comply, but L players are only sincere with probability $2/3$.

When $q = 1/2$ and there is less of a need to discipline L types's messages via refusals to mediate, the mediator need not walk out with probability one after messages (h, h) . A second type of equilibria exists:

Equilibria 2. Par1: $q = 1/2$. *The mediator recommendations are: $r(l, l) = (50, 50)$, $r(h, l) = (70, 30)$, $r(h, h) = w$ with probability $p_w = 0.535$ and $r(h, h) = (50, 50)$ with probability $1 - p_w$; when a recommendation is made, it is always accepted; at the message stage: $\tau_H = 1$ and $\tau_L = 0.565$. $P = 0.605$.⁴⁴*

Relative to observed actions in Tables 5 and 6, equilibria 2 for $q = 1/2$ provide plausible predictions. In response to (h, h) , HM in the lab refuses to mediate somewhat too rarely, but L subjects lie more than expected and recommendations are too often rejected, inducing lower peace than predicted. Equilibria 1 find less support in the data: when $q = 1/2$, we do not see full sincerity by the L type; when $q = 1/3$, HM's recommendations are qualitatively in line with the equilibrium and, as remarked

⁴³The focus on equilibria with $\tau_H = 1$ has a stronger rationale. It can be shown that any equilibrium in which $r(l, l) = (50, 50)$ with probability 1, $r(h, l) = (70, 30)$ with positive probability, $\tau_L > 0$, and $\tau_H > 1 - \sigma_L - \tau_L$ (H says h more often than does L) involves full sincerity from the H type.

⁴⁴As shown in the online Appendix, the strategies described can be supported by different beliefs about off-equilibrium acceptance strategies. Hence the plural term "equilibria".

earlier, we do see an increase in refusals to mediate, but such refusals remain too low following (h, h) , and too high following the other pairs of messages.

6.2 Unmediated communication

The UC game is a bargaining game with cheap talk messages. Even restricting attention to uncorrelated equilibria in undominated strategies, this game too admits a large number of equilibria, cautioning us from giving too much weight to the equilibria described below. Yet, for an experiment, the equilibria we discuss have a priori desirable properties: they are simple, in the precise sense that demand strategies are either conditioned on type only, or on type and a single set of messages (as opposed to both messages sent and received); they include equilibria where messages are uninformative and thus also hold in the absence of communication; and finally they yield a stark and very useful prediction: although each equilibrium set is large, the probability of peace is constant across the whole set.

Proposition A2 in the online Appendix characterizes the equilibria below for arbitrary q and θ . Here we describe their main qualitative features, when specialized to the experimental parameters.

For $q = 1/3$, a particularly intuitive class of equilibria exists in which demand strategies are pure and do not depend on messages: H types always demand 70, and L types always demand 50. The equilibria impose constraints on the posterior probabilities of opponent's types, given messages, and these constraints limit the range of acceptable message strategies. Denoting by $\delta_d(T, m, m')$ the probability that type T who sent message m and received message m' demands d :

Equilibria 1. Par0: $q = 1/3$. *At the demand stage:* $\delta_{70}(H, m, m') = 1$, $\delta_{50}(L, m, m') = 1$. *At the message stage, for any* $(\tau_L + \sigma_L) \in (0, 1)$, $\tau_H \in [\max(0, 1 - \sigma_H - (4/3)\tau_L), \min(1, (4/3)(1 - \tau_L - \sigma_L))]$, $\sigma_H \leq (4/3)\sigma_L$. *The ex ante probability of peace, P , equals* $(1 - q)^2 = 4/9 = 0.444$.

Note that the equilibrium set includes fully uninformative messages ($\tau_H = 1 - \tau_L - \sigma_L$, $\sigma_L = \sigma_H$) and the demand strategies remain equilibrium strategies of the game without communication. Communication, even when informative, plays no role: the peace probability is constant over the full range of acceptable messages.

As shown in Table 7, this class of equilibria explains the data reasonably well, whether in terms of message and demand strategies or peace. Such equilibria however do not exist for $q = 1/2$. We need to allow L 's demand strategies to be mixed:

Equilibria 2. Par1 and Par0: $q = 1/2$ and $q = 1/3$. *At the demand stage:* $\delta_{70}(H, m, m') = 1$,

$\delta_{70}(L, m, m') = 2 \left[1 - \frac{3}{7} \left(\frac{1}{1 - \pi_m} \right) \right] = 1 - \delta_{30}(L, l, m')$, where π_m is the posterior probability a player is H given message m .⁴⁵ At the message stage, for any $(\tau_L + \sigma_L) \in (0, 1)$, $\tau_H \in [\underline{\tau}_H(\tau_L, \sigma_H, \sigma_L), \overline{\tau}_H(\tau_L, \sigma_H, \sigma_L)]$ and $\sigma_H \in [\underline{\sigma}_H(\sigma_L), \overline{\sigma}_H(\sigma_L)]$. The ex ante probability of peace, P , equals 0.586 if $q = 1/2$, and 0.345 if $q = 1/3$.

The boundaries on the message strategies are not very illuminating, and we leave them to the online Appendix. For both values of q , they include fully uninformative messages, implying that demand strategies remain equilibria in the game without communication. In fact, for $q = 1/2$, these are the only equilibria that exist without communication. Again, even when messages are informative, the ex ante peace probability remains constant: the mixing probabilities at the demand stage effectively nullify the information provided by the message.

The probability of peace is lower with $q = 1/3$ than in the case of $q = 1/2$ under both sets of equilibria: the smaller likelihood that the opponent is H makes L types more aggressive and results in more frequent conflict. Because of the large possible range of equilibrium messages, and hence of mixing probabilities over demands, lower peace under $q = 1/3$ is the only treatment effect that can be claimed with some confidence. It is indeed observed in the data (see Table 3).⁴⁶

The predictions of the second class of equilibria are reported in Table 7 as well, with demand strategies anchored by the observed point values for τ_L , τ_H , σ_L , and σ_H .

The second set of equilibria can explain observed peace and messages, but not demand strategies, especially for L subjects. Under both parametrizations, L types in the lab tend to demand 50. With H types demanding 70, such a demand yields $(1 - q)50$, and thus is inferior to demanding and guaranteeing oneself 30 if $q < 2/5$ (or more generally, if $q < (2\theta - 1)$): the first class of equilibria existing with $q = 1/3$ cannot be supported with $q = 1/2$.

⁴⁵Hence for example

$$\pi_h = \frac{q\tau_H}{q\tau_H + (1 - q)(1 - \tau_L - \sigma_L)}.$$

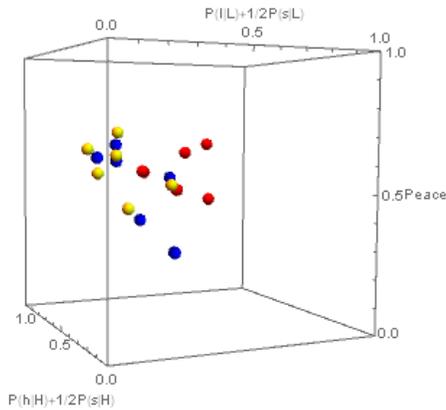
⁴⁶In addition, the hypothesis of equal probability of peace in the absence of communication is supported by the data from the initial experimental rounds with no communication. See the discussion of the NC data in the online Appendix.

$q = 1/3$								
	P	τ_H	σ_H	$\delta_{70}(H)$	$\delta_{70}(L, l)$	$\delta_{70}(L, h)$	$\delta_{70}(L, s)$	$\delta_{50}(L)$
data	0.49	0.74	0.10	0.71	0.11	0.21	0.13	0.72
equil1	0.44	[0.5, 0.74]	≤ 0.19	1	0	0	0	1
equil2	0.35	[0.19, 0.80]	[0.05, 0.39]	1	0.91	0.57	0.85	0

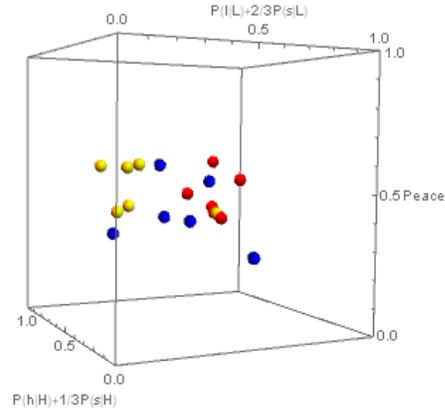
$q = 1/2$								
	P	τ_H	σ_H	$\delta_{70}(H)$	$\delta_{70}(L, l)$	$\delta_{70}(L, h)$	$\delta_{70}(L, s)$	$\delta_{50}(L)$
data	0.57	0.81	0.12	0.52	0.02	0.15	0.14	0.73
equil2	0.59	[0.47, 0.80]	[0.02, 0.13]	1	0.95	0	0.07	0

Table 7. Unmediated Communication: Data and Equilibria

We conclude this section by representing graphically our data from the three treatments in the 3D figure we have used repeatedly, reporting sincerity (adjusted for silence) on the horizontal axes, and peace on the vertical axis. Each sphere corresponds to an experimental session; red spheres correspond to CM, blue to HM and yellow to UC. The figure shows clearly the increase in L 's sincerity in moving from UC to HM to CM, the constancy of the peace frequency across the treatments, and the higher variance in peace across sessions for HM, probably mirroring the high complexity of the treatment.



All data. $q = 1/2$



All data. $q = 1/3$

7 Conclusions

[To be completed]

- We find that subjects are significantly more sincere under CM than under UC or HM, but the frequency of peace is comparable across all three treatments, and for both parametrizations.
- We believe there are several reasons for the result:
 - First, the optimal mediation program under CM suffers from multiple equilibria,
 - Second, the primary theoretical reason for the superiority of mediation to direct communication is the possibility of obfuscation. But the optimal mediation program with obfuscation is fragile: the locus of equilibria in the neighborhood of the highest-peace equilibrium is discontinuous in outcomes. Any positive probability of lying by the opponent, no matter how small, causes a discontinuous upward jump in the frequency of conflict.
 - There is no such discontinuity if the mediation program does not include obfuscation.
 - Yet both mediation programs, with and without obfuscation, fall short of their best theoretical promise.
 - In our data, subjects deviate from equilibrium strategies but the deviations cause them only small losses.
 - The small losses do not reflect low incentives in the game, but "good-enough" play, given the empirical play of the other subjects. We reject very strongly the hypothesis of random subject choices. And if subjects were playing randomly they would incur substantially higher losses.
 - The third reason for our results is that "good-enough" play under CM is consistent with a frequency of peace that does not differ significantly from what they achieve under direct communication.

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8 Appendix

8.1 Mediation without Commitment: Proposition 2

Proposition 2. *Assume $q < (2\theta - 1)/\theta$. If the mediator cannot commit to refuse mediation, a truthful equilibrium exists if and only if $q \geq (2\theta - 1)$. If $q > (2\theta - 1)$ the probability of peace is strictly lower than can be achieved by a mediator with commitment power.*

Proof. In line with the experimental design described later, we call the mediator without commitment the Human Mediator (HM). We focus on a Perfect Bayesian Equilibrium (PBE) in undominated strategies and begin by establishing the following Lemma:

Lemma A1. *Assume $q < (2\theta - 1)/\theta$. If a truthful equilibrium exists, it must take the following form: (i) Following messages (l, l) , HM offers $(1/2, 1/2)$ with any probability $p \in [0, 1]$ and $(\theta, 1 - \theta)$ with probability $1 - p$, randomizing uniformly which player is offered θ . The offer is always accepted. (ii) Following (h, l) , HM offers $(\theta, 1 - \theta)$, which is always accepted. (iii) Following (h, h) , if HM prefers walking out to rejection, then HM walks out; if HM is indifferent between walking out and rejection, HM will either walk out or make any offer, but the offer is always rejected.*

Proof of Lemma A1. Suppose both types of player are sincere. In any PBE in undominated strategies, L accepts $1/2$. Thus, following (l, l) , HM can maximize payoffs by offering $(1/2, 1/2)$ which will be accepted with probability 1 (w.p. 1); hence HM will never walk out. Following (l, l) , HM can offer $(\theta, 1 - \theta)$ with positive probability only if it is accepted w.p. 1.

Following (h, l) , if HM offers $(\theta, 1 - \theta)$, it will be accepted w.p. 1; this must so because either $(\theta, 1 - \theta)$ is not offered after (l, l) —in which case it reveals to L that the opponent is H —or it is offered after (l, l) , in which case it must be accepted w.p. 1, and thus must be accepted w.p. 1 after (h, l) , because the two information sets cannot be distinguished. Hence after (h, l) HM does not walk out. Can it be that HM mixes between $(\theta, 1 - \theta)$ and $(1/2, 1/2)$ (both with positive probability)? Since $(\theta, 1 - \theta)$ would be accepted w.p. 1, $(1/2, 1/2)$ can only be offered with positive probability if it is accepted w.p. 1. But then, following (h, h) , HM would offer $(1/2, 1/2)$ w.p. 1 since it would be accepted w.p. 1 (and $(\theta, 1 - \theta)$ would be rejected w.p. 1 (since H 's always reject $1 - \theta$). But then, it would not be an equilibrium for L to be sincere (by saying h , L would receive a strictly higher payoff if the other player is H). Thus, it must be that, if (h, l) is followed by $(\theta, 1 - \theta)$ with some positive probability, then the probability must equal 1. In other words, (h, l) must be followed by $(\theta, 1 - \theta)$

w.p. 1 or w.p. 0.

Is it possible that (h, l) is followed by $(\theta, 1 - \theta)$ w.p. 0? Suppose so. First, if (h, l) is followed by $(1/2, 1/2)$ w.p.1, it will be rejected w.p.1 by the H type. To see this note that an H who sent message h will accept $1/2$ only if:

$$\begin{aligned} \Pr(H_j|(1/2, 1/2))\Pr(H_j \text{ accepts } 1/2)(1/2 - \theta/2) + \Pr(L_j|(1/2, 1/2))(1/2 - \theta) &\geq 0 \iff \\ \Pr(H_j|(1/2, 1/2))\Pr(H_j \text{ accepts } 1/2)(1/2 - \theta/2) &\geq \Pr(L_j|(1/2, 1/2))(\theta - 1/2) \iff \\ \Pr(1/2, 1/2|hh)q\Pr(H_j \text{ accepts } 1/2)(1 - \theta) &\geq \Pr(1/2, 1/2|hl)(1 - q)(2\theta - 1) \end{aligned}$$

If $\Pr(1/2, 1/2|hl) = 1$, the condition becomes:

$$\Pr(1/2, 1/2|hh)\Pr(H_j \text{ accepts } 1/2) \geq \left(\frac{1-q}{q}\right)\left(\frac{2\theta-1}{1-\theta}\right)$$

But:

$$\left(\frac{1-q}{q}\right)\left(\frac{2\theta-1}{1-\theta}\right) > 1 \iff q < \frac{2\theta-1}{\theta}$$

which is satisfied in the model. Hence if (h, l) is followed by $(1/2, 1/2)$ w.p.1, $(1/2, 1/2)$ is always rejected by the H type. Hence HM will not offer $(1/2, 1/2)$ w.p.1.

Can it be that HM mixes between $(1/2, 1/2)$ and w (walking out), both with positive probability, following (h, l) ? This requires HM to be indifferent between the two offers. But recall that, following (h, l) , $(\theta, 1 - \theta)$ would be accepted w.p. 1. If HM prefers peace to w , then $(\theta, 1 - \theta)$ dominates both w and any mixture that assigns positive probability to w . Hence it must be that, following (h, l) , HM offers $(\theta, 1 - \theta)$ w.p.1.

Following (h, h) , an offer of $(\theta, 1 - \theta)$ will be rejected (because players are sincere and H never accepts $1 - \theta$). Can HM offer $(1/2, 1/2)$ with positive probability? If sincere H players expect others sincere H players to accept $(1/2, 1/2)$ with positive probability, then it is uniquely optimal for them to accept. But then offering $(1/2, 1/2)$ is uniquely optimal for HM. But this cannot be part of a sincere equilibrium because then L would strictly prefer to lie. Hence, if HM prefers w to rejection HM must walk out following hh . If HM is indifferent between walking out and rejection, then HM may offer anything (or walk out), but any offer must be rejected.

Two final observations conclude the proof. First, note that if such an equilibrium exists for an arbitrary $p50ll \in [0, 1]$, then the equilibrium exists for all $p50ll \in [0, 1]$: following (l, l) , both $(1/2, 1/2)$

and $(\theta, 1 - \theta)$ are always accepted, and L 's expected payoff from messaging l against a sincere L opponent is $p50ll \cdot (1/2) + (1 - p50ll)[\theta/2 + (1 - \theta)/2] = 1/2$ for all $p50ll$. Second, by construction of the candidate equilibrium strategies, HM is optimizing given others' behavior. \square

We now return to the proof of Proposition 2. To complete such a proof, we need two additional steps. First, we must verify that the truthful equilibrium of Lemma A1 exists if and only if $q \geq (2\theta - 1)$. Second, we need to establish that the probability of peace in such an equilibrium is strictly lower than under optimal mediation with commitment.

Sincerity. First, note that H is indifferent between messaging h and l for any $p50ll$. After messaging h , H is offered θ against L , and accepts, and is brought to war against H , for a total expected payoff of $(1 - q)\theta + q\theta/2$. If H messages l , H is offered $(1 - \theta)$ when opposite a sincere H , and rejects, and either $1/2$ or $(1 - \theta)$ or θ when opposite a sincere H , and rejects all but θ , for the same total expected payoff of $(1 - q)\theta + q\theta/2$. Alternatively, H could send a silent message. Because silent messages are not sent in a truthful equilibrium, we need to specify off equilibrium beliefs. Suppose that any silent message is interpreted by HM as h with some probability $q_s \in [0, 1]$ and as l with the complementary probability $(1 - q_s)$. Since H is indifferent between messages h and l , deviation to silence cannot be advantageous for the H player, for any q_s .

It remains to check that sincerity is a best response for the L type. Under sincerity, L 's expected payoff is $q(1 - \theta) + (1 - q)(1/2)$. If L send message h , L 's expected payoff is $q(0) + (1 - q)\theta \leq q(1 - \theta) + (1 - q)(1/2) \iff q \geq 2\theta - 1$, the condition required in the proposition. It then also follows that, if $q \geq (2\theta - 1)$, deviation to silence cannot be profitable for any q_s . The first part of the proposition is established.

Peace. In the truthful equilibrium of Lemma A1, the probability of peace is $1 - q^2$. In the optimal equilibrium under mediation with commitment, the probability of peace is $\theta(1 - q)^2/(\theta - q)$ (from HMS's Lemma 3). But $1 - q^2 < \theta(1 - q)^2/(\theta - q) \iff (2\theta - 1)/\theta > q > (2\theta - 1)$. \square

8.2 Multiple Equilibria under CM (at the experimental parameter values)

We characterize players' equilibrium strategies keeping fixed the mediator's mechanism as programmed under CM. We consider the multi-agent representation of the extensive form game and concentrate on equilibria that satisfy two requirements. First, to avoid indeterminacies in Bayesian updating that are not relevant to explaining our experimental data, we focus on equilibria where the probability of

observing either message, l or h , is always positive, if possibly arbitrarily small (that is, we rule out the corners $(\tau_L = 0, \tau_H = 1)$ and $(\tau_L = 1, \tau_H = 0)$).⁴⁷ Second, we select equilibria in undominated strategies where, regardless of message: (i) all players accept 70; (ii) L players always accept 50; (iii) H players always reject 30. Denoting by Tm a player of type T who sent message m , what remains to be determined are the acceptance strategies of Hh and Hl players offered 50, and of Ll players offered 30, as well as the first stage message strategies for both types. We simplify notation by denoting by α_m the probability of an Hm type accepting 50, and by β the probability of an Ll type accepting 30. As before, we denote by τ_T the probability that type $T \in \{H, L\}$ is truthful and by $\hat{\tau}_T$ the probability that a message sent by type T is read as T by the computer mediator when silence is accounted for.

Because the mediation program does not include obfuscation under $q = 1/3$, that case is simpler and it is helpful to analyze it first.

8.2.1 Parameter 0: $q = 1/3$

We begin by ignoring the option of silent messages; at the end of the subsection we show how the results generalize when silent messages are included. Consider first the acceptance decisions. When $q = 1/3$, a player announcing h faces either $r = w$, if the mediator refuses to mediate, or $r = 70$, which the player always accepts. Hence non-trivial acceptance decisions only concern Hl offered 50 and Ll offered 30. In both cases accepting is optimal if the opponent is an H , but rejecting is optimal if the opponent is L .

The mediation program has no obfuscation: given the mediator's recommendation, each player knows the message sent by the opponent. (i) Consider first an Ll offered 30 (who thus knows that the opponent, j , sent message h). The player's own acceptance strategy is relevant only if the opponent accepts. But the opponent is offered 70 and all accept 70; hence conditioning on the opponent's acceptance yields no additional information on the opponent's type. The posterior probability of the opponent's type is straightforward⁴⁸:

$$\Pr(j \text{ is } L|h_j) = \frac{2(1 - \tau_L)}{2(1 - \tau_L) + \tau_H} \quad (3)$$

⁴⁷When allowing for silence, an equivalent restriction is to select equilibria with an arbitrarily small but positive probability of silence.

⁴⁸The restriction to equilibria with positive probability of observing either message rules out $\tau_L = 1$ and $\tau_H = 0$ (all types always say l), thus guaranteeing that (3) is well-defined. A similar observation applies to other posterior probabilities below, and is not repeated.

In any equilibrium in which all accept 70, Ll player i will accept 30 with positive probability only if $EU_{Li}(\text{accept } 30) \geq EU_{Li}(\text{reject } 30)$ where:

$$\begin{aligned} EU_{Li}(\text{accept } 30) &= 30 \\ EU_{Li}(\text{reject } 30) &= 35 \Pr(j = L|h_j) \end{aligned}$$

Substituting (3):

$$\begin{aligned} 3\tau_H &= 1 - \tau_L \implies \beta \in [0, 1] \text{ and} \\ 3\tau_H < 1 - \tau_L \implies \beta = 0, \quad 3\tau_H > 1 - \tau_L \implies \beta = 1 \end{aligned} \tag{4}$$

Note that since we are considering the acceptance decision for a player of type L who sent message l , in equilibrium the condition is only relevant when $\tau_L > 0$. If $\tau_L = 0$, the condition anchors off-equilibrium behavior.

(ii) Consider now an Hl who is offered 50 (and thus knows that the opponent, j , sent message l). L players always accept 50, but H players may not. Thus conditioning on j 's acceptance can yield relevant information. Consider a candidate equilibrium where the Hl player expects other Hl players to accept 50 with some probability $\alpha_l \in [0, 1]$. It is immediate that:

$$\begin{aligned} &EU_{Hl}(\text{accept } 50) - EU_{Hl}(\text{reject } 50) = \\ &= 15 \Pr(j \text{ accepts and is } H|50, l_j) - 20 \Pr(j \text{ accepts and is } L|50, l_j) \end{aligned}$$

where:

$$\begin{aligned} \Pr(j \text{ accepts and is } H|50, l_j) &= \frac{\alpha_l(1 - \tau_H)}{(1 - \tau_H) + 2\tau_L}, \\ \Pr(j \text{ accepts and is } L|50, l_j) &= \Pr(j \text{ is } L| l_j) = \frac{2\tau_L}{2\tau_L + (1 - \tau_H)} \end{aligned} \tag{5}$$

Hence:

$$\begin{aligned} 15\alpha_l(1 - \tau_H) &= 20(2\tau_L) \implies \alpha_l \in [0, 1] \text{ and} \\ 15\alpha_l(1 - \tau_H) &> 20(2\tau_L) \implies \alpha_l = 1, \quad 15\alpha_l(1 - \tau_H) < 20(2\tau_L) \implies \alpha_l = 0 \end{aligned} \tag{6}$$

As above, since we are considering the acceptance decision for a player of type H who sent message l , in equilibrium the condition is only relevant for $\tau_H < 1$. If $\tau_H = 1$, the condition anchors off-equilibrium behavior: an H type who deviated and sent message l , would anticipate that when the mediator's recommendation of $(50, 50)$ is received, his future self would know, given $\tau_H = 1$, that j is an L , and thus would reject the recommendation. Note also that $\alpha_l = 0$ is self-enforcing: if all Hl types who sent message l reject the equal split, then the only type who would accept is an L ; but then Hl prefers to reject.

We can now move back to the message stage: $\tau_H = 1$ if $EU_H(h) > EU_H(l)$, and $\tau_H \in [0, 1]$ if $EU_H(h) = EU_H(l)$ (and similarly, $\tau_L = 1$ if $EU_L(l) > EU_L(h)$, and $\tau_L \in [0, 1]$ if $EU_L(l) = EU_L(h)$). Recalling that β is the probability that Ll accepts 30 and $q = 1/3$, the relevant expected utility equations are:

$$\begin{aligned}
EU_H(h) &= (1/3)[\tau_H 35 + (1 - \tau_H)(35/4 + 35(3/4))] + (2/3)[\tau_L 70 + (1 - \tau_L)70] = (1/3)35 + (2/3)70(7) \\
EU_H(l) &= (1/3)[\tau_H 35 + (1 - \tau_H)(\alpha_l^2 50 + (1 - \alpha_l^2)35)] + (2/3)[\tau_L(\alpha_l 50 + (1 - \alpha_l)70) + (1 - \tau_L)70] \\
EU_L(l) &= (1/3)[\tau_H(3/4)\beta 30 + (1 - \tau_H)\alpha_l 50] + (2/3)[\tau_L 50 + (1 - \tau_L)(35/4 + (3/4)(30\beta + 35(1 - \beta)))] \\
EU_L(h) &= (1/3)[\tau_H(0) + (1 - \tau_H)(0)] + (2/3)[\tau_L(35/4 + (3/4)(\beta 70 + (1 - \beta)35)) + (1 - \tau_L)35]
\end{aligned}$$

Four conditions, ((3), (5), and the relevant expected utilities comparisons), together with the constraints $\alpha \in [0, 1]$, $\beta \in [0, 1]$, $\tau_H \in [0, 1]$, $\tau_L \in [0, 1]$, and the no-indeterminacy conditions ($\tau_L = 0 \implies \tau_H \neq 1$) and ($\tau_L = 1 \implies \tau_H \neq 0$) determine the equilibrium values of α , β , τ_H and τ_L . The derivation is straightforward, although considering all different possible cases is cumbersome. Solving a specific case helps to build intuition. Suppose $\alpha_l = 0$ and $\beta = 1$. Then: (i) $EU_H(h) = EU_H(l)$ for all τ_H , τ_L —an H type is indifferent over any message; (ii) $\tau_L = 1$ if $\tau_H > 1/3 + (2/3)\tau_L$ and $\tau_L \in [0, 1]$ if $\tau_H = 1/3 + (2/3)\tau_L$; (iii) for any $\tau_L \in [0, 1]$ and $\tau_H = (1/3) + (2/3)\tau_L$, $\alpha_l = 0$ and $\beta = 1$ satisfy (6) and (4). Thus indeed there exist a continuum of equilibria such that message strategies are: $\tau_L \in [0, 1]$, $\tau_H = 1/3 + (2/3)\tau_L$; and acceptance strategies are: H types only accept 70, L types always accept all offers.

The full set of equilibria is as follows:

$$\begin{aligned}
(i) \quad \beta &= 1, \tau_L = 1, \tau_H = 1; \\
(ii) \quad \alpha_i &= 0, \beta = 1, \tau_L \in (0, 1), \tau_H = 1/3 + (2/3)\tau_L; \\
(iii) \quad \alpha_i &= 0, \beta = 4/7, \tau_L \in (0, 1), \tau_H = 1/3 - \tau_L/3; \\
(iv) \quad \alpha_i &= 0, \tau_L = 0, \tau_H \leq 1/3.
\end{aligned}$$

Equilibrium (i) is the HMS equilibrium.

Silence The equilibria above ignored the option of Silence. We show here that when we account for Silence all results above apply with a simple transformation of variables.

With $q = 1/3$, the mediator's mechanism has no obfuscation and thus if a recommendation is made, it reveals to each player how the mediator has read the two messages. Call \hat{m} a message read as m by the computer mediator, and recall that under treatment CM, the rule according to which silent messages are read by the computer is specified. Consider for example the problem of player i who sent message l_i , received recommendation $(30, 70)$, and wants to evaluate the probability that opponent is H . From the recommendation, player i knows that the opponent's message was \hat{h} , i.e. was read as h by the computer. Then, as usual denoting by σ_T the probability that type T sends a silent message:

$$\begin{aligned}
\Pr(j \text{ is } L | \hat{h}_j) &= \frac{\Pr(\hat{h}_j | j \text{ is } L) \Pr(L)}{\Pr(\hat{h}_j | j \text{ is } L) \Pr(L) + \Pr(\hat{h}_j | j \text{ is } H) \Pr(H)} \\
&= \frac{[1 - \tau_L - \sigma_L + (1/3)\sigma_L](2/3)}{[1 - \tau_L - \sigma_L + (1/3)\sigma_L](2/3) + [\tau_H + (1/3)\sigma_H](1/3)} \\
&\quad \frac{2(1 - \hat{\tau}_L)}{2(1 - \hat{\tau}_L) + \hat{\tau}_H}
\end{aligned}$$

With a change in variable, the formula is identical to (3). The conclusion extends to all results in the previous section, reinterpreted by substituting $\hat{\tau}_H$ and $\hat{\tau}_L$ for τ_H and τ_L . Summarizing, the computer can read the subject's true type with probability 1 only if $\sigma_T = 0$; otherwise, in equilibrium τ_T and σ_T are jointly determined. Using $\hat{\tau}_H$ and $\hat{\tau}_L$ in updating the opponent's expected type, given the recommendation, acceptance strategies remain unchanged.

8.2.2 Parameter 1: $q = 1/2$

Again we begin by ignoring the option of silence, which we will discuss at the end of the subsection.

Consider first acceptance decisions: Ll types offered 30, and Hh and Hl types offered 50.

(i) Consider first type Ll offered 30. The player knows that the opponent sent message h and will accept 70 regardless of type. Thus conditioning on acceptance offers no information. Taking into account $q = 1/2$:

$$\begin{aligned}\Pr(j \text{ is } L|(30, 70), h_j) &= \frac{1 - \tau_L}{1 - \tau_L + \tau_H} \\ \Pr(j \text{ is } H|(30, 70), h_j) &= \frac{\tau_H}{1 - \tau_L + \tau_H}\end{aligned}$$

Ll accepts with positive probability if:

$$30 \Pr(j \text{ is } H|(30, 70), h_j) \geq 5 \Pr(j \text{ is } L|(30, 70), h_j)$$

or :

$$6\tau_H > 1 - \tau_L \implies \beta = 1, \quad 6\tau_H < 1 - \tau_L \implies \beta = 0, \quad \text{and } 6\tau_H = 1 - \tau_L \implies \beta \in [0, 1] \quad (8)$$

(ii) Consider now type Hh , receiving recommendation (50, 50). Under the mediation mechanism, the player does not know the message sent by the opponent.

The relevant posterior probability is:

$$\Pr(j \text{ is } H \text{ and accepts } 50|(50, 50), h_i) = \frac{\Pr(j \text{ is } H, (50, 50), j \text{ accepts } 50|h_i)}{\Pr((50, 50), |h_i)}$$

where:

$$\begin{aligned}\Pr(j \text{ is } H, (50, 50), j \text{ accepts } 50|h_i) &= \\ &= \Pr((50, 50)|h_j, j \text{ is } H, h_i) \Pr(j \text{ is } H \text{ and accepts } 50|h_j, h_i) \Pr(h_j|j \text{ is } H) \Pr(H) + \\ &+ \Pr((50, 50)|l_j, j \text{ is } H, h_i) \Pr(j \text{ is } H \text{ and accepts } 50|l_j, h_i) \Pr(l_j|j \text{ is } H) \Pr(H) = \\ &= ((\tau_H/2)\alpha_h + (3/8)(1 - \tau_H)\alpha_l)(1/2),\end{aligned}$$

and:

$$\Pr((50, 50)|h_i) = \Pr(j \text{ is } H, (50, 50)|h_i) + \Pr(j \text{ is } L, (50, 50)|h_i).$$

Substituting the relevant probabilities, and taking into account that L types always accept 50:

$$\Pr(j \text{ is } H|(50, 50), j \text{ accepts } 50, h_i) = \frac{4\tau_H\alpha_h + 3(1 - \tau_H)\alpha_l}{4\tau_H + 3(1 - \tau_H) + 4(1 - \tau_L) + 3\tau_L}$$

and

$$\begin{aligned} \Pr(j \text{ is } L|(50, 50), j \text{ accepts } 50, h_i) &= 1 - \Pr(j \text{ is } H|(50, 50), j \text{ accepts } 50, h_i) = \\ &= \frac{4(1 - \tau_L) + 3\tau_L}{4\tau_H + 3(1 - \tau_H) + 4(1 - \tau_L) + 3\tau_L}. \end{aligned}$$

Hh will accept 50 with positive probability if:

$$15\Pr(j \text{ is } H|(50, 50), j \text{ accepts } 50, h_i) \geq 20\Pr(j \text{ is } L|(50, 50), j \text{ accepts } 50, h_i) \quad (9)$$

or:

$$15(4\tau_H\alpha_h + 3(1 - \tau_H)\alpha_l) = 20(4(1 - \tau_L) + 3\tau_L) \implies \alpha_h \in [0, 1]$$

$$15(4\tau_H\alpha_h + 3(1 - \tau_H)\alpha_l) < 20(4(1 - \tau_L) + 3\tau_L) \implies \alpha_h = 0, \quad (10)$$

$$15(4\tau_H\alpha_h + 3(1 - \tau_H)\alpha_l) > 20(4(1 - \tau_L) + 3\tau_L) \implies \alpha_h = 1 \quad (11)$$

Condition (9) corresponds to (2) in the text, specialized to the experimental parameters.

(iii) Similarly, an H type who sent message l and is offered a (50, 50) split, will compute the posterior probability:

$$\begin{aligned} \Pr(j \text{ is } H|(50, 50), j \text{ accepts } 50, l_i) &= \\ &= \frac{3\tau_H\alpha_h + 8(1 - \tau_H)\alpha_l}{3\tau_H + 8(1 - \tau_H) + 3(1 - \tau_L) + 8\tau_L} \end{aligned}$$

and will accept 50 with positive probability if:

$$15\Pr(j \text{ is } H|(50, 50), j \text{ accepts } 50, l_i) \geq 20\Pr(j \text{ is } L|(50, 50), j \text{ accepts } 50, l_i)$$

or:

$$\begin{aligned}
15(3\tau_H\alpha_h + 8(1 - \tau_H)\alpha_l) &= 20(3(1 - \tau_L) + 8\tau_L) \implies \alpha_l \in [0, 1] \\
15(3\tau_H\alpha_h + 8(1 - \tau_H)\alpha_l) &< 20(3(1 - \tau_L) + 8\tau_L) \implies \alpha_l = 0 \\
15(3\tau_H\alpha_h + 8(1 - \tau_H)\alpha_l) &> 20(3(1 - \tau_L) + 8\tau_L) \implies \alpha_l = 1
\end{aligned} \tag{12}$$

Conditions (8), (11), and (12) pin down the three probabilities β , α_h , and α_l as functions of τ_H and τ_L . Given these probabilities, the comparison of expected utilities at the message stage determines equilibrium τ_H and τ_L . If $\alpha_h = 1$, by Proposition 3, $\tau_H = 1$, $\tau_L = 1$. But if $\tau_H = 1$, then $\beta = 1$ by (8). The equilibrium in weakly undominated strategies then corresponds to the HMS equilibrium. Outside of such an equilibrium, $\alpha_h = 0$. Imposing $\alpha_h = 0$, the relevant expected utilities are:

$$\begin{aligned}
EU_H(h) &= (1/2)[\tau_H 35 + (1 - \tau_H)((5/8)35 + (3/8)(50\alpha_l + 35(1 - \alpha_l)))] + (1/2)70 \\
EU_H(l) &= (1/2)[\tau_H 35 + (1 - \tau_H)(50\alpha_l^2 + 35(1 - \alpha_l^2))] + \\
&\quad + (1/2)[\tau_L(\alpha_l 50 + (1 - \alpha_l)70) + (1 - \tau_L)((5/8)70 + (3/8)(50\alpha_l + 70(1 - \alpha_l)))] \\
EU_L(l) &= (1/2)[\tau_H(5/8)30\beta + (1 - \tau_H)50\alpha_l] + (1/2)[\tau_L 50 + (1 - \tau_L)((5/8)(30\beta + 35(1 - \beta)) + (3/8)50)] \\
EU_L(h) &= (1/2)[(1 - \tau_H)((3/8)50\alpha_l] + \\
&\quad + (1/2)[\tau_L((5/8)(70\beta + 35(1 - \beta)) + (3/8)50) + (1 - \tau_L)(50/2 + 35/2)]
\end{aligned} \tag{13}$$

As before, four conditions, (12), (8), and the relevant expected utilities equations, determine β , α_l , τ_L and τ_H . One preliminary observation simplifies the identification of the equilibria:

Lemma A2. *If $q = 1/2$, there exist no equilibrium where $\alpha_l > 0$.*

Proof. The proof is in two steps. (1) Suppose first $\alpha_l \in (0, 1)$. Then, from (12):

$$6(1 - \tau_H)\alpha_l = 3 + 5\tau_L \implies \tau_H = 1 - \left(\frac{3 + 5\tau_L}{6\alpha_l}\right) \tag{14}$$

Substituting (14) in (13), we find that for any β :

$$EU_H(h) - EU_H(l) = (5/32)(3 + 5\tau_L)(3 + 5\alpha_l) > 0.$$

But then $\tau_H = 1$ and (14) is violated. Thus $\alpha_l \in (0, 1)$ is impossible.⁴⁹

(2) Suppose then $\alpha_l = 1$. From (12), it follows that:

$$\tau_H \leq (1/2) - (5/6)\tau_L \tag{15}$$

Note that there cannot be an equilibrium with $\alpha_l = 1$ if L prefers sincerity and thus $\tau_L = 1$. But from (13):

$$EU_L(l) - EU_L(h) = (5/16)[(47 - 5\beta) - \tau_H(50 + 30\beta) + \tau_L(18 - 30\beta)],$$

an expression that is minimal at τ_H maximum value. Substituting (15):

$$EU_L(l) - EU_L(h) > 0 \iff (5/48)[66 + 30\beta + \tau_L(179 - 165\beta)] > 0.$$

The condition is always satisfied. Hence $\tau_H = 1$; but then by (15) there cannot be an equilibrium with $\alpha_l = 1$, and the Lemma is proven. \square

Proposition 3 and Lemma A2 establish $\alpha_l = 0$ and, unless $\tau_L = 1$ and $\tau_H = 1$, $\alpha_h = 0$. Studying (13) and (8), we can identify the full set of equilibria.⁵⁰

- (i) $\alpha_h = 1, \beta = 1, \tau_L = 1, \tau_H = 1$;
- (ii) $\alpha_h = 0, \beta = 1, \tau_L = 1, \tau_H = 1$;
- (iii) $\alpha_h = 0, \alpha_l = 0, \tau_L = 0, \tau_H \leq 4/15$;
- (iv) $\alpha_h = 0, \alpha_l = 0, \beta = 1, \tau_L \in (0, 1), \tau_H = 4/15 + (6/15)\tau_L$;
- (v) $\alpha_h = 0, \alpha_l = 0, \beta = 1, \tau_L = 1, \tau_H \in [2/3, 1]$;
- (vi) $\alpha_h = 0, \alpha_l = 0, \beta \in (0, 3/7), \tau_L = 3/(18 - 35\beta), \tau_H = (1/6)(1 - 3/(18 - 35\beta))$;
- (vii) $\alpha_h = 0, \beta = 0, \tau_L = 1/6, \tau_H \leq 5/36$.

Equilibrium (i) is the HMS equilibrium.

⁴⁹We are imposing $\alpha_h = 0$. But $\alpha_h = 1 \implies (\tau_H = 1, \tau_L = 1)$. On the equilibrium path, α_l is irrelevant; off-equilibrium, by (12) an H player who lied would still reject 50.

⁵⁰Equilibrium (iii) has message probabilities $\tau_L = 0$ and $\tau_H \leq 4/15$; if $\tau_H < 1/6$, the equilibrium is supported by the (sequentially rational) belief that were L to send message l and be offered 30, at the acceptance stage the offer would be rejected, if $\tau_H \in (1/6, 4/15]$, the equilibrium is supported by the rational belief that the offer would be accepted.

Silence As in the case of $q = 1/3$, with silence interpreted by the computer mediator according to the prior, the equilibria characterized above extend to the possibility of silent messages with a simple change of variable: τ_T becomes $\hat{\tau}_T$ in all equations above and it is $\hat{\tau}_T$ that is determined in equilibrium (that is, τ_T and σ_T are jointly determined).

Although the conclusion continues to hold, with $q = 1/2$, there is one complication: when messages are obfuscated by the mediator, a subject who sent a silent message will not know not only what message the opponent sent but also how the subject's own message was read by the computer. The reason this complication does not invalidate the previous analysis is that, in the absence of silence, equilibrium acceptance strategies depend only on type. More precisely, given the focus on equilibria in undominated strategies, the only acceptance strategies that could depend on the message sent are α_l and α_h .⁵¹ But, barring full sincerity, $\alpha_l = \alpha_h = 0$ in all equilibria: H types reject 50 regardless of whether they sent message l or h . When silent messages are used, full sincerity is impossible, and for all $\hat{\tau}_L$ and $\hat{\tau}_H$ equilibria must exist where H types reject 50 regardless of how their message has been read by the computer. Hence, denoting by α_s the probability that an H type who sent a message s accepts 50, there must be equilibria with $\alpha_l = \alpha_h = \alpha_s = 0$: all H types reject 50. It follows that, substituting $\hat{\tau}_T$ for τ_T , the equilibria described above remain equilibria when silent messages are possible.

8.3 Trembling-hand Perfection

As mentioned in the text, if $(2\theta - 1) < q < (2\theta - 1)/\theta$, the best equilibrium under optimal mediation is trembling-hand perfect (even while fragile in the sense of Proposition 3). Consider the following.

A perfect equilibrium cannot include weakly dominated strategies. Thus, if the equilibrium is perfect, all accept θ , L always accepts $1/2$, and H always rejects $(1 - \theta)$, all of which are in line with the HMS equilibrium. The L type ex-post participation constraint is slack in equilibrium; the three incentive constraints that bind in equilibrium and could be violated in the presence of trembles are the H type acceptance of $1/2$, following message h , the L type truthfulness constraint, and the H type truthfulness constraint including the possibility of double deviation (i.e. sending message l and then rejecting a recommendation of $1/2$). We write below the three conditions that must be satisfied

⁵¹Recall that the recommendation (70, 30) can only follow messages that have been read as (h, l) . Hence there is no uncertainty on how one's own message (or for that matter, the opponent's) has been read. The possibility of silence affects the updating probability on the opponent's type and makes β a function of $\hat{\tau}_L, \hat{\tau}_H$. With this change in variable, the equilibrium conditions in (8) can be rewritten as before.

for the prescribed strategies to be best responses, given trembles around equilibrium behavior. We then show that a vector of trembles exists such that all conditions are satisfied. Throughout we use the notation α_m^x (β_m^x) to denote the probability that an H (L) player who sent message m accepts the offer of x .

Consider first the acceptance strategy for a sincere H type who is offered $1/2$ and in the HMS equilibrium accepts it. Call Hh player i , and j the opponent. Then:

$$\begin{aligned} EU_{Hh}(\text{accept } 1/2) &\geq EU_{Hh}(\text{reject } 1/2) \iff \\ (1/2 - \theta/2) \Pr(j \text{ accepts and is } H|h_i, (1/2, 1/2)) &\geq (\theta - 1/2) \Pr(j \text{ accepts and is } L|h_i, (1/2, 1/2)) \end{aligned}$$

or, borrowing from the proof of Proposition 3 in the text:

$$(1/2 - \theta/2)q \left[q_H \tau_H \alpha_h^{1/2} + q_M (1 - \tau_H) \alpha_l^{1/2} \right] \geq (\theta - 1/2)(1 - q) \left[q_H (1 - \tau_L) \beta_h^{1/2} + q_M \tau_L \beta_l^{1/2} \right]$$

where, from (1) in the text:

$$\begin{aligned} q_M &= \left(\frac{1 - \theta}{2\theta - 1} \right) \left(\frac{1 + q - 2\theta}{\theta - q} \right) \\ q_H &= \left(\frac{1 - q}{q} \right) \left(\frac{1 + q - 2\theta}{\theta - q} \right) \end{aligned}$$

Consider trembles such that: $\alpha_h^{1/2} = 1 - \varepsilon_{\alpha_h^{1/2}}$, $\alpha_l^{1/2} = \varepsilon_{\alpha_l^{1/2}}$, $\beta_h^{1/2} = 1 - \varepsilon_{\beta_h^{1/2}}$, $\beta_l^{1/2} = 1 - \varepsilon_{\beta_l^{1/2}}$, $\tau_H = 1 - \varepsilon_{\tau_H}$, $\tau_L = 1 - \varepsilon_{\tau_L}$. We want to know whether there exist a vector $\varepsilon_1 = \{\varepsilon_{\alpha_h^{1/2}}, \varepsilon_{\alpha_l^{1/2}}, \varepsilon_{\beta_h^{1/2}}, \varepsilon_{\beta_l^{1/2}}, \varepsilon_{\tau_H}, \varepsilon_{\tau_L}\}$ such that:

$$\begin{aligned} \lim_{\varepsilon_1 \rightarrow 0} \left[(1/2 - \theta/2)q \left(q_H (1 - \varepsilon_{\tau_H}) (1 - \varepsilon_{\alpha_h^{1/2}}) + q_M \varepsilon_{\tau_H} \varepsilon_{\alpha_l^{1/2}} \right) + \right. \\ \left. - (\theta - 1/2)(1 - q) \left(q_H \varepsilon_{\tau_L} (1 - \varepsilon_{\beta_h^{1/2}}) + q_M (1 - \varepsilon_{\tau_L}) (1 - \varepsilon_{\beta_l^{1/2}}) \right) \right] \geq 0 \end{aligned}$$

Set $\varepsilon_{\alpha_h^{1/2}} = a_h^{1/2}/n$, $\varepsilon_{\tau_H} = t_H/n$, $\varepsilon_{\alpha_l^{1/2}} = a_l^{1/2}/n$, $\varepsilon_{\beta_h^{1/2}} = b_h^{1/2}/n$, $\varepsilon_{\tau_L} = t_L/n$, $\varepsilon_{\beta_l^{1/2}} = b_l^{1/2}/n$, where

$\{a_h^{1/2}, t_H, a_l^{1/2}, b_h^{1/2}, t_L, b_l^{1/2}\}$ is a vector of positive constants. Condition (??) becomes:

$$\lim_{n \rightarrow \infty} \left[(1/2 - \theta/2)q \left(q_H(1 - t_H/n)(1 - a_h^{1/2}/n) + q_M(t_H/n)(a_l^{1/2}/n) \right) + \right. \\ \left. - (\theta - 1/2)(1 - q) \left(q_H(t_L/n)(1 - b_h^{1/2}/n) + q_M(1 - t_L/n)(1 - b_l^{1/2}/n) \right) \right] \geq 0$$

We also need to verify that there exists trembles such that both types prefer to be truthful. For a player of type L we require $EU_L(l) \geq EU_L(h)$ where:

$$EU_L(l) = q(\tau_H[(1 - q_M)(1 - \theta)\alpha_h^\theta \beta_l^{1-\theta} + q_M(1/2)\alpha_h^{1/2}\beta_l^{1/2}] + (1 - \tau_H)[1/2)\alpha_l^{1/2}\beta_l^{1/2}]) + \\ + (1 - q)(\tau_L[(1/2)(\beta_l^{1/2})^2 + (\theta/2)(1 - (\beta_l^{1/2})^2)]) + \\ + (1 - \tau_L)[(1 - q_M)((1 - \theta)\beta_l^{1-\theta}\beta_h^\theta + (\theta/2)(1 - \beta_l^{1-\theta}\beta_h^\theta)) + q_M((1/2)\beta_l^{1/2}\beta_h^{1/2} + \theta/2(1 - \beta_l^{1/2}\beta_h^{1/2}))]$$

and:

$$EU_L(h) = q(\tau_H[q_H(1/2)\alpha_h^{1/2}\beta_h^{1/2}] + (1 - \tau_H)[(1 - q_M)(\theta\alpha_l^{1-\theta}\beta_h^\theta) + q_M(1/2)\alpha_l^{1/2}\beta_h^{1/2}] + \\ + (1 - q)(\tau_L[(1 - q_M)(\theta\beta_l^{1-\theta}\beta_h^\theta + (\theta/2)(1 - \beta_l^{1-\theta}\beta_h^\theta)) + q_M((1/2)\beta_l^{1/2}\beta_h^{1/2} + (\theta/2)(1 - \beta_l^{1/2}\beta_h^{1/2}))]) + \\ + (1 - \tau_L)[q_H((1/2)(\beta_h^{1/2})^2 + (\theta/2)(1 - (\beta_h^{1/2})^2)) + (1 - q_H)(\theta/2)]$$

For a player of type H , we require $EU_H(h) \geq EU_H(l)$ where:

$$EU_H(h) = q(\tau_H[(1 - q_H)(\theta/2) + q_H((1/2)(\alpha_h^{1/2})^2 + (\theta/2)(1 - (\alpha_h^{1/2})^2))] + (1 - \tau_H)[q_M((1/2)\alpha_h^{1/2}\alpha_l^{1/2} + \\ + (\theta/2)(1 - \alpha_h^{1/2}\alpha_l^{1/2})) + (1 - q_M)(\theta\alpha_h^\theta\alpha_l^{1-\theta} + (\theta/2)(1 - \alpha_h^\theta\alpha_l^{1-\theta}))]) + \\ + (1 - q)(\tau_L[(1 - q_M)\theta + q_M((1/2)\alpha_h^{1/2}\beta_l^{1/2} + \theta(1 - \alpha_h^{1/2}\beta_l^{1/2}))]) + \\ + (1 - \tau_L)[(1 - q_H)\theta + q_H((1/2)\alpha_h^{1/2}\beta_h^{1/2} + \theta(1 - \alpha_h^{1/2}\beta_h^{1/2}))]$$

and:

$$\begin{aligned}
EU_H(l) = & q(\tau_H[(1 - q_M)((1 - \theta)\alpha_h^\theta\alpha_l^{1-\theta} + (\theta/2)(1 - \alpha_h^\theta\alpha_l^{1-\theta})) + \\
& + q_M((1/2)\alpha_h^{1/2}\alpha_l^{1/2} + (\theta/2)(1 - \alpha_h^{1/2}\alpha_l^{1/2}))] + (1 - \tau_H)[(1/2)(\alpha_l^{1/2})^2 + (\theta/2)(1 - (\alpha_l^{1/2})^2)]) + \\
& + (1 - q)(\tau_L[(1/2)\alpha_l^{1/2}\beta_l^{1/2} + \theta(1 - \alpha_l^{1/2}\beta_l^{1/2})] + (1 - \tau_L)[(1 - q_M)((1 - \theta)\alpha_l^{1-\theta}\beta_h^\theta + \theta(1 - \alpha_l^{1-\theta}\beta_h^\theta)) + \\
& + q_M((1/2)\alpha_l^{1/2}\beta_h^{1/2} + \theta(1 - \alpha_l^{1/2}\beta_h^{1/2}))])
\end{aligned}$$

As above, set $\alpha_h^\theta = 1 - a_h^\theta/n$, $\alpha_h^{1/2} = 1 - a_h^{1/2}/n$, $\alpha_l^{1/2} = a_l^{1/2}/n$, $\alpha_l^{1-\theta} = a_l^{1-\theta}/n$, $\beta_h^\theta = 1 - b_h^\theta/n$, $\beta_h^{1/2} = 1 - b_h^{1/2}/n$, $\beta_l^{1/2} = 1 - b_l^{1/2}/n$, $\beta_l^{1-\theta} = 1 - b_l^{1-\theta}/n$, and recall $\tau_H = 1 - t_H/n$, $\tau_L = 1 - t_L/n$. We want to verify that there exist a vector of positive constants $\{t_H, t_L, a_h^{1/2}, a_h^\theta, a_l^{1/2}, a_l^{1-\theta}, b_l^{1/2}, b_l^{1-\theta}, b_h^{1/2}, b_h^\theta\}$ such that (??) is satisfied, as well as:

$$\lim_{n \rightarrow \infty} [EU_L(l) - EU_L(h)] \geq 0$$

and:

$$\lim_{n \rightarrow \infty} [EU_H(h) - EU_H(l)] \geq 0$$

It is not difficult to find a vector that satisfies the conditions at the experimental parameter values if $q = 1/2$ and $\theta = 0.7$, as in our experimental parameterization. For example, all three conditions are satisfied at $\{t_H = 1, t_L = 1, a_h^{50} = 1, a_h^{70} = 1, a_l^{50} = 1, a_l^{30} = 1, b_l^{50} = 4, b_l^{30} = 8, b_h^{50} = 8, b_h^{70} = 4\}$. The equilibrium is perfect as long as beliefs assign higher probability to L types' trembles that result in rejections, and low probability to deviations from truthfulness and to trembles in H 's acceptance strategies. The result is not surprising: as Proposition 3 leads us to expect, the condition most difficult to satisfy is the acceptance of offer 50 by H types in the presence of noise in behavior. Even in the presence of noise, however, acceptance is a best response if the probability of deviations from truthfulness and from other H 's accepting is low, relative to the probability of rejections by L types. The positive conclusion reflects the latitude in the choice of trembles.

The result is not limited to the experimental parameter values. We have verified numerically that the vector of trembles identified above support trembling-hand perfection for arbitrary q and θ in the interval $(2\theta - 1) < q < (2\theta - 1)/\theta$, with $\theta/2 > 1 - \theta$.

9 Online Appendix.

9.1 Human mediation treatment: equilibria

We concentrate on equilibria where: $\tau_H = 1$, $r(l, l) = \{50, 50\}$ w.p.1, and dominant acceptance strategies are taken (both players accept 70, L accepts 50, and H rejects 30). We prove the following proposition, which corresponds to the equilibria discussed in the text.

Proposition HM.

(i)

Par1: $q = \frac{1}{2}$. There is an equilibrium in which $r(h, h) = w$ w.p. 1; $\tau_L = 1$; α_h sufficiently low, $\alpha_l = 0$, $\beta_l = 1$, β_h arbitrary; $P = \frac{3}{4}$.

Par0: $q = \frac{1}{3}$. There is an equilibrium in which $r(h, h) = w$ w.p. 1; $\tau_L = \frac{2}{3}$; α_h sufficiently low, $\alpha_l = 0$, $\beta_l = 1$, β_h sufficiently low; $P = \frac{56}{81} \approx 0.691$.

(ii) Par1: $q = \frac{1}{2}$. There is an equilibrium in which $r(h, h) = w$ w.p. $p_w \approx 0.535$, $r(h, h) = \{50, 50\}$ w.p. $1 - p_w$; $\tau_L \approx 0.565$; $\alpha_h \approx 0.580$, $\alpha_l = 0$, $\beta_l = 1$, β_h arbitrary; $P \approx 0.605$.

To prove the proposition, we make use of Lemma A3 below. The significance of this lemma is that the equilibrium selection, together with the restriction that, in equilibrium, $r(h, l) = \{70, 30\}$ w.p. greater than 0, implies that in any PBE: (1) $r(l, l) = \{50, 50\}$ w.p. 1, which is accepted w.p. 1, (2) $r(h, l) = \{70, 30\}$ w.p. 1., which is accepted w.p. 1, (3) $\alpha_l = 0$, (4) $\beta_l = 1$, and (5) $\beta_h = 1$ if $r(h, h) = \{70, 30\}$ w.p. greater than 0 (otherwise any β_h is optimal for L). Hence, in addition to confirming the optimality of $\tau_H = 1$ and finding an optimal τ_L , it remains only to determine (a) HM's strategy following h, h , and (b) α_h , H 's probability of accepting 50 after messaging h . Furthermore, the optimality conditions for (a) and (b) are given by part (v) of the lemma.

Lemma A3. In any PBE such that $\tau_H = 1$, $r(l, l) = \{50, 50\}$ w.p.1, dominant acceptance strategies are taken, and $r(h, l) = \{70, 30\}$ w.p. >0 , the following must hold: (i) if $r(h, l) = \{70, 30\}$ w.p. greater than 0, then $\beta_l = 1$ and thus $r(h, l) = \{70, 30\}$ is accepted w.p. 1; (ii) if $r(h, h) = \{70, 30\}$ w.p. greater than 0 (randomizing which player receives 30), then $\beta_h = 1$; (iii) if $r(h, l) = \{70, 30\}$ w.p. greater than 0, then $r(h, l) = \{70, 30\}$ w.p. 1; (iv) if $r(h, l) = \{70, 30\}$ w.p. greater than 0, then $\alpha_l = 0$; and (v):

- *HM prefers $r(h, h) = \{70, 30\}$ to $r(h, h) = w$ if and only if*

$$(1 - q_h)\beta_h \geq \frac{1}{2} \iff \tau_L \leq \frac{1 - 2q}{1 - q} \text{ if } \beta_h = 1,$$

where $q_h = \frac{q}{q + (1 - \tau_L)(1 - q)} \in [q, 1]$

- *HM prefers $r(h, h) = \{50, 50\}$ to $r(h, h) = w$ if and only if*

$$q_h^2 \alpha_h^2 + 2q_h(1 - q_h)\alpha_h + (1 - q_h)^2 \geq \frac{1}{2},$$

where $q_h = \frac{q}{q + (1 - \tau_L)(1 - q)} \in [q, 1]$

- *HM prefers $r(h, h) = \{50, 50\}$ to $r(h, h) = \{70, 30\}$ if and only if*

$$q_h^2 \alpha_h^2 + 2q_h(1 - q_h)\alpha_h + (1 - q_h)^2 \geq (1 - q_h)\beta_h,$$

where $q_h = \frac{q}{q + (1 - \tau_L)(1 - q)} \in [q, 1]$

- *If $r(h, l) = \{70, 30\}$ w.p. greater than 0 and $r(h, h) = \{50, 50\}$ w.p. greater than 0, then H prefers to accept 50 after messaging h if and only if*

$$\tau_L \geq 1 - \frac{3}{4} \left(\frac{q}{1 - q} \right) \alpha_h$$

Proof. (i) Define $\Delta 30lL$ as the expected utility difference between accepting and rejecting 30 for L who messages l . Assuming $\tau_H = 1$, that dominant acceptance strategies are taken, and $r(h, l) = \{70, 30\}$ w.p. greater than 0 (which implies Bayes rule applies),

$$\Delta 30lL \propto p30hl(q30 - (1 - q)(1 - \tau_L)5) - \tilde{p}30ll(1 - q)\tau_L 5,$$

where $p30hl$ is the probability with which $r(h, l) = \{70, 30\}$ and $\tilde{p}30ll$ is *one-half* the probability with which $r(l, l) = \{70, 30\}$ (i.e. the probability $\{70, 30\}$ is offered *and* it is this player who is offered 30). Thus, if $\tilde{p}30ll = 0$ and $p30hl > 0$, $\Delta 30lL > 0$.

(ii) If $r(h, h) = \{70, 30\}$ w.p. greater than 0, then players who message h and receive 30 know the other player messaged h . Since we assume $\tau_H = 1$, the belief that the other player is H is given by $q_h = \frac{q}{q+(1-\tau_L)(1-q)}$, which is between q and 1. Since the other player will always accept 70, the expected payoff of accepting is 30. The expected payoff of rejecting is $q_h 0 + (1 - q_h)35$, which is strictly less than 30.

(iii) Since $r(h, l) = \{70, 30\}$ is accepted with probability one by part (i), it cannot be that $r(h, l) = w$ with positive probability since it yields a lower payoff for HM.

We suppose that $r(h, l) = \{50, 50\}$ with positive probability in equilibrium, and derive a contradiction. Since $r(h, l) = \{70, 30\}$ is accepted with probability one, $r(h, l) = \{50, 50\}$ must be accepted with probability one (or else HM would never offer it). Hence, if $r(h, h) = \{50, 50\}$ with positive probability, it is accepted with probability one (same information set for those who message h).

Case 1: Suppose $r(h, h) = \{50, 50\}$ with probability 0. This cannot be an equilibrium since $r(h, h) = \{50, 50\}$ yields a strictly higher payoff for HM than $r(h, h) = w$ and $r(h, h) = \{70, 30\}$ (H type will always reject 30).

Case 2: Suppose $r(h, h) = \{50, 50\}$ with positive probability. Since this yields a higher payoff for HM than $r(h, h) = w$ and $r(h, h) = \{70, 30\}$, it must be that $r(h, h) = \{50, 50\}$ w.p. 1. But this cannot be an equilibrium because then the L -type would strictly prefer to message h (all offers are accepted and types messaging h would sometimes get more), and then the H type would prefer to reject an offer of 50.

(iv) Assuming $\tau_H = 1$ and that $r(h, l) = \{70, 30\}$ w.p. greater than 0, which implies $r(h, l) = \{70, 30\}$ w.p. 1 by part (iii), if H deviates and messages l and receives 50, she knows her opponent is L and hence it is strictly optimal to reject, i.e. $\alpha_l = 0$.

(v) For simplicity, subtract 20 from HM's payoffs so that rejection yields 0, walking out yields 20, and acceptance yields 40. Let uW_{hh} , $u50_{hh}$, and $u70_{hh}$ be HM's expected payoffs from walking out, offering $\{50, 50\}$, and offering $\{70, 30\}$, respectively, after observing h, h . These are given as

$$uW_{hh} = 20$$

$$u50_{hh} = 40[q_h^2 \alpha_h^2 + 2q_h(1 - q_h)\alpha_h + (1 - q_h)^2]$$

$$u_{70hh} = 40[(1 - q_h)\beta_h]$$

HM prefers $r(h, h) = \{70, 30\}$ to $r(h, h) = w$ if and only if

$$\begin{aligned} 40(1 - q_h)\beta_h &\geq 20 \iff \\ (1 - q_h)\beta_h &\geq \frac{1}{2} \end{aligned}$$

If $\beta_h = 1$, then this condition becomes

$$\begin{aligned} (1 - q_h)\beta_h &\geq \frac{1}{2} \iff \\ \frac{(1 - \tau_L)(1 - q)}{q + (1 - \tau_L)(1 - q)} &\geq \frac{1}{2} \iff \\ (1 - \tau_L)(1 - q) &\geq \frac{1}{2}\{q + (1 - \tau_L)(1 - q)\} \iff \\ (1 - \tau_L)(1 - q) &\geq q \iff \\ 1 - \tau_L &\geq \frac{q}{1 - q} \iff \\ \frac{1 - 2q}{1 - q} &\geq \tau_L \end{aligned}$$

HM's other indifference conditions are immediate.

Define Δ_{50hH} as the expected utility difference between accepting and rejecting 50 for H who messages h . Assuming $\tau_H = 1$, that dominant acceptance strategies are taken, $r(h, l) = \{70, 30\}$ w.p. greater than 0 (which implies $r(h, l) = \{50, 50\}$ w.p. 0 by part (iii)), and $p(h, h) = \{50, 50\}$ w.p. greater than 0, then

$$\begin{aligned} \Delta_{50hH} &\propto p_{50hh}\{q\tau_H\alpha_h15 - (1 - q)(1 - \tau_L)20\} \\ &\quad p_{50hl}\{q(1 - \tau_H)\alpha_l15 - (1 - q)\tau_L20\} \end{aligned}$$

and thus

$$\begin{aligned}
\Delta 50hH &\geq 0 \iff \\
q\tau_H\alpha_h 15 - (1-q)(1-\tau_L)20 &\geq 0 \iff \\
\tau_L &\geq 1 - \frac{3}{4}\left(\frac{q}{1-q}\right)\alpha_h.
\end{aligned}$$

■ This concludes the proof of the Lemma.

Proof of Proposition HM.

(i) We search for equilibria in undominated strategies in which $\tau_H = 1$, $r(l, l) = \{50, 50\}$ w.p. 1, $r(h, l) = \{70, 30\}$ w.p. greater than 0, and $r(h, h) = w$ w.p. 1.

In such an equilibrium, by Lemma A3, it must be that $r(h, l) = \{70, 30\}$ w.p. 1 and $\beta_l = 1$. Assuming all of these conditions, the expected payoffs to L of messaging l and h , respectively, are:

$$\begin{aligned}
ulL &= q\{\tau_H 30 + (1-\tau_H)(\alpha_l 50 + (1-\alpha_l)0)\} + (1-q)\{\tau_L 50 + (1-\tau_L)30\} \\
&= q30 + (1-q)(30 + \tau_L 20) \\
&= q30 + 30 + \tau_L 20 - q30 - q\tau_L 20 \\
&= 30 + \tau_L 20 - q\tau_L 20
\end{aligned}$$

and

$$\begin{aligned}
uhL &= q\{\tau_H 0 + (1-\tau_H)0\} + (1-q)\{\tau_L 70 + (1-\tau_L)(35)\} \\
&= (1-q)\{35 + \tau_L 35\} \\
&= 35 + \tau_L 35 - q35 - q\tau_L 35,
\end{aligned}$$

and so

$$\begin{aligned}
ulL &\geq uhL \iff \\
30 + \tau_L 20 - q\tau_L 20 &\geq 35 + \tau_L 35 - q35 - q\tau_L 35 \iff \\
q\tau_L 15 &\geq 5 + \tau_L 15 - q35 \iff \\
q35 - 5 &\geq \tau_L(15 - q15) \\
\frac{q35 - 5}{15 - q15} &\geq \tau_L
\end{aligned}$$

Hence, if $q = \frac{1}{2}$, this is always satisfied strictly, meaning it must be that $\tau_L = 1$.

If $q = \frac{1}{3}$, then the condition becomes $ulL \geq uhL \iff \frac{2}{3} \geq \tau_L$. If $\frac{2}{3} > \tau_L$, then $ulL > uhL$ and it must be that $\tau_L = 1$, a contradiction. If $\frac{2}{3} < \tau_L$, then $ulL < uhL$ and it must be that $\tau_L = 0$, a contradiction. Hence it must be that $\tau_L = \frac{2}{3}$.

Following h, h , HM must prefer to walk out rather than offer $\{70, 30\}$:

$$(1 - q_h)\beta_h \leq \frac{1}{2}$$

When $q = \frac{1}{2}$, $\tau_L = 1$ and $q_h = 1$, so this condition is satisfied for any β_h . When $q = \frac{1}{3}$, $\tau_L = \frac{2}{3}$ and $q_h = \frac{3}{7}$, so the condition is satisfied for sufficiently low β_h .

Following h, h , HM must prefer to walk out rather than offer $\{50, 50\}$:

$$q_h^2 \alpha_h^2 + 2q_h(1 - q_h)\alpha_h + (1 - q_h)^2 \leq \frac{1}{2}$$

which is satisfied for both values of q for sufficiently low α_h .

Finally, we must now check that $\tau_H = 1$ is optimal. First note that if H messages l and receives 50, it is optimal for her to reject, i.e. $\alpha_l = 0$, since she will be facing an L type and so she would receive 70. So H will always reject 50 and below and accept 70 and above. Hence, no matter the message she sends, she will always receive 35 against an H -type and 70 against an L -type. So H is indifferent between messages, meaning $\tau_H = 1$ is optimal in particular.

Summarizing, for $q = \frac{1}{2}$, there is an equilibrium involving $\tau_L = 1$, α_h sufficiently low, $\alpha_l = 0$, $\beta_l = 1$, β_h arbitrary, and the resulting probability of peace is $1 - q^2 = \frac{3}{4}$. The resulting probability of

peace is $1 - q^2 = \frac{3}{4}$. For $q = \frac{1}{3}$, there is an equilibrium involving $\tau_L = \frac{2}{3}$, α_h sufficiently low, $\alpha_l = 0$, $\beta_l = 1$, β_h sufficiently low, and the resulting probability of peace is

$$\begin{aligned}
1 - (q^2 + 2q(1 - q)(1 - \tau_L) + (1 - q)^2(1 - \tau_L)^2) &= \\
1 - \left(\frac{1}{9} + 2\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\frac{1}{3} + \left(\frac{2}{3}\right)^2\left(\frac{1}{3}\right)^2\right) &= \\
1 - \left(\frac{1}{9} + \frac{4}{27} + \frac{4}{81}\right) &= \\
1 - \left(\frac{9}{81} + \frac{12}{81} + \frac{4}{81}\right) &= \\
1 - \frac{25}{81} &= \\
\frac{56}{81} &\approx 0.691
\end{aligned}$$

(ii) We search for equilibria in undominated strategies in which $\tau_H = 1$, $r(l, l) = \{50, 50\}$ w.p. 1, $r(h, l) = \{70, 30\}$ w.p. greater than 0, and $r(h, h) = w$ w.p. $p_w \in (0, 1)$ and $r(h, h) = \{50, 50\}$ w.p. $1 - p_w$.

By Lemma A3, since $r(h, l) = \{70, 30\}$ w.p. greater than 0 and $r(h, h) = \{50, 50\}$ w.p. greater than 0, $r(h, l) = \{70, 30\}$ w.p.1 and H prefers to accept 50 after messaging h if and only if

$$\tau_L \geq 1 - \frac{3}{4}\left(\frac{q}{1 - q}\right)\alpha_h$$

Following h, h , HM must be indifferent between walking out and offering $\{50, 50\}$:

$$q_h^2\alpha_h^2 + 2q_h(1 - q_h)\alpha_h + (1 - q_h)^2 = \frac{1}{2}.$$

If $\alpha_h = 0$, then this cannot be satisfied (the LHS is $(1 - q_h)^2$, and $q_h \in [q, 1]$). If $\alpha_h = 1$, then this can also not be satisfied as the LHS equals $q_h^2 + 2q_h(1 - q_h) + (1 - q_h)^2 = q_h^2 + 2q_h - 2q_h^2 + 1 - 2q_h + q_h^2 = 1$. Hence, a necessary condition is that

$$\tau_L = 1 - \frac{3}{4}\left(\frac{q}{1 - q}\right)\alpha_h$$

Plugging this into HM's indifference condition yields a non-linear equation in α_h where the LHS is strictly increasing in α_h . Solving the equation numerically gives a unique solution for each parameter value:

- $q = \frac{1}{2}$: $\alpha_h \approx 0.580$ and $\tau_L \approx 0.565$
- $q = \frac{1}{3}$: $\alpha_h \approx 0.580$ and $\tau_L \approx 0.783$

Since $\tau_L \in (0, 1)$, we must have that $ulL = uhL$, where

$$\begin{aligned}
ulL &= q\{\tau_H 30 + (1 - \tau_H)(\alpha_l 50 + (1 - \alpha_l)0)\} + (1 - q)\{\tau_L 50 + (1 - \tau_L)30\} \\
&= q30 + (1 - q)(30 + \tau_L 20) \\
&= q30 + 30 + \tau_L 20 - q30 - q\tau_L 20 \\
&= 30 + \tau_L 20 - q\tau_L 20
\end{aligned}$$

and

$$\begin{aligned}
uhL &= q\{\tau_H(p_w 0 + (1 - p_w)50\alpha_h) + (1 - \tau_H)0\} \\
&\quad + (1 - q)\{\tau_L 70 + (1 - \tau_L)(p_w 35 + (1 - p_w)50)\} \\
&= q(1 - p_w)50\alpha_h + (1 - q)\{\tau_L 70 + (1 - \tau_L)(50 - 15p_w)\} \\
&= q(1 - p_w)50\alpha_h + (1 - q)\{\tau_L 70 + 50 - 15p_w - \tau_L 50 + \tau_L p_w 15\}
\end{aligned}$$

Equating $ulL = uhL$ gives an equation in p_w where the RHS is strictly decreasing in p_w . For $q = \frac{1}{3}$, and the values of α_h and τ_L we found, there is no solution in p_w , and thus no equilibrium. For $q = \frac{1}{2}$, there is a solution, $p_w \approx 0.535$.

We must check that HM prefers walking out to offering $\{70, 30\}$:

$$(1 - q_h)\beta_h \leq \frac{1}{2}.$$

For the value of τ_L we found, $q_h \approx 0.697$, and so this is satisfied for any β_h .

Finally, we must now check that $\tau_H = 1$ is optimal. First note that if H messages l and receives 50, it is optimal for her to reject, i.e. $\alpha_l = 0$, since she will be facing an L type and so she would receive 70. So if she messages l , she will receive 70 against an L who messages l , 70 against an L who messages h (she would be offered 30, which she will reject), and 35 against an H (H messages h , so she will be offered 30 which she will reject). So messaging l gives H a payoff of $ulH = (1 - q)70 + q35 = 70 - 35q$. If instead, she messages h , then against another H , either HM will walk out in which case she gets 35 or she will be offered 50, which she is indifferent between accepting and rejecting; suppose she rejects and receives 35. Against an L who messages l , she will be offered 70 which she will accept and receive (the L will accept 30 ($\beta_l = 1$) by Lemma HM). Against an L who messages h , either HM will walk out in which case she gets 70 or she will be offered 50, which she is indifferent between accepting and rejecting; suppose she rejects and receives 70. Hence, messaging h gives H a payoff of $uhH = (1 - q)70 + q35 = 70 - 35q$. So H is indifferent between messages, meaning $\tau_H = 1$ is optimal in particular.

Summarizing, for $q = \frac{1}{3}$, there is no equilibrium. For $q = \frac{1}{2}$, there is an equilibrium involving $\tau_L \approx 0.565$, $\alpha_h \approx 0.580$, $\alpha_l = 0$, $\beta_l = 1$, β_h arbitrary, $p_w \approx 0.535$, and the resulting probability of peace is

$$\begin{aligned}
& q^2(1 - p_w)\alpha_h^2 + \\
& 2q(1 - q)\{(1 - \tau_L)(1 - p_w)\alpha_h + \tau_L\} + \\
& (1 - q)^2\{(1 - \tau_L)^2(1 - p_w) + 2\tau_L(1 - \tau_L) + \tau_L^2\} \approx 0.605.
\end{aligned}$$

■

9.2 Unmediated communication in the lab: equilibria

We focus on equilibria in undominated strategies where no player demands w , and, given $\theta/2 > 1 - \theta$, H types never demand $1 - \theta$. The logic guiding the characterization of the equilibria is straightforward. Whether different demand strategies are best responses to each other depends on the posterior probabilities of the opponent's types, given the messages. The necessary restrictions on the posterior probabilities amount to restrictions on the probabilities τ_T and σ_T . In equilibrium, messages are random, and both types are indifferent over sending any of the three messages. Denote

by $\delta_d(T, m, m')$ the probability that type T who has sent message m and received message m' demands d . Then:

Proposition A2.

(1) For any $q < (2\theta - 1)/\theta$, $\theta/2 > 1 - \theta$, there exist equilibria in undominated strategies such that, at the demand stage:

$$\begin{aligned}\delta_\theta(H, m, m') &= 1 \text{ for all } m, m' \\ \delta_\theta(L, m, m') &= 1 - \delta_{1-\theta}(L, l, m') = 2 \left(1 - \frac{1 - \theta}{\theta(1 - \pi_m)} \right)\end{aligned}$$

where π_m is the posterior probability that a player who sent message m is of type H , or:

$$\pi_l = \frac{(1 - \sigma_H - \tau_H)q}{(1 - \sigma_H - \tau_H)q + \tau_L(1 - q)}; \quad \pi_h = \frac{q\tau_H}{q\tau_H + (1 - q)(1 - \sigma_L - \tau_L)}; \quad \pi_s = \frac{q\sigma_H}{q\sigma_H + (1 - q)\sigma_L}.$$

At the message stage, $(\tau_L + \sigma_L) \in (0, 1)$, $\sigma_L > 0$, and for any such τ_L and σ_L , τ_H and σ_H satisfy the constraints

$$\begin{aligned}\tau_H &\geq \max \left[\left(\frac{3\theta - 2}{2(1 - \theta)} \right) \left(\frac{1 - q}{q} \right) (1 - \sigma_L - \tau_L), 1 - \sigma_H - \left(\frac{2\theta - 1}{1 - \theta} \right) \left(\frac{1 - q}{q} \right) \tau_L \right] \\ \tau_H &\leq \min \left[\left(\frac{2\theta - 1}{1 - \theta} \right) \left(\frac{1 - q}{q} \right) (1 - \sigma_L - \tau_L), 1 - \sigma_H - \left(\frac{3\theta - 2}{2(1 - \theta)} \right) \left(\frac{1 - q}{q} \right) \tau_L \right] \\ \sigma_H &\in \left[\left(\frac{3\theta - 2}{2(1 - \theta)} \right) \left(\frac{1 - q}{q} \right) \sigma_L, \left(\frac{2\theta - 1}{1 - \theta} \right) \left(\frac{1 - q}{q} \right) \sigma_L \right] \\ (\tau_H + \sigma_H) &\in (0, 1).\end{aligned}\tag{16}$$

Given θ and q , the ex ante probability of peace, P is constant and given by:

$$P = \frac{[\theta(5 - q) - 2][2 - \theta(3 - q)]}{\theta^2}.$$

(2) If $q \leq 2\theta - 1$, there exist equilibria in undominated strategies such that, at the demand stage:

$$\begin{aligned}\delta_\theta(H, m, m') &= 1 \text{ for all } m, m' \\ \delta_{1/2}(L, m, m') &= 1 \text{ for all } m, m'\end{aligned}$$

At the message stage, $(\tau_L + \sigma_L) \in (0, 1)$, $\sigma_L > 0$, and for any such τ_L and σ_L , τ_H and σ_H satisfy the constraints

$$\begin{aligned}\tau_H &\in \left[1 - \sigma_H - \left(\frac{2\theta - 1}{1 - \theta} \right) \left(\frac{1 - q}{q} \right) \tau_L, \left(\frac{2\theta - 1}{1 - \theta} \right) \left(\frac{1 - q}{q} \right) (1 - \sigma_L - \tau_L) \right] \\ \sigma_H &\leq \left(\frac{2\theta - 1}{1 - \theta} \right) \left(\frac{1 - q}{q} \right) \sigma_L \\ (\tau_H + \sigma_H) &\in (0, 1).\end{aligned}\tag{17}$$

The ex ante probability of peace is $P = (1 - q)^2$.

Proof.

The logic of the proof is straightforward, but the derivation is cumbersome. We begin by proving result (1). It is convenient to start by ruling out the option of silence. Suppose $m \in \{l, h\}$.

(1). Step 1. Suppose $m \in \{l, h\}$ only. Denote by $S_{T,m|m'}(x)$ the expected share of a player of type T who sent message m , received message m' and demands x , where $x \in X = \{1 - \theta, 1/2, \theta\}$, the set of possible (undominated) demands. Ignoring silence, there are eight different $(T, m|m')$ combinations, which we distinguish by labels: $A \equiv (L, l|l)$; $B \equiv (L, l|h)$; $C \equiv (L, h|l)$; $D \equiv (L, h|h)$; $E \equiv (H, h|l)$; $F \equiv (H, h|h)$; $G \equiv (H, l|l)$; $R \equiv (H, l|h)$. These labels correspond to the information state a player moves from when expressing a demand, including the player's privately known type, and can be used to identify players at that stage of the game. Call α_x the probability that A demands x , and similarly for the other labels: β_x for B , κ_x for C , δ_x for D , η_x for E , φ_x for F , γ_x for G , and ρ_x for R . Because labels depend on the messages exchanged, only some matches are possible: A can be matched either with another A or with a G (and similarly G can only be matched with A or with another G); D can be matched either with another D or with an F (and similarly F can only be matched with D or with another F); B can be matched with either E or C , C can be matched with either B or R , R can be matched with either C or E , and finally E can be matched with either R or B .

Characterizing demand strategies, as function of type and messages, amounts to comparing expected shares for different demands, taking into account the possible matches and the opponent's expected demand. Which demand results into a higher expected share depends on the demand strategy used by the opponent and on the posterior probabilities of the different types, given the messages. Two preliminary observations are useful: (1) Any player can guarantee herself $1 - \theta$ by demanding it. (2)

Given $\theta/2 > 1 - \theta$ and the restriction on players never playing w , demanding $1 - \theta$ is dominated for any H player (since war against an L yields θ , and war against an H yields $\theta/2 > 1 - \theta$). Demands of $1 - \theta$ by H players are ignored in what follows.

Thus for example A and G 's expected shares, for different demands, are given by:

$$\begin{aligned} S_A(1 - \theta) &= 1 - \theta \\ S_A(1/2) &= \pi_l(1 - \gamma_\theta)/2 + (1 - \pi_l)[(1 - \alpha_\theta)/2 + \alpha_\theta(\theta/2)] \\ S_A(\theta) &= \pi_l(1 - \gamma_{1/2} - \gamma_\theta)\theta + (1 - \pi_l)[\theta(1 - \alpha_{1/2} - \alpha_\theta) + (\alpha_{1/2} + \alpha_\theta)(\theta/2)] \end{aligned}$$

$$\begin{aligned} S_G(1/2) &= \pi_l[(1 - \gamma_\theta)/2 + \gamma_\theta(\theta/2)] + (1 - \pi_l)[(1 - \alpha_\theta)/2 + \alpha_\theta\theta] \\ S_G(\theta) &= \pi_l[(1 - \gamma_\theta)\theta + \gamma_\theta(\theta/2)] + (1 - \pi_l)\theta \end{aligned}$$

where, in the absence of silence, π_l , the posterior probability that the opponent is H after the opponent has sent message l , is given by:

$$\pi_l = \frac{q(1 - \tau_H)}{q(1 - \tau_H) + (1 - q)\tau_L}$$

Note that if $\tau_H = 1 - \tau_L$ the messages are fully uninformative, and $\pi_l = \pi_h = q$.

In characterizing equilibria that are relevant for the lab, allowing for a small but positive probability of any message is a simple and realistic means of guaranteeing that posterior probabilities are always well-defined. In other words, we select equilibria such that any information state allowed by the structure of the game is reached with positive probability along the equilibrium path. When silence is ruled out, we impose $\tau_L \in (0, 1)$, with open bounds.

The equations corresponding to the other labels can be written in similar fashion and are not reported here.

Demand stage.

At the demand stage, given messages, the following demands are mutual best responses.

A and G: (1) G demands θ ; A demands θ if $\pi_l \leq (3\theta - 2)/\theta$, mixes between θ and $1 - \theta$ if $\pi_l \in ((3\theta - 2)/\theta, (2\theta - 1)/\theta)$, and demands $1 - \theta$ if $\pi_l \geq (2\theta - 1)/\theta$. (2) G demands θ ; A demands $1/2$ if $\pi_l \leq 2\theta - 1$. (3) G demands $1/2$; A demands $1/2$ if $\pi_l \geq (2\theta - 1)/\theta$.

D and F: (1) F demands θ ; D demands θ if $\pi_h \leq (3\theta - 2)/\theta$, mixes between θ and $1 - \theta$ if

$\pi_h \in ((3\theta - 2)/\theta, (2\theta - 1)/\theta)$, and demands $1 - \theta$ if $\pi_h \geq (2\theta - 1)/\theta$. (2) F demands θ ; D demands $1/2$ if $\pi_h \leq 2\theta - 1$. (3) F demands $1/2$; D demands $1/2$ if $\pi_h \geq (2\theta - 1)/\theta$.

B, C, R and E : (1) Both E and R demand θ , B demands $1 - \theta$ and C demands θ if $\pi_l \leq (2\theta - 1)/\theta$ and $\pi_h \geq (3\theta - 2)/\theta$. (2) Both E and R demand θ , C demands $1 - \theta$ and B demands θ if $\pi_h \leq (2\theta - 1)/\theta$ and $\pi_l \geq (3\theta - 2)/\theta$. (3) Both E and R demand θ , and both B and C mix between $1 - \theta$ and θ if $\pi_h \in [(3\theta - 2)/\theta, (2\theta - 1)/\theta]$ and $\pi_l \in [(3\theta - 2)/\theta, (2\theta - 1)/\theta]$. (4) Both E and R demand θ , B and C demand $1/2$ if $\pi_l \leq 2\theta - 1$ and $\pi_h \leq 2\theta - 1$.

Message stage

Consider now the problem for an L and an H type, choosing which message to send at the message stage. The objective is to maximize the expected share of the pie, which we now denote as $S_T(m)$ for a player of type T who sends message m . We use the symbol \widehat{S}_Y to indicate the expected share of player with label Y at the allocation stage under mutual best response demand strategies. Thus:

$$\begin{aligned}
S_L(l) &= [(1 - q)\tau_L + q(1 - \tau_H)]\widehat{S}_A + [q\tau_H + (1 - q)(1 - \tau_L)]\widehat{S}_B \\
S_L(h) &= [(1 - q)\tau_L + q(1 - \tau_H)]\widehat{S}_C + [q\tau_H + (1 - q)(1 - \tau_L)]\widehat{S}_D \\
S_H(h) &= [(1 - q)\tau_L + q(1 - \tau_H)]\widehat{S}_E + [q\tau_H + (1 - q)(1 - \tau_L)]\widehat{S}_F \\
S_H(l) &= [(1 - q)\tau_L + q(1 - \tau_H)]\widehat{S}_G + [q\tau_H + (1 - q)(1 - \tau_L)]\widehat{S}_R
\end{aligned} \tag{18}$$

The terms in square brackets are the probabilities of being matched with an opponent who sends message l (the first term) or h (the second term).

Equilibria

Consider the following candidate equilibria: $\{\tau_L \in (0, 1), \tau_H \in (0, 1), \gamma_\theta = \eta_\theta = \rho_\theta = \varphi_\theta = 1, \alpha_\theta = 1 - \alpha_{1-\theta} = \beta_\theta = 1 - \beta_{1-\theta} = 2\left(1 - \frac{1-\theta}{\theta(1-\pi_l)}\right) \in (0, 1), \delta_\theta = 1 - \delta_{1-\theta} = \kappa_\theta = 1 - \kappa_{1-\theta} = 2\left(1 - \frac{1-\theta}{\theta(1-\pi_h)}\right) \in (0, 1)\}$. That is, a set of equilibria indexed by τ_L and τ_H where: all H types always demand θ at the demand stage, regardless of messages; all L types mix between demanding $1 - \theta$ and demanding θ at the demand stage, with strictly positive mixing probabilities that depend on the message sent; all types, L and H , send an untruthful message with positive probability. If such an equilibrium exists, then $\widehat{S}_A = \widehat{S}_B = \widehat{S}_C = \widehat{S}_D = 1 - \theta$, $\widehat{S}_G = \widehat{S}_E = \pi_l(\theta/2) + (1 - \pi_l)\theta$, and $\widehat{S}_F = \widehat{S}_R = \pi_h(\theta/2) + (1 - \pi_h)\theta$. It follows from 21 above that randomizing between a truthful and untruthful message is indeed a best response. From the analysis of the demand strategies above, we know that the conjectured solution

imposes constraints on the posterior probabilities π_h and π_l . More precisely, we require:

$$\begin{aligned}\pi_h &\in [(3\theta - 2)/\theta, (2\theta - 1)/\theta] \\ \pi_l &\in [(3\theta - 2)/\theta, (2\theta - 1)/\theta]\end{aligned}\tag{19}$$

For any $\tau_L \in (0, 1)$, ruling out silence, conditions 19 correspond to the restrictions on τ_H identified in Proposition A2 (inequalities (16), with $\sigma_H = \sigma_L = 0$).

Finally, call p the probability that an L player demands $(1 - \theta)$, unconditional on message, or:

$$p \equiv 1 - \tau_L \alpha_\theta - (1 - \tau_L) \delta_H$$

Given $\alpha_\theta = 2 \left(1 - \frac{1-\theta}{\theta(1-\pi_l)}\right)$ and $\delta_\theta = \left(1 - \frac{1-\theta}{\theta(1-\pi_h)}\right)$, we find:

$$p = \frac{2 - \theta(3 - q)}{\theta(1 - q)} = p(\theta, q)$$

The probability that an L player demands $(1 - \theta)$ depends on q and θ , but not on the message sent: even when the message is informative, that is, away from the babbling line $\tau_H = 1 - \tau_L$, the mixing probabilities at the demand stage effectively nullify the information provided by the message. The probability of the opponent demanding $(1 - \theta)$ does not vary with the message. Hence neither does the ex ante probability of peace, denoted by P :

$$\begin{aligned}P &= 2q(1 - q)p + (1 - q)^2[1 - (1 - p)^2] = \\ &= \frac{[\theta(5 - q) - 2][2 - \theta(3 - q)]}{\theta^2}\end{aligned}$$

The semi-pooling equilibria where types partially distinguish themselves through their messages do not have higher peace than the corresponding equilibria with babbling⁵², or in the absence of communication.

Step 2. Adding silence: $\sigma_L > 0$, $\sigma_H > 0$.

Adding silent messages does not affect the logic of the derivation above. It complicates the analysis because new information states must be considered at the demand stage, reflecting players who either

⁵²We say "corresponding" equilibria with babbling because we have not ruled out other equilibria where the messages are fully uninformative but are used as coordinating devices.

received or sent (or both sent and received) a silent message. Consider for example a player labeled $A_{s2}(L, l|s)$, an L player who sent an l message and received a silent message. A_{s2} can be matched either with $A_{s1}(L, s|l)$ or with $G_{s1}(H, s|l)$ (with index $s1$ denoting a player who sent a silent message, and $s2$ denoting a player who received it). Replicating the steps above, it is not difficult to verify that mixing between $d = 1 - \theta$ and $d = \theta$ is a best response for A_{s2} if G_{s1} demands θ with certainty and A_{s1} randomizes between θ (with probability α_{s1}) and $1 - \theta$ (with probability $1 - \alpha_{s1}$) as long as:

$$\alpha_{s1} = 2 \left(1 - \frac{1 - \theta}{\theta(1 - \pi_s)} \right) \in [0, 1]$$

where π_s is the posterior probability that an opponent who sent a silent message is H . Or:

$$\pi_s = \frac{q\sigma_H}{q\sigma_H + (1 - q)\sigma_L}$$

The constraint $\alpha_{s1} \in [0, 1]$ correspond to $\pi_s \in [(3\theta - 2)/\theta, (2\theta - 1)/\theta]$, or:

$$\sigma_H \in \left[\frac{3\theta - 2}{2(1 - \theta)} \left(\frac{1 - q}{q} \right) \sigma_L, \frac{2\theta - 1}{1 - \theta} \left(\frac{1 - q}{q} \right) \sigma_L \right] \quad (20)$$

for $\sigma_L \in [0, 1 - \tau_L]$.

Condition (20) must be satisfied, together with conditions 19. With $\sigma_L > 0$, $\sigma_H > 0$, and imposing $(\tau_H + \sigma_H) \in (0, 1)$, the conditions amount to the boundaries on τ_H and σ_H reported in Proposition A1. The boundaries continue to include the possibility of babbling: $(\tau_H = 1 - \tau_L - \sigma_L, \sigma_L = \sigma_H)$. Note that the open boundaries $\sigma_T > 0$, $(\tau_T + \sigma_T) \in (0, 1)$ guarantee that the all posterior probabilities are well-defined.

Now consider the message choices for an L player. Taking silence into account, expected shares become:

$$\begin{aligned} S_L(l) &= [(1 - q)\tau_L + q(1 - \sigma_H - \tau_H)]\widehat{S}_A + [(1 - q)\sigma_L + q\sigma_H]\widehat{S}_{A_{s2}} + [q\tau_H + (1 - q)(1 - \sigma_L - \tau_L)]\widehat{S}_B \\ S_L(h) &= [(1 - q)\tau_L + q(1 - \sigma_H - \tau_H)]\widehat{S}_C + [(1 - q)\sigma_L + q\sigma_H]\widehat{S}_{D_{s2}} + [q\tau_H + (1 - q)(1 - \sigma_L - \tau_L)]\widehat{S}_D \\ S_L(s) &= [(1 - q)\tau_L + q(1 - \sigma_H - \tau_H)]\widehat{S}_{A_{s1}} + [(1 - q)\sigma_L + q\sigma_H]\widehat{S}_{L_{ss}} + [q\tau_H + (1 - q)(1 - \sigma_L - \tau_L)]\widehat{S}_{D_{s1}} \end{aligned} \quad (21)$$

where we use label D_{s1} for player $(L, s|h)$, D_{s2} for $(L, h|s)$, and L_{ss} for $(L, s|s)$. In the candidate

equilibrium, all expected shares at the demand stage, conditional on messages and on best response demand strategies, equal $(1 - \theta)$. Thus the player is indifferent over all three messages, and messages can be randomized. The same observation applies to an H player, who thus again is indifferent. The randomization over the messages is supported.

As above, call p the probability that an L player demands $(1 - \theta)$, unconditional on message, or:

$$p \equiv 1 - \tau_L \alpha_\theta - \sigma_L \alpha_{\theta, s1} - (1 - \tau_L - \sigma_L) \delta_H$$

where $\alpha_{\theta, s1}$ is the probability with which an L player demands θ after a silent message, or $\alpha_{\theta, s1} = 2 \left(1 - \frac{1-\theta}{\theta(1-\pi_s)} \right)$. Given $\alpha_\theta = 2 \left(1 - \frac{1-\theta}{\theta(1-\pi_l)} \right)$ and $\delta_\theta = \left(1 - \frac{1-\theta}{\theta(1-\pi_h)} \right)$, once again we find:

$$p = \frac{2 - \theta(3 - q)}{\theta(1 - q)} = p(\theta, q)$$

As before, p does not depend on the message sent, and hence is not affected by the possibility of a silent message. As before, even informative communication has no impact on the ex ante probability of peace P :

$$P = \frac{[\theta(5 - q) - 2][2 - \theta(3 - q)]}{\theta^2}$$

(2). Result (2) follows from the identical logic. It is not difficult to verify that, at the demand stage, all H players demanding θ and all L players demanding $1/2$ are mutual best responses if $\pi_l \leq 2\theta - 1$, $\pi_h \leq 2\theta - 1$, and, when incorporating the possibility of silence, $\pi_s \leq 2\theta - 1$. The inequalities correspond to constraints (17) in the proposition. As long as these constraints are satisfied, messages are irrelevant and mixing over messages is indeed a best response at the message stage. \square

With $\theta = 0.7$, conditions (16) become:

$$\begin{aligned} \tau_H &\in [\max[(1/6)(1 - \sigma_L - \tau_L), 1 - \sigma_H - (4/3)\tau_L], \min[(4/3)(1 - \sigma_L - \tau_L), 1 - \sigma_H - (1/6)\tau_L]] \\ \sigma_H &\in [(1/6)\sigma_L, (4/3)\sigma_L] \end{aligned}$$

if $q = 1/2$, and:

$$\begin{aligned} \tau_H &\in [\max[(1/3)(1 - \sigma_L - \tau_L), 1 - \sigma_H - (8/3)\tau_L], \min[(8/3)(1 - \sigma_L - \tau_L), 1 - \sigma_H - (1/3)\tau_L]] \\ \sigma_H &\in [(1/3)\sigma_L, (8/3)\sigma_L] \end{aligned}$$

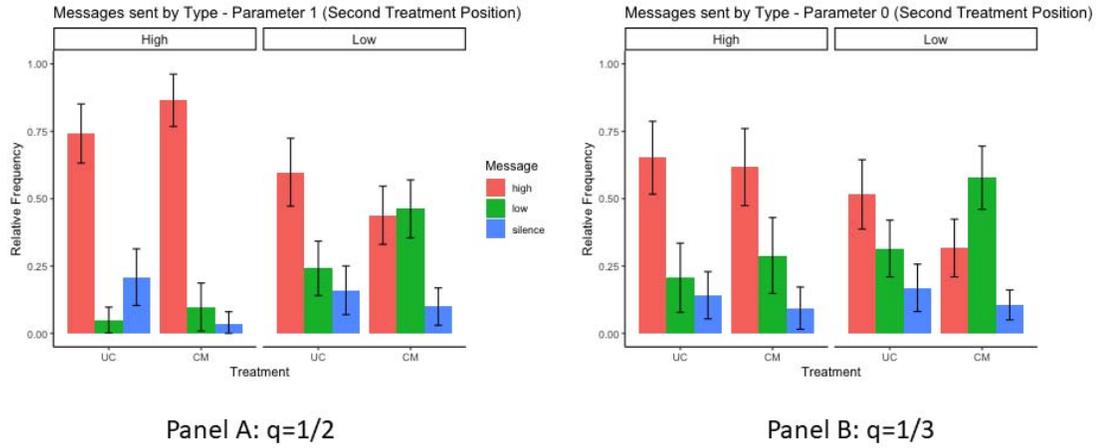


Figure 13: UC and CM: sincerity with equal experience.

if $q = 1/3$.

The constraints corresponding to the second equilibrium, if $q = 1/3$, are reported in the text.

9.3 Additional Experimental Results

9.3.1 Sincerity and Peace in UC and CM, between Subjects

We report here evidence on sincerity and the frequency of peace in UC and CM, comparing sessions where the two treatments are played by subjects in rounds 11-30, i.e. just after the NC treatment, and with the same experience.

9.3.2 The No Communication (NC) rounds

All subjects started a session by playing 10 rounds of the unmediated treatment without any communication. After being matched in pairs and independently assigned types, each subject submitted a demand in the set $\{1 - \theta, 1/2, \theta, w\}$; if the two demands were compatible, the resource was split accordingly, if not, conflict followed, the resource shrank to θ and was split according to the subjects' types $-\theta/2$ to each if the types were equal, θ to H and 0 to L otherwise.

	<i>Dependent variable:</i>
	IsPeace
TreatmentHM	0.082** (0.037)
TreatmentCM	-0.028 (0.032)
Order2	0.066** (0.029)
Parameter1	0.154*** (0.025)
PairTypeHigh-Low	0.322*** (0.049)
PairTypeLow-Low	0.635*** (0.053)
Period	0.0002 (0.001)
TreatmentHM:PairTypeHigh-Low	-0.129*** (0.047)
TreatmentCM:PairTypeHigh-Low	0.011 (0.040)
TreatmentHM:PairTypeLow-Low	-0.300*** (0.047)
TreatmentCM:PairTypeLow-Low	0.016 (0.042)
Order2:PairTypeHigh-Low	-0.082** (0.035)
Order2:PairTypeLow-Low	-0.050 (0.037)
Parameter1:PairTypeHigh-Low	0.066** (0.033)
Parameter1:PairTypeLow-Low	-0.002 (0.033)
PairTypeHigh-Low:Period	0.0002 (0.001)
PairTypeLow-Low:Period	0.002** (0.001)
Constant	0.017 (0.037)
Observations	4,320
R ²	0.206
Adjusted R ²	0.203
Residual Std. Error	0.446 (df = 4302)

Note: *p<0.1; **p<0.05; ***p<0.01

The default treatment is UC (ignoring NC), Order 1, $q = 1/3$, and when looking at different pair types, the default pair is HH. Standard errors are clustered by pairs.

Table 3: Peace

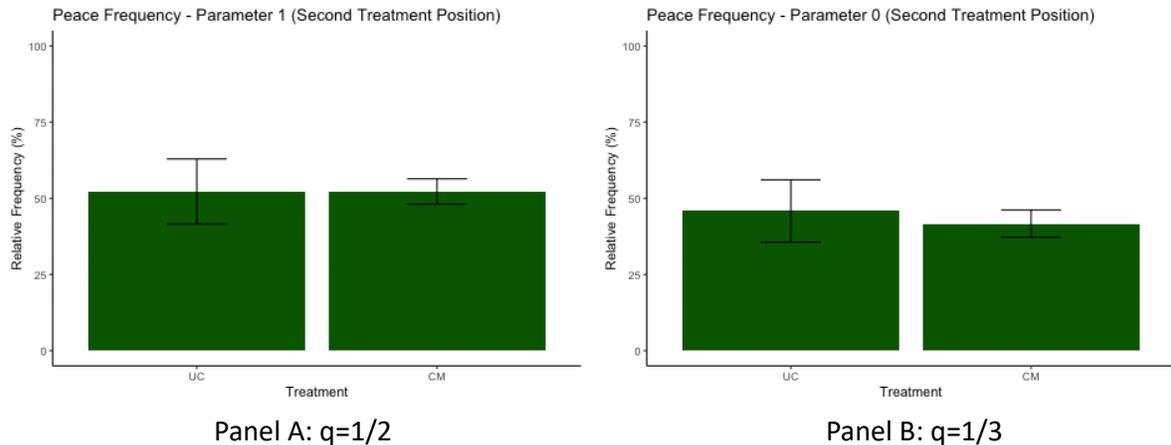


Figure 14: UC and CM: frequency of peace with equal experience.

These initial 10 rounds were always played before any other treatment and had the goal of familiarizing subjects with the computer interface and the bargaining game, in a simpler environment. For completeness, we briefly report here the theoretical results for the NC game as well as the main regularities observed in the data.

As mentioned in the text, the UC equilibrium demand strategies described in Section 6.2 are equilibrium demand strategies under NC if the posterior probability of the opponent being H is set equal to the prior, i.e. to q . Denoting by $\delta_d(T)$ the probability that type T demands d , and by P the ex ante probability of peace, the equilibria under NC are as follows:

Par1: $q = 1/2$. There is a unique equilibrium: $\delta_{70}(H) = 1; \delta_{70}(L) = 0.29$ and $\delta_{30}(L) = 0.71$; $P = 0.586$.

Par0: $q = 1/3$. There are three equilibria: (1) $\delta_{70}(H) = 1; \delta_{50}(L) = 1; P = 0.444$. (2) $\delta_{70}(H) = 1; \delta_{70}(L) = 0.71$ and $\delta_{30}(L) = 0.29$; $P = 0.345$. (3) $\delta_{70}(H) = 1; \delta_{70}(L) = 0.33, \delta_{50}(L) = 0.38$, and $\delta_{30}(L) = 0.29$; $P = 0.409$.

The equilibrium under Par1, as well as the first two equilibria under Par0 can be obtained from the UC equilibria discussed in Section 6.2. We have not attempted to characterize a UC equilibrium under Par0 that would parallel the third equilibrium above.

The frequency of peace observed in the data is 0.556 under $q = 1/2$ (with s.e.'s clustered at the session level, the 95 percent CI is $[0.454, 0.657]$), and 0.528 under $q = 1/3$ (with $CI = [0.468, 0.587]$); thus peace fits the prediction quite well for $q = 1/2$ and is higher than expected under $q = 1/3$. (The

predicted treatment effect, with higher peace under $q = 1/2$, is observed in the data, but with large confidence intervals). On the other hand, as shown in **Table YY**, demand strategies in the lab align qualitatively with the first equilibrium under $q = 1/3$ but deviate from predictions otherwise, in great part because in no other equilibrium does the L type demand 50 with high probability, a regularity we instead see consistently in the data.

		$q = 1/2$						$q = 1/3$			
demand		70	50	30	w	demand		70	50	30	w
H	data	0.66	0.29	0.003	0.04	H	data	0.80	0.14	0	0.06
	equil	1	0	0	0		equil1,2,3	1	0	0	0
L	data	0.07	0.63	0.30	0	L	data	0.10	0.85	0.04	0.01
	equil	0.29	0	0.71	0		equil1	0	100	0	0
							equil2	0.71	0	0.29	0
							equil3	0.33	0.38	0.29	0

Table 9: Data from the initial NC rounds.

9.4 Experimental procedures and instructions

Upon entering the lab, subjects were seated at random computer posts, divided by partitions; each subject was identified exclusively by a randomly assigned id and all communication among subjects took place exclusively via computers. After subjects were seated and consent forms were signed, the experimenter read the instructions aloud and showed images of the experimental screenshots, answering aloud and publicly any question that did arise. We reproduce here instructions and screenshots for a representative Parameter 1, Order 1 session.

MEDIATION INSTRUCTIONS

Four parts: NC, UC, M, MC.

PAR1: $q = 1/2$; $\theta = 0.7$.

(Payoffs for HM: M=60, W=40, m=20).

Make yourself comfortable, put your phones away, and please don't talk or use the computer. Thank you for agreeing to participate in this experiment.

You will be paid for your participation privately and in cash, at the end of the experiment. Your earnings during the experiment are denominated in POINTS. For this experiment every 100 POINTS earns you 10 DOLLARS. The experiment will consist of multiple rounds. At the end, five rounds will be selected randomly, and you will be paid the sum of your earnings over those five rounds. Pay attention to each round because it may well end up being one of those for which you will be paid.

If you have any questions during the instructions, please raise your hand.

The experiment studies a game of negotiation: you will be matched with another person, and the two of you will decide how to share a resource worth 100 points. In case of disagreement, the resource shrinks to 70 points (think of the 30 points lost as time and resources wasted to disagreement). You will be randomly assigned types, High or Low, and how the resource is divided in case of disagreement will depend on your types.

I will describe each part of the experiment before it starts.

PART 1

We begin with PART 1.

At the start of each round, the computer will assign you a type, which, as we said, can be either High or Low. The two types are equally probable: each person is likely to be H with probability $1/2$, and L with probability $1/2$.

You will see a screenshot like this: [SCREENSHOT ON TYPE]

Here, as at several other points during the experiment, you will move to the next screen by clicking the Continue button. Please remember to do so.

After having been assigned your type, you will be randomly matched with another person in the room. You will not know which person you are matched to, nor will you know the person's type. Knowing your type does not give you any information about your match's type. All you know is that he or she is equally likely to be H or L with probability $1/2$ each. Your type and your match's type matter because they affect how the resource is shared in case of Disagreement.

After having been informed of your assigned type, you will be asked to say how much of the resource you demand for yourself. Remember that the resource is worth 100. You can ask for 30, 50, 70, or you can Walk Out of the negotiation.

- If your demand and the demand of your match are compatible (i.e. do not sum to more than 100), then they will be satisfied. You will receive what you asked for, and the round will end.

- If the two demands are instead incompatible (they sum to more than 100), or if one of you Walks Out, then there is Disagreement. The resource shrinks from 100 to 70 points. The reduced resource is then allocated automatically by the computer. If one of you is H and the other is L, then H receives the full 70 points, and L receives 0. If both of you are H, or both of you are L, then each receives one half of the reduced resource, that is, 35 points. This will conclude the round.

The screen where you express your demand will look like this:

[SCREENSHOT: NO COMMUNICATION DEMAND]

Notice that you have a reminder of your type on the upper left corner.

Disagreement occurs if either of you chooses W (Walk Out), or if the two of you choose (70, 50), or (70, 70). Remember: If there is disagreement, the resource shrinks from 100 to 70 points.

After the two demands have been submitted, you will be told your match's demand; whether there is Agreement or Disagreement, and your payoff for the round.

If there is Agreement, your payoff will equal your demand. Your screen will look like this [SCREENSHOT: OUTCOME WITH AGREEMENT].

If there is disagreement, your payoff will depend on your type and your match's type. Your screen will look like this [SCREENSHOT: OUTCOME WITH DISAGREEMENT]. In this example, you asked for 70 and your match asked for 50 points. The two demands were incompatible, and the resource shrank to 70 points in total. Your payoff consists of 0 points which indicates that your match is of type H and you are of type L.

This will conclude the round. We will then move to the next round: you will again be assigned a type randomly (H or L with equal probability of 1/2), and will be matched randomly with another person in the room. The type you were in round 1 or the person you were matched with do not influence in any way the type you are assigned in round 2 or your new match. The experiment will then continue as described earlier.

The REMINDER slide summarizes this part of the experiment.

Are there any questions?

We will begin with two practice rounds. You will not be paid for these rounds, whose purpose is only to familiarize yourself with the computer interface and the rules of the experiment.

[OPEN ZTREE; copy program]

Please double-click on the icon marked Leaf16 on your desktop. If asked, click RUN.

If you have any questions from now on, raise your hand, and an experimenter will come and assist you.

RUN PRACTICE ROUNDS: [RUN; START TREATMENT]

We have now concluded the practice rounds. Are there any questions? Remember that you will not be paid for these rounds.

CLOSE THE TREE

Please click Alt F4. Then double-click on the icon marked Leaf16 and if asked click RUN.

We will now begin the experiment. The first part will last 10 rounds.

[RUN; START TREATMENT]

PART 2

We will now move to the second part of the experiment. Part 2 will run in a similar fashion to part 1. At the start of each round, the computer will again assign you a type, High or Low, with equal probability of $\frac{1}{2}$ each. You will again be matched randomly with another person in the room, whose type you will not know.

Now, unlike in Part 1, after types are assigned and matches are made, you will be asked to send a message to your match, communicating your type. You have three options: High, Low, or Silence. You can be truthful, or not truthful, as you choose, or you can be silent. The screen you will see will look like this:

[SCREENSHOT: SEND MESSAGE] As before, in the upper blue strip is a reminder of your type.

You will then receive the message sent by your match, which again can be either H or L or S. After having seen the message, you will be asked to say how much of the resource you demand for yourself. Remember that the resource is worth 100 points. As in Part 1, you can ask for 30, 50, 70, or you can Walk Out of the negotiation. Payoffs will work exactly as in the previous round: you will receive what you asked if the two demands do not sum up to more than 100 (and thus there is Agreement); if the demands sum up to more than 100, there is Disagreement, the resource shrinks to 70 points and is allocated according to your type and the type of your match.

The only difference with respect to Part 1 is your ability to send a message communicating your type before deciding on your demands.

The screen where you express your demand will look like this:

[SCREENSHOT: DEMAND] Note that blue strip at the top now reminds you both of your type and of the message you have sent. The screen also communicates to you the message your partner

has sent.

After the two demands have been submitted, you will be told your match's demand; whether there is Agreement or Disagreement, and your payoff for the round.

This will conclude the round. We will then move to the next round: you will again be assigned a type randomly (H or L, each with equal probability $1/2$), and will be matched randomly with another person in the room. The experiment will then continue as described earlier.

The Reminder slide will remain projected to remind you of the rules.

Part 2 will last 20 rounds.

Please move the cursor to the top left corner of your screen. Click and the Continue button will appear at the bottom right corner. Click Continue and begin Part 2.

PART 3.

We will now move to the third part of the experiment.

At the start of each round, you will be matched randomly in groups of three people. One person in the group will be called Mediator. The Mediator receives confidential messages and makes recommendations on how the other two people in the group—who will be called the two Players—are to share the resource. For convenience, the two Players will sometimes be identified as Player 1 and Player 2, but 1 and 2 are just labels with no other meaning.

The computer will tell you if you are the Mediator or a Player.

After the match has occurred, the two Players will be randomly assigned a type. As before, each type can be either H or L with equal probability, and which type is assigned to one Player has no influence on the type assigned to the other Player. If you are a Player, you will know your own type, but will not know the other Player's type. If you are the Mediator, you will not know the type of either Player. Everyone knows that a Player is assigned type H or L with equal probability of $\frac{1}{2}$ each.

After matches are made and roles and types are assigned, if you are a Player, you will be asked to send a message communicating your type, as you did in Part 2. As before, you have three options: High, Low, or Silence. The difference is that now you will send the message to the Mediator, and not to the other Player in your group. As before you can be truthful, or not truthful, or you can be Silent.

The screen will look like this:

[SCREENSHOT: SEND MESSAGE]

The message you send to the Mediator is confidential and will not be seen by the other Player.

Once the two messages are received by the Mediator, the Mediator can make a recommendation on how to share the resource, or can choose to Walk Out of the mediation.

- If the Mediator makes a recommendation and both Players accept it, then there is Agreement, the resource is shared according to the recommendation, and the Mediator earns 60 points.
- If one or both Players reject the recommendation, then there is Disagreement, the resource shrinks to 70 points and is allocated by the computer to the two Players according to their type, as in Parts 1 and 2. In case of Disagreement, the Mediator's payoff is 20 points.
- If the Mediator Walks out of the negotiation, the Disagreement scenario is triggered automatically: the resource shrinks, and the Players' payoffs depend on their type, as in the regular Disagreement case. However if Disagreement is triggered by the Mediator Walking out, the Mediator's payoff is 40 points (as opposed to 20 when Disagreement comes from the Players rejecting the Mediator's recommendations).

The reminder slide that remains projected during this part of the experiment will remind you of the rules.

Note that the Mediator can make a recommendation but has no power to force the Players to accept it.

The Mediator's screen will look like this:

[SCREENSHOT: MEDIATOR'S CHOICE]. The screen shows the two messages received from the two Players, and the options the Mediator has for a feasible recommendation. The first number indicates the amount recommended for Player 1, and the second the amount recommended for Player 2. The choices are (50,50), (30,70), (70, 30). Alternatively, the Mediator can choose to Walk Out of the mediation task.

The Mediator's choice is then transmitted to the two Players.

If the Mediator has chosen to Walk Out, then each Player will see a screen like this:

[SCREENSHOT: MEDIATOR WALKED OUT].

At the same time, the Mediator will also see a screen repeating the decision to Walk Out and reporting the Mediator's corresponding payoff. [SCREENSHOT: YOU WALKED OUT].

If the Mediator has made a recommendation, each Player's screen will look like this: [SCREENSHOT: PLAYER'S RESPONSE TO THE MEDIATOR'S PROPOSAL]. The Player is asked whether to accept or reject the recommendation.

Each Player is then told whether the other Player accepted the recommendation, and the final outcome of the mediation, including the Player's payoff for the round. [SCREENSHOT: OUTCOME FOR PLAYER, AGREEMENT].

At the same time, the Player's decisions and the outcome are communicated to the Mediator. The Mediator is also reminded of the messages received and the recommendation made. [SCREENSHOT: OUTCOME FOR MEDIATOR, AGREEMENT]. Because the outcome is Agreement, the Mediator earns 60 points.

This concludes the round. We will then move to the next round, where groups of three will again be formed randomly, and roles will be assigned randomly. Although roles are assigned randomly and groups are formed randomly, each of you will be Mediator for the same number of rounds. Types are then assigned, again randomly, with each Player being of type H or L with equal probability of $\frac{1}{2}$ each. The experiment will then continue as just described.

[SCREENSHOT: REMINDER SLIDE SUBJECT MEDIATOR]

Part 3 will last 30 rounds.

Are there any questions?

Please move the cursor to the top left corner of your screen. Click and the Continue button will appear at the bottom right corner. Click Continue and begin Part 3.

PART 4

Part 4 is almost identical to Part 3. The only difference is that the Mediator is played by the computer.

As in Part 3, the two Players in each group send their messages to the Computer-Mediator, the Mediator chooses whether to Walk Out or to make a recommendation, and each Player decides whether to accept or to reject the Mediator's recommendation.

If either the Mediator Walks Out or one or both Players reject the Mediator's recommendation, then there is Disagreement, the resource shrinks to 70 points and is allocated according to Players' types (divided equally if the Players are of the same type, given fully to the H type if the two Players have type H and L).

If the Mediator makes a recommendation and both Players accept it, then there is Agreement, the recommendation is implemented, each Player earns the corresponding points.

The Computer Mediator follows the following plan:

If the two messages are (L, L), it recommends (50, 50).

If they are (H, L), it recommends either (70, 30) with probability 5/8 or (50, 50) with probability 3/8.

If they are (H, H), it recommends either (50, 50) with probability 1/2 or Walks Out with probability 1/2.

If the computer receives a Silent message from a player, it interprets it according to the likely frequency of each type—as an H with probability 1/2 and an L with probability 1/2. Thus if, for example, the two messages are (S,L), the computer reads them as (L,L) with probability 1/2 (and acts accordingly) or as (H,L) with probability 1/2 (and acts accordingly).

[SCREENSHOT COMPUTER MEDIATOR PLAN]

This screenshot will remain up throughout Part 4 to remind you of the Computer Mediator plan.

After each round, you will be rematched randomly with another player, and types will be re-assigned.

Part 4 will last for 20 rounds.

Are there any questions?

Please move the cursor to the top left corner of your screen. Click and the Continue button will appear at the bottom right corner. Click Continue and begin Part 4.

[Before the end of the last round: remind them to remain with the final screen with their earnings].

END OF THE EXPERIMENT

This is the end of the experiment. You should now see a popup window, which displays your total earnings. Please divide the number of points by 10, round up to the nearest dollar, and record this on your payment receipt sheet. Please also enter \$10.00 on the show-up fee row. Add your earnings and the show-up fee and enter the sum as the total. Finally, please record your Computer ID on the form. Add some not intelligible signature. When you are done, click “Continue”.

[Run Questionnaire]

We will pay each of you in private in the next room in the order of your computer numbers. Please do not use the computer; be patient, and remain seated until we call you to be paid. Do not converse with the other participants. Thank you for your cooperation.

[SAVE DATA and erase from folder]