# DISCLOSURE BY GROUPS*

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March, 2025

**Abstract**

This paper introduces a model of group communication, in which a group of senders with conflicting interests collectively communicate with a receiver through the disclosure or non-disclosure of information about a relevant state. Collective disclosure decisions are reached via the aggregation of group members' disclosure recommendations via a predetermined *deliberation procedure*. In contrast with classic results from single-agent disclosure, (sequential) equilibria of the group disclosure game typically do not involve full disclosure. We investigate the relation between the group's deliberation procedure and features of equilibrium communication. In particular, we characterize changes in the deliberation procedure that increase a group's informativeness; and show that the receiver interprets group messages less favorably for group members who have relatively more power.

# 1 Introduction

Communication decisions are often done by organizations or groups of people, rather than by individuals: political parties collectively agree on "stances" their members should publicly hold regarding politically relevant issues; decisions on what reporting to include in a magazine or newspaper's upcoming issue are normally made by editorial boards, rather than by individual editors; lobbying activities are mostly conducted by interest group coalitions or trade associations; and most evidence that supports decisions made by policy makers and regulators is

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produced and provided by committees of experts. In various such contexts, there is ample evidence that the composition and organizational structure of groups determine their communication decisions as well as how their communication is interpreted: for example, the structure of legislative committees affects their informativeness, and consequently the effectiveness of the legislature, and the diversity of interests in lobbying coalitions impacts their lobbying success.[1] In this paper, we study how misaligned interests and the structure that aggregates them in a group determine how the group strategically communicates and how they are understood by their audience.

In our model, communication is done through disclosure of hard information, as in Grossman (1981) and Milgrom (1981): a sender (or, in our case, a group of senders) chooses whether or not to disclose to a receiver a piece of evidence containing information about a payoff-relevant state. If the evidence is disclosed, the receiver understands it and makes decisions based on that information. If the evidence is not disclosed, the receiver does not learn anything directly, but infers some information indirectly from the fact that not disclosing was a decision made strategically by the sender. We add two ingredients to this classic disclosure benchmark, incorporating two key facets of decision-making by a group: conflicts of interests and a power structure to resolve them.

First, we posit that different individuals in the group may have diverse preferences over the revelation of a particular outcome realization to the receiver. For instance, in the context of an expert committee that advises policy-making, each committee member may be differentially affected by a policy decision to be ultimately made based on their recommendations, perhaps because these individuals have distinct backgrounds or political affiliations. As a consequence, members of the committee can disagree as to what pieces of information they would like the committee to report to the policy-maker. In our model, a piece of evidence is defined by the value that accrues to each individual member of the group if it is disclosed to the receiver. If the evidence is instead not disclosed, then each group member receives a payoff equal to the receiver's posterior belief about their individual value, given no disclosure. We capture conflicts of interest by assuming that the *outcome distribution* is such that group members' values are not perfectly correlated, which implies that group members receive diverse payoffs from disclosing some pieces of evidence, as well as from not disclosing them.

Second, we model the procedure through which the group makes their disclosure decisions: after seeing the evidence realization, each group member makes a recommendation, either sug-

[1] See, for example, the extensive empirical literature following the proposal of the "informational theory" of legislative committees by Gilligan and Krehbiel (1987) and Gilligan and Krehbiel (1989). Regarding the effect of coalition composition on lobbying success, see Junk (2019). Also see Egerod et al. (2024), who document how the organization of trade associations affect their lobbying behavior.

gesting that it be disclosed to the receiver or not. These recommendations are aggregated into a group disclosure decision through a pre-determined mapping, which we denote the *deliberation procedure*. This mapping from individuals' recommendations into a group decision describes in reduced form the outcome of the group's deliberation, in particular expressing each individual's power to enforce their preferred choice as that of the group.

In some contexts, this procedure reflects formal rules and hierarchies in an organization,[2] whereas in other contexts it may reflect less tangible factors, such as individual relationships between each member of the group and the receiver or informal contracts between the group members.[3] Our framework is flexible and permits a large class of deliberation procedures. We assume only that the procedure respects unanimous decisions — disclosure ensues if it is favored by all group members and the evidence is not disclosed if disclosure is opposed by all — and monotonicity, so that when disclosure is favored by a larger set of group members, the evidence is disclosed with a higher probability.

Our first result, Theorem 1, proposes an initial characterization of the equilibrium set in the group disclosure game. If the deliberation procedure is such that every group member can unilaterally choose disclosure — that is, such that the evidence is disclosed whenever at least one group member favors its disclosure — then there is a unique equilibrium, in which every evidence realization is disclosed to the observer. In this full disclosure equilibrium, the receiver interprets the absence of disclosure with maximal skepticism about every group member's value: upon seeing no disclosure, they form the posterior belief that every group member drew their lowest-possible value.

Perhaps more interestingly, if the deliberation procedure is such that at least one group member cannot unilaterally choose disclosure, then there exists at least one equilibrium without full disclosure. This result is in contrast with classic findings from single-agent evidence disclosure models as in Grossman (1981) and Milgrom (1981), which show that full disclosure is the unique equilibrium outcome. In single-agent environments, "no disclosure" is a message that is interpreted by the observer with skepticism. After all, the strategic absence of disclosure must

[2] For example, in the United States, at the start of congress, committees publish procedural rules that determine, among other things, guidelines for communications with the public. These guidelines vary across committees. For example, in 2017-18, the procedures for the Special Committee on Aging determined that "committee findings and recommendations shall be printed only with the approval of a majority of the committee"; the Committee on Commerce, Science and Transportation resolved that "public hearings of the full committee, or any subcommittee thereof, shall be televised or broadcast only when authorized by the chairman and the ranking minority member of the full committee"; and the Select Committee on Ethics decided that the release of reports to the public be determined by either the chairman or the vice-chairman, who were thus given the authorization to speak on behalf of the committee. (Quotes taken from the published Authority and Rules of Senate Committees, 2017-18.)

[3] In the literature on organizational sociology, Zuckerman (2010) and Freeland and Zuckerman Sivan (2018) argue for the importance of these less tangible factors in determining group members' "voice rights," their individual rights to speak on behalf of the organization.

indicate that the realized evidence was bad news to the sender. This equilibrium skepticism in turn implies that not disclosing yields a low value to the sender, who instead prefers to disclose all but the very worst possible news.

In a group disclosure setting, this "unravelling" logic is broken because the observer is unable to definitively attribute a group's decision to not disclose to specific group members. By observing the group's decision to not disclose, but not the individual recommendations that led to that decision, the observer knows that there exist group members who drew "bad news" and recommended no disclosure, but does not know how many did so, or their identity. In particular, the observer understands that no disclosure might have ensued despite a particular group member having observed good news, for that group member cannot enforce their preferred choice of disclosure as the group's decision. A consequence is that "no disclosure" is interpreted with skepticism *about the group*, which does not immediately translate into skepticism about that particular individual's value.

Whereas Theorem 1 describes when equilibria without full disclosure exist, our results in Section 4 provide further description of the set of equilibria without full disclosure. Theorem 2 and Proposition 1 describe conditions on the primitives of the model — the evidence distribution and the deliberation procedure — under which the disclosure game is a game of strategic complements between group members.[4] When that is the case, the game has extremal equilibria, in terms of the amount of disclosure (and therefore the group's informativeness): there is an equilibrium with most disclosure, which is always the full disclosure equilibrium, and an equilibrium with least disclosure.

In Section 5, we return to our starting goal of understanding how the power structure in a group affects how that group strategically communicates. In our framework, that translates into a question of how changes in the group's deliberation procedure affect equilibrium communication. Specifically, we are interested in two features of equilibrium: the amount of disclosure, and therefore the informativeness of the group to the observer, and the equilibrium interpretation of the group's "no disclosure message," which describes the observer's skepticism about each individual's value that ensues after no disclosure.

There are two key aspects of a deliberation procedure: First, how "easy" it is for a group to reach a disclosure decision, in terms of the degree of consensus that is required for the group to choose disclosure. Second, the relative power of each group member, described by how often

[4] The game has strategic complementarities if when an individual's fellow group members use higher thresholds to recommend disclosure, then it is optimal for that individual to use a higher disclosure threshold as well. We show, for example, that if a group has two members, strategic complementarity arises when group members' values are positively correlated. For larger groups, we show that the supermodularity of the deliberation procedure plays a role in determining the complementarity of group members' strategies.

the group's decision agrees with that particular group member's recommendation. Proposition 2 shows that the amount of equilibrium disclosure increases if disclosure becomes proportionally easier, that is, if the degree of consensus required for the group to reach a disclosure decision decreases, but individual group members' relative power remain unchanged. In contrast, dis-proportional increases in the ease of disclosure do not necessarily increase the amount of disclosure in equilibrium. In particular, the amount of equilibrium disclosure is not necessarily minimized by the procedure that makes it hardest for the group to choose disclosure.

Finally, Proposition 3, establishes that changes in the deliberation procedure that increase a group member's relative power lead to a decrease in the observer's "no disclosure belief" about that group member's value. That is, if a group member is more powerful, then no disclosure decisions are more often attributed to them, and the observer is thus more skeptical about their value upon seeing no disclosure. We see this result as establishing a new principle inherent to group communication: the interpretation of messages coming from a group depends on the audience's perception of the power structure in that group. This principle, and the empirical predictions it entails, is validated in an experimental setting by Avoyan and Onuchic (2024).

In Section 6, we complete our analysis by characterizing conditions on the group's deliberation procedure such that a full disclosure equilibrium satisfying sequential consistency exists. Theorem 3 shows that is the case if and only if at least one group member can unilaterally enforce disclosure as the group's decision. Beyond its implication for the robustness of equilibria without full disclosure in a group setting, we view Theorem 3 as a technical contribution to the literature on disclosure games. Previous work typically considers refinement criteria such as "truth-learning" as in Hart et al. (2017), defeated equilibria as in Mailath et al. (1993) (used by Celik and Drugov (2024) as a criterium to refine out equilibria with full disclosure in a different setting), or receiver-optimality (used by Rappoport (2024)). We find that, in a group disclosure setting, the consistency notion that defines sequential equilibria is often sufficient to rule out full equilibria that are supported by highly-skeptical off-path beliefs.

## 1.1 Related Literature

Our paper contributes to a large literature on multi-sender communication. Using different communication protocols, seminal contributions by Milgrom and Roberts (1986), Battaglini (2002), and Gentzkow and Kamenica (2016) study models in which multiple senders communicate with a single receiver.[5] All of those papers consider environments in which senders "competitively" communicate with a receiver by unilaterally sending messages to the same receiver. This com-

[5]Several more recent contributions, including Hagenbach et al. (2014), Hu and Sobel (2019), and Baumann and Dutta (2022), also study models of multi-sender evidence disclosure.

petitive communication benchmark corresponds to one possible deliberation procedure in our broader framework of group communication.

In our model, the group communicates using an evidence disclosure protocol, as in the large literature stemming from Grossman (1981) and Milgrom (1981). We contribute to this literature by studying disclosure by a group. Our paper is especially close to models with multidimensional evidence, such as Dziuda (2011) and Martini (2018). In particular, Martini (2018) shows that if a single sender separably values the receiver's posterior about each dimension of the state, then equilibria without full disclosure may exist if the sender's preferences are sufficiently convex. The mechanism behind the existence of such equilibria is similar to that in our paper, in that the receiver cannot distinguish the dimension in which the sender drew "bad news." Despite this connection, the group disclosure problems are inherently different from the setting of individual multi-dimensional disclosure, and the former cannot be mapped into instances of the latter through appropriately chosen sender preferences.

Our first result shows that equilibria of the group disclosure game often feature non-disclosure of some evidence. The extensive literature on single-agent disclosure games also provides a variety of mechanisms that prevent the "unravelling" result from Milgrom (1981).[6] In particular, Dye (1985) observes that equilibria that do not feature full disclosure exist in a single-agent problem when the observer is unsure whether the sender has access to evidence. In the group context, despite senders always having access to evidence, they may be unable to disclose it because other group members may have vetoed it. The observer in our context is, as in Dye (1985), unsure about why the evidence was not disclosed. Our mechanism is also connected to that in Seidmann and Winter (1997) and Giovannoni and Seidmann (2007), who argue that equilibria with some non-disclosure arise when, upon seeing no-disclosure, the observer is unsure whether the sender intended to bias their belief upwards or downwards. In the group context, the observer is similarly unable to attribute the decision to not disclose the outcome to the interests of a particular individual in the group.

Our proposed framework of communication by an organized group is also connected to models in which communication happens through an network or a hierarchy, such as Galeotti et al. (2010), Ambrus, Azevedo and Kamada (2013), and Galeotti et al. (2013). Squintani (2020) studies strategic transmission of verifiable information in networks of (perhaps biased) experts and decision makers. He shows that communication to a decision maker through a path of intermediary players—who can sequentially choose to "veto" information transmission—breaks down unless all intermediaries are biased in the same direction relative to the decision

[6] See, for example, Dranove and Jin (2010) for a review of both theoretical and empirical explanations of why verifiable information may not be voluntarily disclosed through a process of unravelling.

maker.[7] One of the deliberation procedures we consider in our group disclosure model is the consensus procedure, in which every team member can veto disclosure. We similarly find that communication between the group and the observer is harmed (although not completely broken down) because deliberation aggregates preferences from multiple agents.

Finally, while this paper proposes a group disclosure framework and studies how the deliberation procedure affects only communication outcomes, our companion paper Onuchic and Ramos (2023) incorporates a stage of group disclosure in a model of team production and describes also how the choice of deliberation procedure can affect effort incentives in a group.

# 2 Group Disclosure Environment

There is a group $N = \{1, 2, ..., n\}$, composed of $n$ group members. The group draws an outcome $\omega$, described by its value to each group member $i$, $\omega_i$. The outcome is drawn from a distribution $\mu$ over a finite outcome space $\Omega = \Omega_1 \times ... \times \Omega_n \subset \mathbb{R}^n$. The group makes a single decision, of whether to disclose the realized outcome, thereby revealing it to some outside observer, or to conceal it.

The payoff to each group member $i$ from revealing or concealing the outcome is given by the belief about $\omega_i$ that is induced on the observer in each case. If the group chooses to disclose $\omega$, the outsider perfectly observes $\omega$ and group member $i$'s payoff is equal to the realized $\omega_i$. If instead $\omega$ is not disclosed, then $i$'s value is equal to the observer's inference about their value, given that there was no disclosure. Specifically, $i$'s payoff equals the observer's mean posterior about $\omega_i$, $\mathbb{E}\left[\omega_i \middle| \text{ no disclosure}\right]$. Before formalizing this payoff structure and providing further details on the group's decision making, we discuss possible interpretations of this environment.

**Interpretation.** A possible scenario is one of a team in a tech company that is assigned the project of designing a new tool. The team is made up various professionals, including an engineer and a marketer. After working on this project for a while, the team produces an initial prototype (the outcome), which is very well done in terms of its technical aspects, but poorly "packaged." At this point, the team is approached by a higher-up manager (the outside third-party) who asks them to report on their progress. The team must decide whether to reveal the prototype to the manager or not to do so (maybe claiming that they need more time, or that no prototype has yet been produced). If the team reveals the prototype, the manager will be positively impressed by the engineer, who contributed the technical aspects, but negatively

[7] Squintani (2020) uses this observation as a step in his main exercise, in which he studies the design of networks of ideologically differentiated experts and decision makers, with the goal of maximizing the flow of information.

impressed by the marketer, who is responsible for the below-par packaging. In this case, even though the team produced a single observed outcome, its disclosure yields a different value to each team member — a high $\omega_{engineer}$ and a low $\omega_{marketer}$.

Alternatively, think of a meeting of the editorial board of a magazine, where various editors need to decide whether to include an inflammatory piece (the observable outcome) in the upcoming publication (in which case the outcome will be seen by the outside third-party, the potential readers of the magazine). The editors have different views on the ideal editorial leaning for the magazine, maybe relating to their own political views, and therefore assign different value to the inclusion of this piece in the magazine's new issue. Again, even though there is a single observable outcome in hand, the publishable piece, its publication yields a different value to each member of the editorial board — so that $\omega_{editorA} \neq \omega_{editorB}$.

In each of these examples, we stress that a group can decide about the disclosure of a single piece of information — the prototype or the inflammatory news piece — but group members have perhaps distinct values associated that outcome's disclosure. Accordingly, we make the following assumption about the distribution $\mu$, which imposes some minimal structure on the correlation between group members' outcome values.[8] It implies, for example, that outcome values are not perfectly correlated across individuals in the group.

**Assumption 1.** *For every $i \in N$ and set $J \subset N$ such that $i \notin J$,*

$$\mu\big(\omega_i = \min(\Omega_i) \mid \omega_j = \min(\Omega_j) \textit{ for all } j \in J\big) \in (0,1).$$

**Decision-making Process.** After seeing the outcome $\omega$, each group member $i$ makes an individual disclosure recommendation: $x_i(\omega) = 1$ indicates that agent $i$ recommends that the outcome be disclosed, and $x_i(\omega) = 0$ indicates that $i$ recommends that $\omega$ be concealed from the outside third party. Group members can also use mixed recommendation strategies, in which case we let $x_i(\omega) \in (0,1)$ be the probability that $i$ recommends the disclosure of $\omega$. The groups' individual disclosure recommendations are then mapped into a group disclosure decision according to some *deliberation procedure*. The group's deliberation procedure $D : [0,1]^n \to [0,1]$ is a primitive of the model, which describes how individual recommendations

[8]The correlation between outcome values across group members can reflect the direct preferences of the group members, as in the interpretations we discussed. It can also reflect group members' social preferences. For example, if group member $i$ places weight $1-\alpha$ on their own payoff and $\alpha$ on the payoff of their partner $j$ (and vice-versa for group member $j$), then we can redefine the outcome values (and therefore the distribution of outcome values) as $\hat{\omega}_i = (1-\alpha)\omega_i + \alpha\omega_j$ and $\hat{\omega}_j = (1-\alpha)\omega_j + \alpha\omega_i$. Stronger social preferences, as reflected by a higher $\alpha$ would then yield stronger correlation in the outcome values $\hat{\omega}_i$ and $\hat{\omega}_j$.

are aggregated into a collective disclosure decision. If $x(\omega) = (x_1(\omega), ..., x_n(\omega))$ is the vector of recommendations regarding the disclosure of outcome $\omega$, then

$$d(\omega) = D\left(x(\omega)\right) \in [0, 1]$$

is the probability that the group chooses to disclose $\omega$ to the outside observer.

In a real-world scenario, deliberation may be a lengthy process made up of formal rules and communication between group members which somehow aggregates the interests of the group into a collective decision.[9] In this model, we interpret the deliberation procedure $D$ as a reduced-form description of the aggregation that ensues from the group's decision-making process. Assumption 2 states some minimal features that we require from the procedure $D$:

**Assumption 2.** *The deliberation process* $D : [0, 1]^n \to [0, 1]$

1. *Respects unanimity:* $D\left((1, ..., 1)\right) = 1$ *and* $D\left((0, ..., 0)\right) = 0$.
2. *Is monotone:* $x \leqslant x'$ *implies* $D(x) \leqslant D(x')$.
3. *Mixed strategies:*

$$D\left((x_i, x_{-i})\right) = x_i D\left((1, x_{-i})\right) + (1 - x_i) D\left((0, x_{-i})\right).$$

First, the aggregation must agree with unanimous group decisions, so that if all team members recommend disclosure or all group members recommend non-disclosure, then the unanimous decision is followed. Next, we require that the probability of disclosure be increasing in the group members' recommendations. Finally, condition 3 states that the group's decision after group member $i$'s recommendation is $x_i$ exactly coincides with the group's decision when $i$ recommends disclosure with probability $i$ and no disclosure with probability $1 - x_i$. Condition 3 implies that a deliberation procedure is fully described by the probability of disclosure when each group member uses a pure strategy recommendation $x_i = 1$ or $x_i = 0$.

For illustration, suppose that the group has only two members, so that $N = \{1, 2\}$. Condition 1 imposes that $D((0, 0)) = 0$ and $D((1, 1)) = 1$. The deliberation procedure is then fully defined by $D(1, 0) \in [0, 1]$ and $D(0, 1) \in [0, 1]$, the disclosure probability when person one group member recommends disclosure and the other recommends no disclosure. For example, if $D(1, 0) = D(0, 1) = 1$, then disclosure can be chosen *unilaterally* by each group member,

[9] Indeed, previous literature, such as Gerardi and Yariv (2007), highlights the interplay of formal rules and communication in shaping equilibrium behavior in a deliberative committee.

since the probability of disclosure is 1 when at least one group member recommends it. In contrast, if $D(1,0) = D(0,1) = 0$, disclosure only happens if it is a *consensus* decision across the group members (that is, if both group members recommend it).

**Payoffs and Equilibrium.** Once the group makes its disclosure decision, the outcome is accordingly seen/not seen by the outside observer, who then forms a posterior belief about the outcome that led to that observation. If $\omega$ is disclosed, then the observer perfectly understands it and group member $i$'s payoff is equal to the realized $\omega_i$, for each $i \in N$. If instead $\omega$ is not disclosed, then $i$'s payoff is equal to the observer's mean posterior about $\omega_i$, given by

$$\omega_i^{ND} \equiv \mathbb{E}\left[\omega_i|\text{no disclosure}\right] = \frac{\sum_{\Omega} \omega_i (1 - d(\omega))\mu(\omega)}{\sum_{\Omega}(1 - d(\omega))\mu(\omega)}, \tag{1}$$

if $\sum_{\Omega}(1 - d(\omega))\mu(\omega) > 0$. Note that if no disclosure is an off-path (measure zero) event, then the observer's mean posterior is indeterminate. Throughout the paper, we refer to $\omega_i^{ND}$ as the observer's *no-disclosure belief* about $i$'s value. These no-disclosure beliefs are equilibrium objects, computed under the premise that the observer understands the groups' disclosure strategy $d$; this entails that the observer understands group members' equilibrium disclosure recommendation strategies as well as the procedure $D$ that aggregates these individual recommendations.

Our equilibrium notion is weak Perfect Bayesian Equilibrium.We further refine the equilibrium set in two ways. We focus on weak PBEs in which: (i) each individual makes disclosure recommendations based only on their own outcome value, that is, for each $i \in N$ and each $\omega, \omega' \in \Omega$ with $\omega_i = \omega_i'$, $x_i(\omega) = x_i(\omega')$; and (ii) each individual makes disclosure recommendations as if they are pivotal, that is, for each $i \in N$ and $\omega \in \Omega$, $\omega_i > \omega_i^{ND} \Rightarrow x_i(\omega) = 1$ and $\omega_i < \omega_i^{ND} \Rightarrow x_i(\omega) = 0$. As usual in voting models, we impose these refinements to rule out equilibria in which individuals position themselves for/against disclosure solely because they believe themselves not to be pivotal, and the equilibrium strategies indeed support that their recommendations are not pivotal.[10] [11] Throughout the paper, we refer to a weak PBE that satisfies

[10]For example, if the procedure $D$ is the majority rule, so that the group discloses if at least $n/2$ members recommend disclosure, then there exists an equilibrium in which all group members always recommend no disclosure (for all outcomes). If the entire group recommends no disclosure, then one individual's recommendation to disclose would not change the group's decision, because it would not change the majority recommendation, and so each individual is indifferent between recommending disclosure or no disclosure of each outcome, and therefore willing to always recommend no disclosure. In this case, individual recommendations do not necessarily reflect their preferences, because their recommendations are not pivotal.

[11]If the procedure $D$ is such that *every group member is active* — that is, for each $i \in N$, there exists $x_{-i} \in [0,1]^n$ such that $D(x_i = 1, x_{-i}) > D(x_i = 0, x_{-i})$ — then refinement (ii) corresponds to the requirement that agents do not play weakly dominated strategies. Moreover, given (ii), requirement (i) binds only when an outcome realization is such that $\omega_i = \omega_i^{ND}$ for some group member $i$; in that case, in which $i$ is indifferent between disclosure or non-disclosure, (i) requires that $i$ does not correlate their disclosure recommendation with

(i) and (ii) simply as *equilibrium*.

# 3 Equilibrium Group Disclosure

Our first main result, Theorem 1, highlights that equilibrium play in the group disclosure game differs qualitatively from what arises in a parallel model where disclosure decisions are made by single individuals, for example as in Milgrom (1981) or Grossman (1981). This previous literature shows that full disclosure is the only possible equilibrium outcome in a single-agent disclosure model. In such an environment, "no disclosure" is a message that is interpreted by the observer with skepticism, as they understand the absence of disclosure to be a strategic choice by the sender, whose value realization must be low. This equilibrium skepticism in turn implies that not disclosing yields a low value to the sender, who instead prefers to disclose all but perhaps their very lowest possible value realizations. Theorem 1 instead shows that this "unravelling" dynamic does may not arise in the group disclosure game, which typically has equilibria in which some outcomes are not disclosed to the observer.

Specifically, equilibria without full disclosure exist when the group's deliberation procedure is such that not every group member has the power to enforce the disclosure of an outcome. Formally, we say that group member $i$ *can unilaterally choose disclosure* if the deliberation procedure is such that $x_i = 1$ implies $D((x_i, x_{-i})) = 1$. Moreover, we say that an equilibrium has full disclosure if the observer can always perfectly infer the realized outcome $\omega \in \Omega$ on path; or, equivalently, if there is at most one $\omega \in \Omega$ that is not disclosed (i.e, such that $d(\omega) < 1$).

**Theorem 1.** *Given a deliberation procedure $D$, let $I \subseteq N$ be the set of group members who can unilaterally choose disclosure.*

1. *A full-disclosure equilibrium exists, and an equilibrium without full disclosure exists if and only if $I \neq N$.*

2. *In any equilibrium without full disclosure,*

$$\omega_i^{ND} \begin{cases} = \min(\Omega_i), \text{ if } i \in I \\ > \min(\Omega_i), \text{ if } i \notin I. \end{cases}$$

A full proof of Theorem 1 is available in Appendix A. The theorem first shows that equilibria without full disclosure exist when the group's deliberation procedure is such that not every

the outcome's value to other group members. Condition (i) would be moot if outcome values were distributed continuously, so that realizations in which $\omega_i = \omega_i^{ND}$ for some group member $i$ would constitute a set with zero measure.

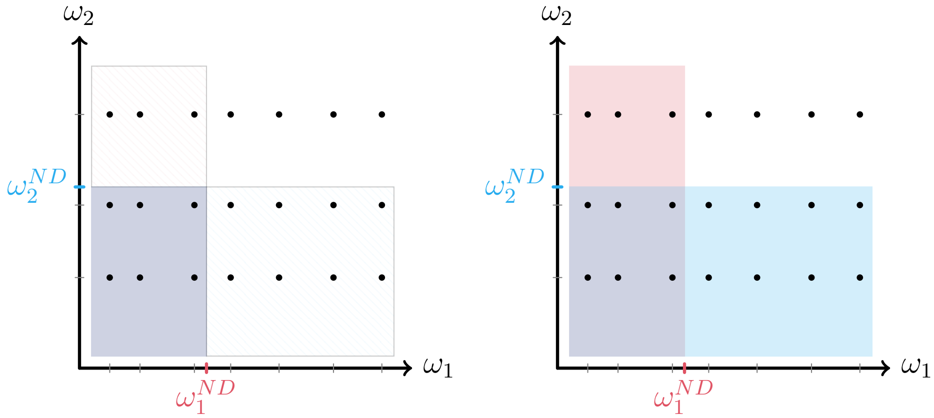


**Figure 1:** Both panels depict candidate equilibria without full disclosure for a group with $n = 2$ group members. The left-hand panel supposes the deliberation procedure is such that both group members can unilaterally choose disclosure. The right-hand panel supposes the deliberation procedure is such that disclosure decisions must be made via consensus.

group member can unilaterally choose disclosure — that is, if the group's procedure $D$ is not the *unilateral* deliberation procedure, according to which $D(x) = 1$ if $x_i = 1$ for any $i \in N$.

To understand the relationship between the deliberation procedure and the existence of an equilibrium without full disclosure, refer to Figure 1. In each panel, the figure depicts the space of possible group outcomes in a two-person team, with values for group member 1 plotted on the $x$-axis and values for group member 2 on the $y$-axis. Let's conjecture that an equilibrium without full disclosure exits, in which $\omega_1^{ND} > \min(\Omega_1)$ and $\omega_2^{ND} > \min(\Omega_2)$. Given this pair of beliefs, individual rationality for group member $i$ implies that they recommend the disclosure of an outcome if and only if the realization of $\omega_i$ is larger than the conjectured $\omega_i^{ND}$. In both panels of Figure 1, the red-shaded area depicts group outcomes that group member 1 recommends to conceal and the blue-shaded area represents those that agent 2 recommends to conceal.

These individual recommendations must then be aggregated according to the group's deliberation procedure in order to reach the group's disclosure strategy. Suppose first that $D$ is such that both group members can unilaterally choose disclosure. In this case, given the individual recommendations, the group's disclosure strategy is to conceal only outcomes with $\omega_1 \leqslant \omega_1^{ND}$ *and* $\omega_2 \leqslant \omega_2^{ND}$ — as plotted in the purple-double-shaded rectangle on the left panel of Figure 1. Finally note that the initially conjectured beliefs $\omega_1^{ND}$ and $\omega_2^{ND}$ cannot be consistent with the group's disclosure strategy — and therefore cannot constitute an equilibrium — for every concealed outcome has a worse value for each individual than these initial conjectures.

The same logic applies to any starting pair of beliefs that could support an equilibrium without full disclosure, in which $\omega_1^{ND} > \min(\Omega_1)$ or $\omega_2^{ND} > \min(\Omega_2)$, so we conclude that an equilibrium without full disclosure cannot be supported when the group uses the unilateral deliberation procedure. Our argument is a straightforward generalization of the usual "unravelling" logic to multiple dimensions: if the group uses the unilateral procedure, then any equilibrium in which the observer is not fully skeptical about both group members "unravels" both in terms of group member 1's value and of group member 2's value.

Suppose instead that the group's deliberation procedure is such that disclosure must be chosen via consensus, so that neither group member can unilaterally enforce disclosure. In this case, both the red- and the blue-shaded areas are not disclosed by the team, for at least one of the group members recommends that each of those outcomes be concealed: the entire L-shaped region in the right panel of Figure 1 comprises the set of outcomes that are not disclosed by the group. In this L-shaped no disclosure region, there are some outcome realizations that are "good news" for group member 1, with $\omega_1$ larger than the initially conjectured $\omega_1^{ND}$ which are not disclosed because group member 2 favors their concealment; and likewise the disclosure of some "good news" about individual 2 ($\omega_2 > \omega_2^{ND}$) is blocked by group member 1. A consequence is that the Bayes-consistent update made by the observer upon seeing no disclosure is not necessarily lower than the initially conjectured no disclosure beliefs. The Theorem exactly states that there is at least one such initially conjectured pair of beliefs of no disclosure that satisfies Bayes-consistency.

The existence of an equilibrium without full disclosure in this case — and the failure of the "unravelling" argument — rests on the fact that, when no disclosure happens, the observer understands that strategic decision to mean that the realized outcome has a low value for one or more of the group members, each of whom have the power to enforce no disclosure as the collective decision, but the observer cannot fully attribute that decision to either of the two group members. This imperfect attribution generates some complementarity in the group members' disclosure recommendation strategies: each group member is willing to sometimes recommend no disclosure, because they know that their partner also does so, which allows them to "plausibly deny" their role in the group's decision. If instead one's partner (or partners) were to always recommend disclosure, there would be no plausible deniability, and therefore one's incentives would be to always recommend disclosure as well.

Indeed, we also show that an equilibrium with full disclosure, in which every group member always recommends disclosure, exists regardless of the group's deliberation procedure. To see this, suppose that the observer's no-disclosure beliefs satisfy $\omega_i^{ND} = \min(\Omega_i)$ for every group member $i \in N$. In that case, every group member is willing to recommend the disclosure of all outcomes — for no outcome yields a strictly worse payoff than the observer's no disclosure belief — and consequently the groups's unanimous recommendation to disclose each outcome is enforced as the group's collective decision. In turn, because all outcomes are disclosed, no disclosure happens only off the equilibrium path and therefore the observer's beliefs we conjectured are consistent with Bayes updating.

Finally, the second statement in the theorem distinguishes between group members who can and cannot unilaterally choose disclosure in terms of the observer's beliefs of no disclosure: no disclosure is interpreted with maximal skepticism about the value of any group member $i$ who can unilaterally choose disclosure — that is, $\omega_i^{ND} = \min(\Omega_i)$, the worst possible realization of $i$'s value — but not so for the value of group members who cannot unilaterally choose to disclose. The relation between an individual's power to choose disclosure on behalf of the group and individual skepticism (which we further explore in section 5.2) is a new mechanism introduced in an environment of group communication: the interpretation of messages coming from the group (in this case, the "no disclosure message") depends on the audience's perception of the balance of power in that group.

# 4 The Set of Equilibria without Full Disclosure

Theorem 1 shows that equilibria without full disclosure exist in the group disclosure game for almost all deliberation procedures (with the exception of the procedure in which every group member can unilaterally choose disclosure). In this section, we further characterize the set of equilibria without full disclosure, describing how its features relate to the group's deliberation procedure and to the outcome distribution. We first introduce two examples that describe various possible features of the equilibrium set.

In example 4.1.1, we show that, fixing the distribution of outcomes, the set of equilibria without full disclosure can look qualitatively different depending on the deliberation procedure used by the group. Specifically, there is a unique equilibrium without full disclosure when the deliberation procedure is sufficiently close to either the consensus or the unilateral procedure. For intermediate procedures, the equilibrium set has multiple elements, including asymmetric equilibria, despite the environment being fully symmetric environment. Moreover, these equilibria cannot be ranked in terms of the "amount of disclosure:" in one of them, there is more disclosure of outcomes with low values for agent 1, while the other features more disclosure of outcomes with low values for agent 2.

Example 4.1.2 introduces another symmetric environment in which there are multiple equilibria without full disclosure. In this case, both equilibria are symmetric and can be ranked in terms of the amount of disclosure. In this example, the equilibrium set admits extremal equilibria: it has an equilibrium with least disclosure (the full disclosure equilibrium) and an equilibrium with least disclosure. In the rest of the section, we argue that the existence of extremal equilibria arises in "regular" environments in which the disclosure game is a game of strategic complements between the group members. We also provide conditions on the model primitives — the distribution of outcomes and the deliberation procedure — under which the game indeed has strategic complementarities.

## 4.1 Illustrative Environments

### 4.1.1 Example 1

Suppose there are two group members, and the deliberation procedure and distribution of outcome values are symmetric. Specifically, let $D(0,0) = 0$, $D(1,1) = 1$, and $D(1,0) = D(0,1) = \delta < 1$. And let the set of possible outcome values be $\Omega = \Omega_1 \times \Omega_2$, with $\Omega_1 = \Omega_2 = \{1, 2, 11\}$. Outcomes $\omega = (1,2)$ and $\omega = (2,1)$ occur with probability $4/15$ each, while every other possible outcome occurs with probability $1/15$. We will describe the set of (pure strategy) equilibria without full disclosure for three cases: when $\delta$ is low, when $\delta$ is high, and for intermediate values of $\delta$. The detailed algebra for each of these cases is available in Appendix E.

*Case 1.* Low values of $\delta$: $\delta \leqslant 12/17$. When $\delta$ is low, each group member has little power to unilaterally enforce the disclosure of the realized outcome. In particular, if $\delta = 0$, the procedure corresponds to the consensus procedure, according to which disclosure decisions must be reached via consensus. When $\delta$ is low enough, there is a unique equilibrium without full disclosure, in which each group member recommends disclosure if and only if their own realized value is $11$.

*Case 2.* High values of $\delta$: $\delta \geqslant 3/4$. When $\delta$ is high, each group member has large power to unilaterally enforce the disclosure of the realized outcome. In particular, if $\delta \to 1$, the protocol approaches the unilateral procedure. When $\delta$ is high, there is a unique equilibrium without full disclosure, in which each group member recommends disclosure if and only if their own realized value is either $2$ or $11$.

*Case 3.* Intermediate $\delta$ values: $\delta \in (12/17, 3/4)$. These procedures are sufficiently far from both the unilateral and consensus deliberation procedures. In this case, despite the environment being symmetric — both in terms of the deliberation procedure and of the outcome distribution — there exist only two pure-strategy equilibria without full disclosure, which are both *asym-*

*metric*.[12] In each of the two asymmetric equilibria, one group member (group member 1, say) recommends no disclosure if and only if their outcome value is 1, and one group member (say, group member 2) recommends no disclosure if and only if their outcome value is either 1 or 2.

#### 4.1.2 Example 2

Again, let us consider a symmetric environment, with a group that has two group members. Suppose the deliberation procedure is the consensus procedure: $D(0,0) = 0$, $D(1,1) = 1$, and $D(1,0) = D(0,1) = 0$. The set of possible outcome values is $\Omega = \Omega_1 \times \Omega_2$, with $\Omega_1 = \Omega_2 = \{1, 2, 4\}$. Outcomes $\omega = (1,1)$, $\omega = (2,4)$ and $\omega = (4,2)$ occur with probability $4/18$ each, while every other possible outcome occurs with probability $1/16$. In this environment, we have two equilibria without full disclosure, which are both symmetric and ranked in terms of the "amount of disclosure."

In the first equilibrium, each group member recommends no disclosure if and only if they draw an outcome value of 1. In the second equilibrium, each group member recommends no disclosure if and only if their drawn outcome value is either 1 or 2. In this second equilibrium, aggregating the individual strategies according to the consensus procedure, we find that all outcomes in which at least one group member has a value of 1 or 2 are not disclosed. It therefore induces strictly less disclosure than the first equilibrium, in which only outcomes in which at least one group member drew a value of 1 are not disclosed.

### 4.2 Group Disclosure as a Game with Strategic Complementarity

As discussed in section 3, when not all group members can unilaterally enforce disclosure, the imperfect attribution of blame for no disclosure creates some strategic complementarities between group members. We now investigate conditions on primitives — the distribution of outcomes and the deliberation procedure — under which the group disclosure game has strategic complementarities over the whole strategy space, that is, in which each group member's incentives to recommend no disclosure are increasing in the "amount" of no disclosure recommended by their partners.

In any equilibrium in pure strategies, each group member uses a threshold strategy: there is some $t_i \in \Omega_i$ such that $i$ recommends disclosure ($x_i(\omega) = 1$) if $\omega_i > t_i$, and recommends no disclosure ($x_i(\omega) = 0$) if $\omega_i \leqslant t_i$. For each vector of threshold strategies $t_{-i} \in \times_{j \neq i} \Omega_j$ for $i$'s fellow group members, using threshold $t_i$ is *individually rational* for $i$ if $t_i \leqslant$

[12]There exists also a mixed-strategy equilibrium which is symmetric. This symmetric equilibrium cannot be ranked with the two asymmetric equilibria in terms of the "amount of disclosure."

$\mathbb{E}[\omega_i|$ no disclosure, $(t_i, t_{-i})]$ and $\mathbb{E}[\omega_i|$ no disclosure, $(t_i, t_{-i})] \leqslant t_i^+$, where $t_i^+$ is the lowest value in $\Omega_i$ that is strictly larger than $t_i$. That is, $t_i$ is individually rational if, given that the observer understands that the group is using strategies $(t_i, t_{-i})$, their belief of no disclosure about $i$'s value is weakly larger than $t_i$ — so that $i$ indeed wants to conceal realizations in which their own value is weakly lower than $t_i$ — and lower than $t_i^+$ — so that $i$ indeed wants to disclose outcomes in which their own value is strictly larger than $t_i$.

We say that the group disclosure game *has strategic complementarities* if each group member $i$'s individually rational threshold is increasing in the other group members' thresholds $t_{-i}$. In Appendix B, we define this notion formally, accounting for group members' possible use of mixed recommendation strategies.

To understand the mechanism behind strategic complementarity in the group disclosure game, consider a group with $n = 2$. Fixing a strategy for group member $i$, the more often $i$'s partner recommends "no disclosure" — that is, the larger the threshold $t_{-i}$, the less the observer "blames" $i$ when the group chooses not to disclose: upon seeing no disclosure, the observer's perception of $i$'s value of no disclosure, $\omega_i^{ND}$, is higher. This increased perception in turn makes $i$ more willing to conceal realizations, increasing $i$'s individually rational threshold $t_i$. This simplistic intuition exactly describes how group members' disclosure thresholds are strategic complements in a group with $n = 2$ when the distribution $\mu$ is such that outcome values are independent across group members. However, it misses additional factors that may arise in environments where group members' values are negatively correlated (as in both examples explored early in this section), and when the group may comprise more than two individuals.

### 4.2.1 Primitives and Strategic Complementarity

For the remainder of the paper, we use the following notation to describe the group's deliberation procedure: for each $I \subseteq N$, we let $D(I) = D(x_I)$, where $x_I$ is the vector with $x_i = 1$ for all $i \in I$ and $x_i = 0$ otherwise. $D(I)$ is, therefore, the probability of disclosure when $I$ is the set of group members who recommend disclosure.

We denote by $\mathcal{D}$ the set of possible deliberation procedures for group $N$, those that satisfy Assumption 2.[13] We say that $D \in \mathcal{D}$ is a *restricted-consensus* procedure if there exists some $I \subseteq N$ such that: (i) $D(J) = 1$ if $J \cap I \neq \varnothing$; and (ii) $D(J) = 0$ if $J \cap I = \varnothing$ and $J \cup I \neq N$. In words, condition (i) states that every group member in the set $I$ has the power

[13] The set $\mathcal{D}$ is convex and compact, given by

$$\mathcal{D} := \{(D(I))_{I \subseteq N} : D(I) \in [0,1], D(\varnothing) = 0, D(N) = 1, \text{and } I \subseteq J \Rightarrow D(I) \leqslant D(J)\}.$$

to unilaterally choose disclosure. Condition (ii), in turn, states that if no group member in $I$ recommends disclosure, then disclosure can only be implemented if it is chosen by consensus among the group members not in $I$. Note, in particular, that the consensus procedure is a restricted-consensus procedure, with $I = \varnothing$; and so is the unilateral procedure, with $I = N$.

Finally, given suppose $I$ is the set of group members who can unilaterally choose disclosure. We define the *restricted disclosure game* to be the game that arises when every group member $i \in I$ recommends "no disclosure" if and only if they draw their worst possible value, $\min(\Omega_i)$.[14] If the original deliberation procedure $D$ is such that no group member can unilaterally choose disclosure, then the restricted game coincides with the original game. If $D$ is the unilateral procedure, then the restricted disclosure game is empty. In that case, for the statement of Theorem 2, we say by convention that the restricted disclosure game has strategic complementarities.

**Theorem 2.** *For each outcome distribution $\mu$, there exists a set of deliberation procedures $\mathbb{D}$, which includes every restricted-consensus procedure, such that if the group's deliberation procedure is $D \in \mathbb{D}$, the restricted disclosure game has strategic complementarities.*

*When that is the case, the original group disclosure game has extremal equilibria: there exists an equilibrium with **most disclosure** — the full disclosure equilibrium — and an equilibrium with **least disclosure**, i.e., an equilibrium in which each outcome $\omega$ is disclosed with lower probability than in any other equilibrium.*

A full proof of the theorem is available in Appendix B. For an intuition, let's consider the case in which the group uses the consensus deliberation procedure, in which every group member has the power to veto disclosure. Fix a disclosure threshold $t_i$ for group member $i$, and consider an increase in the other group members' disclosure thresholds. All realizations below threshold $t_i$ are necessarily concealed (regardless of $i$'s partners' recommendations), because $i$ vetoes their disclosure, but an increase in $i$'s partners' strategies implies an increase in the concealment of realizations that are above $t_i$. This change thus leads to an improvement in the observer's belief of no disclosure about $i$'s value, which in turn makes "no disclosure" a more attractive option for $i$. Group member $i$ thus increases their own recommendation threshold after the increase in their partners' thresholds, which establishes the strategic complementarity in group members' disclosure recommendations.

[14] In other words, the restricted game is the group disclosure game for the group $N \setminus I$, with deliberation procedure $\hat{D} : \mathcal{P}(N \setminus I) \to [0, 1]$ given by $\hat{D}(J) = D(J)$ for every $J \subseteq N \setminus I$ and outcome distribution $\hat{\mu}$ with support $\times_{i \in N \setminus I} \Omega_i$ satisfying

$$\hat{\mu}(\hat{\omega}) = \mu\left(\omega_j = \hat{\omega}_j \text{ for each } j \in N \setminus I | \omega_i = \min(\Omega_i) \text{ for each } i \in I\right).$$

The same intuition applies for other restricted-consensus procedures, for example for one in which $I$ is the set of group members who can unilaterally choose disclosure. In that case, per Theorem 1, in any equilibrium without full disclosure, it must be that $\omega_i^{ND} = \min(\Omega_i)$ for every $i \in I$. This implies that in any such equilibrium, every outcome realization $\omega$ with $\omega_i > \min(\Omega_i)$ for some $i \in I$ is necessarily disclosed to the observer. Effectively, this means that the non-trivial disclosure game happens only in the subset of outcome realizations in which $\omega_i = \min(\Omega_i)$ for every $i \in I$. This non-trivial game is exactly our previously defined "restricted disclosure game." Because the group uses a restricted-consensus procedure, the logic establishing strategic complementarities under the consensus procedure (described in the previous paragraph) applies to the restricted game.

Once we establish that there exists a set of deliberation procedures for which the (restricted) game has strategic complementarities, we can adapt standard techniques from the literature on games with strategic complementarities to show that there exists an extremal equilibrium with least disclosure.[15] Moreover, we already know from Theorem 1 that an equilibrium with most disclosure exists, which is the full disclosure equilibrium. Proposition 1 provides further characterization of the set $\mathbb{D}$, relating it to features of the outcome distribution $\mu$.

**Proposition 1.**

1. *If $n = 2$, we say that group members' outcome values are **weakly positively correlated** if for each $i \in \{1, 2\}$, $\mu_i(\omega_i|\omega_j)$ is weakly increasing in $\omega_j$ in the likelihood ratio order. When that is the case, the restricted game has strategic complementarities for any deliberation procedure $D$, so that $D \in \mathbb{D}$.*

2. *Let $n \geqslant 2$ and suppose $\mu$ is such that group members' outcome values are **independently distributed**. The restricted game has strategic complementarities — $D \in \mathbb{D}$ — if the deliberation procedure $D$ is **restricted-supermodular**,[16] that is,*

$$D(K) - D(K \setminus \{i\}) \geqslant D(J) - D(J \setminus \{i\}) \text{ for all } i \in N \setminus I \text{ and } J \subseteq K \subseteq N \setminus I,$$

*where $I$ is the set of group members who can unilaterally choose disclosure.*

[15] Our argument follows those in Vives (1990) and Milgrom and Roberts (1990), which consider games with strategic complementarities; and more closely Van Zandt and Vives (2007), which considers Bayesian games with strategic complementarities.

[16] If $I = \varnothing$, the set of procedures described in the second statement are *supermodular* in the sense that the increase in disclosure probability from an additional group member recommending disclosure is larger the larger is the (non-empty) starting set of group members recommending disclosure. If some group members can unilaterally choose disclosure, so that $I \neq \varnothing$, then $D \in \mathbb{D}$ if the deliberation procedure is supermodular among the group members who cannot unilaterally choose disclosure.

If a group has only two members, then their values being positively correlated is a sufficient condition for the game to have strategic complementarities. Indeed, note that in Example 4.1.1, in which the game does not have strategic complementarities for intermediate values of $\delta$, we had negative correlation in the outcome values to group members $1$ and $2$.

Consider instead a group with more than two members, whose values are independently distributed. An increase in the disclosure thresholds $t_{-i}$ at once increases the concealment of good realizations of $i$'s value (those above $t_i$) and the concealment of bad realizations of $i$'s value (those below $q_i$). The relative importance of these two effects depends on how an increase in $t_{-i}$ changes $i$'s pivotality in the group's decision. If $D$ is supermodular (or restricted-supermodular, when we consider the restricted game), then $i$'s disclosure recommendation is more pivotal when the set of group members who recommend disclosure is larger. So, when $t_{-i}$ increases, the set of group members (other than $i$) who recommend the disclosure of each outcome decreases, and so $i$ becomes relatively less pivotal in the group's decision to disclose. In this case, the first effect dominates the second, which guarantees that group members' strategies are complements.

# 5 The Effect of Deliberation on Equilibrium Disclosure

Beyond determining whether the disclosure game has strategic complementarities, how does the power structure inherent to the group's deliberation procedure $D$ affect equilibrium communication? We provide two answers to this question, first by relating the group's procedure to the "amount of disclosure" that arises in equilibrium, and secondly by establishing a relationship between each group member's relative power in the group and the amount of skepticism about their own value inherent to the observer's equilibrium interpretation of "no disclosure."

## 5.1 The Amount of Equilibrium Disclosure

As a collective, the group can always choose to disclose or conceal an outcome — this is inherent to our assumption that the deliberation procedure respects unanimous decisions — but beyond unanimous decision, procedures can vary in terms of how easy it is for disclosure to be implemented. We say that *disclosure is easier* under a procedure $D'$ than under a procedure $D$ if $D'(J) \geqslant D(J)$ for every set $J \subseteq N$. Moreover, we say that *disclosure is proportionally easier* under a procedure $D'$ than under a procedure $D$ if

$$D'(J) = (1-\alpha)D(J) + \alpha \text{ for each } J \neq \varnothing, N, \text{ for some } \alpha \in [0,1].$$

This proportionality comes from the fact that the probability of disclosure $D'(J)$ is an increase over the probability $D(J)$ of the same magnitude $\alpha$ for each set $J$ of group members who recommend disclosure. The proportional increase in probability of disclosure guarantees that the "relative power" of each subset of individual group members to enforce disclosure is the same in $D$ and $D'$. Proposition 2 uses this ordering to establish comparative statics on the observer's equilibrium beliefs of no disclosure, and consequently on the "amount of disclosure" in the equilibrium. We say that an equilibrium *has more disclosure* than another if the probability that each outcome $\omega \in \Omega$ is disclosed is larger in the former than in the latter.

**Proposition 2.** *Consider $D, D' \in \mathbb{D}$ such that disclosure is proportionally easier under $D'$ than under $D$. The equilibrium with least disclosure under $D'$ has more disclosure than the equilibrium with least disclosure under $D$.*

This result can also be interpreted as comparative statics on the equilibrium set: because the equilibrium with most disclosure is unchanged across procedures, by establishing comparative statics for the equilibrium with least disclosure, Proposition 2 implies that, as disclosure becomes proportionally easier, the amount of disclosure in equilibrium increases in the weak set order sense. Formally, if $D, D' \in \mathbb{D}$ and disclosure is proportionally easier under $D'$ than under $D$, then for each equilibrium under $D$, there exists an equilibrium with more disclosure under $D'$, and for each equilibrium under $D'$, there exists an equilibrium with less disclosure under $D$.

Proposition 2 is reminiscent of comparative statics results in the Dye (1985) framework: in that environment, if $\alpha$ is the probability that the sender has access to evidence, then the amount of disclosure in equilibrium is increasing in $\alpha$. In contrast, in our environment the group always has access to evidence, and has complete power to disclose as a group; $\alpha$ instead is a measure of the power that each non-consensus subgroup has to enforce disclosure.

An implication of Proposition 2 is that the unilateral procedure is the one that induces most disclosure, as disclosure is proportionally easier in the unilateral procedure, compared to any other procedure. Indeed, we know from Theorem 1 that full disclosure is the unique equilibrium under that procedure. Interestingly, the consensus procedure, under which disclosure happens only if all group members recommend it, is not necessarily the procedure that induces least disclosure. More generally, non-proportional increases in the "ease of disclosure" do not necessarily increase the amount of disclosure in equilibrium, as illustrated in the following example.

### 5.1.1 Example 3

There are two group members, and the outcomes are uniformly distributed over the set $\Omega = \Omega_1 \times \Omega_2$, with $\Omega_1 = \Omega_2 = \{1, 3, 6\}$. We know from Proposition 1 that, in this case, for any de-

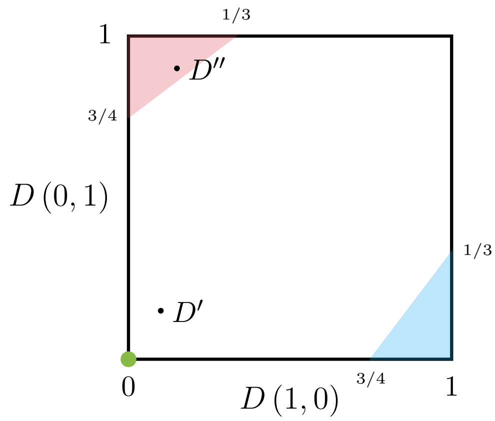


**Figure 2:** The set of deliberation procedures in Example 5.1.1. In a group with $n = 2$, the deliberation procedure is fully described by two numbers, $D(1, 0) \in [0, 1]$ and $D(0, 1) \in [0, 1]$, which are plotted in the $x$-axis and $y$-axis, respectively. The different colored regions correspond to deliberation procedures with different equilibria with least disclosure.

liberation procedure, the group disclosure game has an equilibrium with least disclosure. There are four regions of the space of deliberation procedures — described below and depicted in Figure 2 — that correspond to primitives under which the disclosure game has different equilibria with least disclosure. Detailed algebra for this example is available in Appendix E.

*Region 1.* (Depicted in green in Figure 2) The deliberation procedure is the consensus procedure, so that $D(1, 0) = D(0, 1) = 0$. In this case, the equilibrium with least disclosure corresponds to that in which each group member recommends disclosure if and only if their own outcome value is the highest possible, that is, $\omega_i = 6$.

*Region 2.* (Depicted in white in Figure 2) This region is described by $D(1, 0) \geqslant -1 + 4/3D(0, 1)$ and $D(0, 1) \geqslant -1 + 4/3D(1, 0)$, with at least one inequality being strict. In this case, the equilibrium with least disclosure corresponds to that in which each group member recommends "no disclosure" if and only if their own outcome value is the lowest possible, $\omega_i = 1$.

*Region 3.* (Depicted in blue in Figure 2) This region is described by $D(0, 1) \leqslant -1 + 4/3D(1, 0)$. In this case, the equilibrium with least disclosure corresponds to that in which group member $1$ recommends "no disclosure" if and only if their own outcome value is the lowest possible ($\omega_1 = 1$) and group member $2$ recommends disclosure if and only if their own outcome value is the highest possible ($\omega_2 = 6$).

*Region 4.* (Depicted in pink in Figure 2) This region is described by $D(1,0) \leqslant -1+4/3D(0,1)$. In this case, the equilibrium with least disclosure corresponds to that in which group member 2 recommends "no disclosure" if and only if their own outcome value is the lowest possible ($\omega_2 = 1$) and group member 1 recommends disclosure if and only if their own outcome value is the highest possible ($\omega_1 = 6$).

Given these regions, we can see that a non-proportional increase in the "ease of disclosure" does not necessarily lead to an increase in equilibrium disclosure. For illustration, consider procedure $D'$, in Region 2, and procedure $D''$, in Region 4, both indicated in Figure 2. These equilibria are ordered so that disclosure is easier under $D''$ than $D'$, but not proportionally so. Comparing equilibria under these to procedures, we find that there is no more disclosure under $D''$ than under $D'$ (or vice-versa). To see that, consider two particular specific outcomes, $(3,3)$ and $(1,6)$. Under deliberation procedure $D'$, the outcome $(3,3)$ is disclosed for sure, whereas under procedure $D''$, it is disclosed with probability $D''(0,1) < 1$. In contrast, under $D'$, the outcome $(1,6)$ is disclosed with probability $D'(0,1)$, whereas it is disclosed with probability $D''(0,1) > D'(0,1)$ under procedure $D''$.[17]

Also note that, in this example, disclosure is minimized when the group uses the consensus procedure. This is not true generally: if we slightly perturbed this example, so that the set of possible outcome values for each group member is $\Omega_i = (1, 3.1, 6)$, then the consensus procedure would be incorporated into Region 2, in which the equilibrium with least disclosure is the one in which each group member recommends no disclosure if and only if $\omega_i = 1$. In that case, there would be no procedure that minimizes disclosure, as the equilibria under some procedures in the white region are not comparable with those for procedures in the blue and pink regions in terms of "amount of disclosure."

## 5.2 Individual Power and Individual Skepticism

The vector of the observer's no-disclosure beliefs $\omega^{ND}$ in an equilibrium describes how skeptical the observer is about each individual's value after seeing "no disclosure" — a lower equilibrium $\omega_i^{ND}$ corresponds to more skepticism about $i$'s value. Our next exercise draws a relationship between each individual's power to enforce disclosure as the group's decision and the observer's skepticism about that individual's value. A blunt relation is already established by Theorem 1, which shows that the observer must be maximally skeptical about each individual who can unilaterally choose disclosure (that is, each individual who has full power to

[17] In this particular example, starting from $D''$ (or, indeed, any point in blue or pink area), increasing the ease of disclosure (even non-proportionally) leads to an increase in disclosure in the least-disclosure-equilibrium.

enforce disclosure as the group's decision). Proposition 3 introduces a more nuanced relationship, showing that the observer's equilibrium skepticism about $i$'s value must increase ($\omega_i^{ND}$ must decrease) after a small change in the group's deliberation procedure that increases $i$'s relative power within the group.

To that end, remember that the deliberation procedure can be fully described by a vector of $2^{|N|-2}$ numbers between $0$ and $1$ — $(D(J))_{\varnothing \neq J \subsetneq N}$ — which belong to a compact and convex vector space. And, when an equilibrium with least disclosure exists, let $\bar{\omega}_i$ be the observer's belief of no disclosure about $i$'s value in that equilibrium. Define the gradient $\nabla\bar{\omega}_i$ to be the following vector:

$$\nabla\bar{\omega}_i = \left(\frac{\partial\bar{\omega}_i}{\partial D(J)}\right)_{\varnothing \neq J \subsetneq N}.$$

In turn, a direction of change to a deliberation procedure is a vector $v = (v_J)_{\varnothing \neq J \subsetneq N}$.

The comparative statics exercise in Proposition 3 considers all directional derivatives $\nabla\bar{\omega}_i \cdot v$, with $i \in N$ and $v \in \mathbb{R}^{2^{|N|-2}}$. Starting from a deliberation procedure $D$, we say that a direction of change $v$ *increases group member $i$'s relative power* in the group if it satisfies

$$\min\left\{\frac{v_J}{1-D(J)} : i \in J \neq N\right\} \geqslant \max\left\{0, \max\left\{\frac{v_J}{1-D(J)} : i \notin J \neq \varnothing\right\}\right\}. \tag{2}$$

Conversely $v$ is a direction that *decreases group member $i$'s relative power* if it satisfies

$$\min\left\{0, \min\left\{\frac{v_J}{1-D(J)} : i \notin J \neq \varnothing\right\}\right\} \geqslant \max\left\{\frac{v_J}{1-D(J)} : i \in J \neq N\right\}. \tag{3}$$

Intuitively, a direction $v$ that increases group member $i$'s relative power is one that augments group member $i$'s ability to enforce the disclosure of the outcome, relative to a starting procedure $D$, and relative to the disclosure power of other members of the group. On the left-hand side of (2) is the minimum change in the probability of disclosure when $i$'s recommendation is to disclose — that is, when $i$ is a member of the subset $J$ of group members who recommend disclosure — relative to the probability that group $J$'s recommendation is not followed, according to the initial procedure $D$. On the right-hand side is the maximum change in the probability of disclosure after $i$ recommends not to disclose, relative to the initial procedure $D$.[18] Condition (3) analogously defines directions that decrease group member $i$'s ability to enforce the disclosure of an outcome.

Note that the definition directions that increase or decrease a group member's relative power is not exhaustive. In fact, there are directions that neither increase nor decrease the relative

[18] On the right-hand side, 0 is the change in the probability of disclosure after no group member recommends disclosure —remember that, by assumption 2, we fixed $D(\varnothing) = 0$.

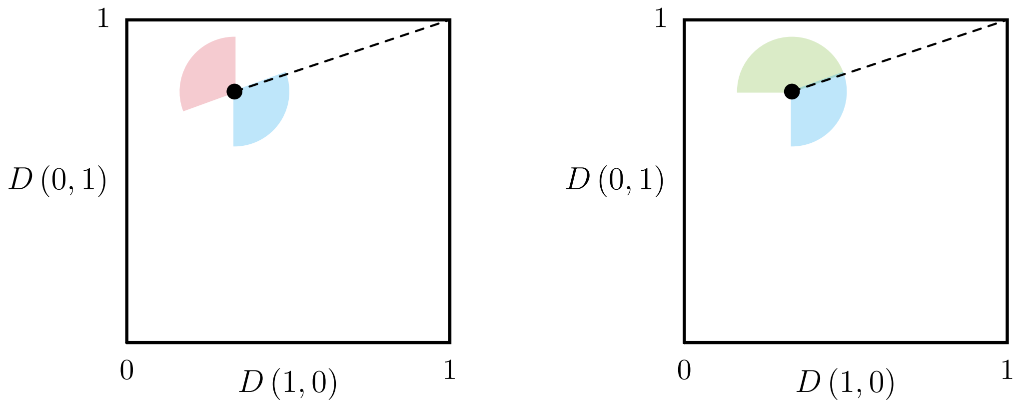


**Figure 3:** Both panels display directions of change in the deliberation procedure in a two-person team. The left panel depicts directions that increase (in blue) or decrease (in pink) group member 1's relative power, starting from an asymmetric procedure. The right panel depicts, for the same starting procedure, directions that increase group member 1's relative power (in blue) and those that increase group member 2's power (in green).

power of each particular group member. Moreover, even in groups with two members, directions that increase one group member's relative power do not necessarily decrease the other group member's power. Figure 3 illustrates these two points. In the left panel, we depict the directions of change that increase and decrease group member 1's relative power, in a group with two group members, starting from an asymmetric procedure in which group member 1 can enforce disclosure with a higher probability than group member 2. On the right panel, for the same starting procedure, we depict in blue directions that increase group member and in green those that increase group member 2's power (in green).

**Proposition 3.** *The gradients $\nabla\bar{\omega}_i$, for each $i \in N$, exist for almost all deliberation procedures $D \in int(\mathbb{D})$. When that is the case,*

- *If $v$ is a direction that increases group member $i$'s relative power, then $\nabla\bar{\omega}_i \cdot v \leqslant 0$, that is, the observer's no disclosure skepticism about $i$'s value increases in direction $v$.*
- *If $v$ is a direction that decreases group member $i$'s relative power, then $\nabla\bar{\omega}_i \cdot v \geqslant 0$, that is, the observer's no disclosure skepticism about $i$'s value decreases in direction $v$.*

Proposition 3, like Theorem 1, highlights a new mechanism inherent to strategic communication done by a group, compared to games in which communication is done by a single sender. In single-agent models of disclosure, the interpretation of strategic communication (and specifically of the "no disclosure" message) necessarily corresponds to maximal skepticism about the sender's value. In group disclosure, this interpretation depends also on the observer's perception of individuals' power to enforce their preferred action as the group's decision. disclosure as the group's decision: the more an individual has power over the group's decision, the more no disclosure decisions are attributed to them, and the more skeptical the observer must be about that individual in equilibrium. This new mechanism, and the empirical predictions it entails, is validated in an experimental setting by Avoyan and Onuchic (2024).

Given the ordering on group members' relative power that we introduced, a natural question is whether having more power increases an individual's payoff? Having greater power to determine disclosure, a group member is able to better align the group's disclosure decision with their own preferences, increasing disclosure of outcomes for which they have a high value and decreasing disclosure of less favorable outcomes. One could naively guess that this would increase the group member's ex-ante expected payoff. Proposition 3 challenges the intuition, showing that increasing a group member's power over the collective decision also leads to the outside observer accounting for that increased power when interpreting the group's no disclosure message, and therefore increasing their skepticism. In our setting, those two effects of increased power exactly compensate each other, and indeed each group member's ex-ante expected payoff is independent of the group's deliberation procedure (and equal to their expected value under the prior $\mu$).

# 6 Full Disclosure and Sequential Consistency

Throughout the paper, we relied on the equilibrium notion of weak PBE, which does not impose any restriction on the observer's beliefs that should follow off-path events. The disclosure game by definition imposes that, following the disclosure of any piece of evidence $\omega$, the observer's belief about each group member $i$'s value (and therefore the payoff to group member $i$) is equal to $\omega_i$. The beliefs that follow a "no disclosure message," on the other hand, are only determined in equilibrium. This has different implications for beliefs following no-disclosure in a full disclosure and in an equilibrium without full disclosure. In an equilibrium without full disclosure, the "no disclosure message" is used on-path with positive probability, and therefore the beliefs it induces in equilibrium are determined by Bayes-consistency. In turn, in a full disclosure equilibrium, "no disclosure" happens only off-path. Under the notion of weak PBE, the beliefs of no disclosure are thus not subject to any consistency requirements.

We now inspect the plausibility of the off-path beliefs of no disclosure that support full disclosure as an equilibrium. Specifically, we evaluate whether these beliefs are consistent with the aggregation of individual recommendation strategies via the team's deliberation procedure, using the notion of sequential consistency. A full disclosure equilibrium $(x, \omega^{ND})$ — our assessment — *satisfies sequential consistency* if there exists a sequence of recommendation strategy profiles and beliefs $(x^k, \omega^k)_{k=1}^{\infty}$ that converges to $(x, \omega^{ND})$ such that each strategy profile $x^k$ is completely mixed and beliefs $\omega^k$ are derived from $x^k$ using Bayes' rule. As with the assessment, we impose that each individual recommendation strategy in the sequence $x_i^k$ be a mapping only from $i$'s own value $\omega_i$ into a probability of recommending disclosure.[19]

Theorem 3 states a necessary and sufficient condition on a group's deliberation procedure $D$ for a full-disclosure equilibrium satisfying sequential consistency to exist.

**Theorem 3.** *A full-disclosure equilibrium satisfying sequential consistency exists if and only if the procedure $D$ is such that at least one group member can unilaterally choose disclosure.*

For an intuition on the proof — which is completed in Appendix D — suppose that there are only two group members. Suppose group member 1 can unilaterally choose disclosure. Then we can construct an assessment in which group member 1 always recommends disclosure, therefore inducing full disclosure, and in which the observer's beliefs of no disclosure are $\omega_1^{ND} = \min(\Omega_1)$ and $\omega_2^{ND} \geqslant \min(\Omega_2)$. These beliefs are consistent when we consider a sequence of completely mixed individual recommendation strategies such that, in the limit, no disclosure is necessarily attributed to a "mistake" in which group member 1 drew their worst possible value $\min(\Omega_1)$ and recommended no disclosure.[20]

If instead no group member can unilaterally choose disclosure, then a full disclosure assessment would necessarily have beliefs $\omega_1^{ND} = \min(\Omega_1)$ and $\omega_2^{ND} = \min(\Omega_2)$ and recommendation strategies where both group members always recommend disclosure. But for any sequence of completely mixed individual recommendation strategies, in the limit, no disclosure would most likely be attributed to a "minimal mistake" by a single group member, rather than to a "double mistake" where both group member 1 and group member 2 recommended no disclosure. Say the "minimal mistake" is due to group member 1. Because group member 1's strategies do not depend on group member 2's values, that means that the asymptotic probability that group member 2's worst possible value $\min(\Omega_2)$ is not disclosed is of the same order as that of another value $\omega_2 > \min(\Omega_2)$. This implies that the observer's consistent belief must be

[19] If we consider recommendation strategy profiles that map the set of possible outcomes $\Omega$ into probabilities of recommending disclosure, then there is always a full disclosure equilibrium satisfying sequential consistency.

[20] By Theorem 1, we know that an equilibrium without full disclosure exists in which $\omega_1^{ND} = \min(\Omega_1)$ and $\omega_2^{ND} > \min(\Omega_2)$. Consider the full-disclosure assessment made up of those beliefs and strategies $x_1(\omega) = 1$ for all $\omega$ and $x_2(\omega) = 1$ if $\omega_2 > \omega_2^{ND}$ and $x_2(\omega) = 0$ otherwise. Take the following sequence of completely mixed strategy profiles: $x_1^k(\omega) = 1 - 1/k$ if $\omega_1 = \min(\Omega_1)$ and $x_1^k(\omega) = 1 - 1/k^2$ if $\omega_1 \neq \min(\Omega_1)$; and $x_2^k(\omega) = 1 - 1/k$ if $\omega_2 \leqslant \omega_2^{ND}$ and $x_2^k(\omega) = 1/k$ if $\omega_2 > \omega_2^{ND}$. The limit beliefs of no disclosure given these strategies coincide with those in the original equilibrium without full disclosure, and we conclude that our full disclosure assessment satisfies sequential consistency.

such that $\omega_2^{ND} > \min(\Omega_2)$, which contradicts the construction of sequentially consistent beliefs in the full-disclosure equilibrium.

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# A Appendix to Section 3

## A.1 Proof of Theorem 1

### A.1.1 Proof of Statement 1

We first argue that a full-disclosure equilibrium always exists. Fix a deliberation procedure $D$, and let's construct an equilibrium with full disclosure. Suppose $\omega_i^{ND} = \min(\Omega_i)$ for every $i \in N$. Given these beliefs, the strategy $x_i(\omega) = 1$ for all $\omega$ is rational for each $i \in N$. Given these strategies, the probability of disclosure of outcome $\omega$ is $D(x(\omega)) = D((1, ..., 1)) = 1$. A consequence is that the "no disclosure message" is only sent off-path, which implies that the initially conjectured beliefs of no disclosure are consistent.

We now argue that an equilibrium without full disclosure exists when $D$ is such that not every group member can unilaterally choose disclosure. To that end, for each vector $v \in co(\Omega)$, let $\chi(v)$ be the set of threshold recommendation strategies defined by thresholds $v$, so that $x \in \chi(v)$ if, for each $i \in N$,

- $\omega_i = \min(\Omega_i)$ or $\omega_i < v_i \Rightarrow x_i(\omega) = 0$,
- $\omega_i = v_i > \min(\Omega_i) \Rightarrow x_i(\omega) = \alpha \in [0, 1]$,
- and $\omega_i > v_i \Rightarrow x_i(\omega) = 1$.

Now define a map $\Phi : co(\Omega) \rightrightarrows co(\Omega)$, which assigns to each vector $v \in co(\Omega)$ the set of beliefs of no disclosure that are consistent with group members using threshold recommendation strategies with thresholds $v$, as follows:

$$\Phi(v) = \left\{ \hat{\omega} \in co(\Omega) : \exists x \in \chi(v) \text{ s. t. } \hat{\omega}_i = \frac{\sum_\Omega \omega_i \left[1 - D\left(x(\omega)\right)\right] \mu(\omega)}{\sum_\Omega \left[1 - D\left(x(\omega)\right)\right] \mu(\omega)} \text{ for each } i \in N \right\}.$$

First note that $\Phi(v)$ is non-empty for every $v \in co(\Omega)$, because the set $\chi(v)$ is non-empty for each $v$. Moreover, due to the structure of the set $\chi(v)$, $\Phi(w)$ is a closed set for all $v \in co(\Omega)$; and $\Phi$ is upper-hemicontinuous. Therefore, $\Phi$ has a closed graph, and by the Kakutani fixed point theorem, $\Phi$ has a fixed point in $co(\Omega)$. It is easy to see that every fixed point $w \in \Phi(w)$ of the mapping $\Phi$ defines an equilibrium of the group disclosure game, with $\omega^{ND} = w$ and $x$ being the threshold recommendation strategies with thresholds $w$ that yield beliefs $w$.

Now assume $D$ is a deliberation procedure such that not every group member can unilaterally choose disclosure, and let $i$ be a group member who cannot unilaterally choose disclosure, so that $D(x_i \in [0, 1], x_{-i} = (0, ..., 0)) < 1$. Let $w \in \Phi(w)$ be a fixed point of $\Phi$, and let $x \in \chi(w)$. Then for every outcome $\omega$ such that $\omega_j = \min(\Omega_j)$ for every $j \neq i$, it must be that

$$d(\omega) = D(x(\omega)) = x_i \in [0, 1], x_{-i} = (0, ..., 0)) < 1.$$

This means that there are multiple outcome realizations that are not disclosed in the equilibrium defined by thresholds $w$; and we conclude that an equilibrium without full disclosure exists. $\square$

### A.1.2 Proof of Statement 2

**First point:** Let us first consider the set of group members that do not have the the power to unilaterally choose disclosure. We rely on the following claim:

**Claim 1.** *In any equilibrium without full disclosure, it must be that* $x_i(\min(\Omega_1), ..., \min(\Omega_n)) < 1$ *for each* $i \in N$.

*Proof of Claim.* Suppose by contradiction that $x_i(\min(\Omega_1), ..., \min(\Omega_n)) = 1$ for some $i \in N$ in an equilibrium without full disclosure. Then it must be that $x_i(\omega) = 1$ for every $\omega \in \Omega$, since $i$'s equilibrium recommendation strategies must be weakly increasing in $\omega_i$. If $i$ is a group member who can unilaterally choose disclosure, then every outcome $x_i(\omega) = 1$ implies that $\omega$ is disclosed with probability one; so that every outcome $\omega \in \Omega$ is disclosed, contradicting the assumption that the equilibrium does not entail full disclosure.

Suppose instead that $i$ is a group member who cannot unilaterally choose disclosure. Because the equilibrium does not have full disclosure, it must be that $d(\min(\Omega_1), ..., \min(\Omega_n)) < 1$; and, because $x_i(\omega) = 1$ for all $\omega$,

$$d(\min(\Omega_1), ..., \omega_i, ..., \min(\Omega_n)) = d(\min(\Omega_1), ..., \min(\Omega_n)) < 1,$$

so that every realization of $\omega_i \in \Omega_i$ is concealed with positive probability. This implies that $\omega_i^{ND} > \min(\Omega_i)$ in this equilibrium. But then individual rationality implies that $i$ recommends not to disclose when $\omega_i = \min(\Omega_i) < \omega_i^{ND}$, which contradicts our assumption that $x_i(\min(\Omega_1), ..., \min(\Omega_n)) < 1$. □

We now complete the proof of the statement. Fix an equilibrium without full disclosure. Suppose $i$ is a group member who cannot unilaterally choose disclosure. Because (by Claim 1) $d(\min(\Omega_1), ... \min(\Omega_n)) < 1$, and using the fact that $i$ cannot unilaterally choose disclosure, it must be that $d(\min(\Omega_1), ..., \omega_i, ..., \min(\Omega_n)) < 1$, so that every realization of $\omega_i \in \Omega_i$ is concealed with positive probability. This implies that $\omega_i^{ND} > \min(\Omega_i)$ in this equilibrium. □

**Second point:** Now turn to the group members that can unilaterally choose disclosure. Let $i$ be one such group member, so that the deliberation procedure is such that $D(x) = 1$ whenever $x_i = 1$. Suppose by contradiction that an equilibrium without full disclosure exists in which $\omega_i^{ND} > \min(\Omega_i)$. Then group member $i$'s disclosure recommendations must satisfy $x_i(\omega) = 1$ whenever $\omega_i > \omega_i^{ND}$; and thus $d(\omega) = D(x(\omega)) = 1$ for every such $\omega$. Consequently, $d(\omega) < 1$ implies $\omega_i \leqslant \omega_i^{ND}$ (fact 1). Next, observe that in any equilibrium, $x_i(\omega)$ is weakly increasing in $\omega_i$, and therefore $\omega \leqslant \omega'$ implies $d(\omega) = D(x(\omega)) \leqslant D(x(\omega')) = d(\omega')$; and in particular, $d\left((\min(\Omega_1), ..., \min(\Omega_n))\right) < 1$ in any equilibrium without full disclosure (fact 2).

Facts 1 and 2, along with assumption 1 which imposes that $\omega = (\min(\Omega_1), ..., \min(\Omega_n))$ is an outcome that happens with positive probability, imply that $\mathbb{E}[\omega_i|$ no disclosure$]$ is strictly smaller than the initially conjectured $\omega_i^{ND}$. This contradicts that the initial conjecture was indeed an equilibrium without full disclosure. Therefore, in any equilibrium without full disclosure, $\omega_i^{ND} = \min(\Omega_i)$ for every group member who can unilaterally choose disclosure. $\square$

# B Appendix to Section 4

## B.1 Definitions: Individual Rationality and Strategic Complementarity

A threshold disclosure recommendation strategy for group member $i$ can be described by the *quantile threshold* $q_i \in [0,1]$ such that $i$ recommends disclosure if and only if the quantile corresponding to their drawn outcome value is larger than $q_i$. More precisely, threshold strategy $q_i$ is to be interpreted as $i$ recommends no disclosure if the drawn outcome $\omega$ is such that $\mu_i(\omega_i) \leqslant q_i$, where $\mu_i$ is the marginal cdf describing the distribution of $i$'s outcome value; $i$ recommends disclosure if $\mu_i^-(\omega_i) := \lim_{w\uparrow\omega_i} \mu_i(w) > q_i$; and $i$ recommends disclosure with probability $\left[q_i - \mu_i^-(\omega_i)\right] / \left[\mu_i(\omega_i) - \mu_i^-(\omega_i)\right]$ if $\mu_i^-(\omega_i) \leqslant q_i < \mu_i(\omega_i)$.

Given a profile of threshold strategies $q = (q_i, q_{-i}) \in [0,1]^n$, and its mapping into group disclosure strategy through the deliberation procedure, let $W_i(q) = \mathbb{E}(\omega_i |\, \text{no disclosure}, q)$.[21] Given other group members' strategies $q_{-i}$, group member $i$'s strategy $q_i$ is *individually rational* if and only if

$$\mu_i^-\left(W_i(q_i, q_{-i})\right) \leqslant q_i \leqslant \mu_i\left(W_i(q_i, q_{-i})\right).$$

We define the *individual rationality mapping* for group member $i$, $\Psi_i : [0,1]^n \to 2^{[0,1]}$, as the set of individually rational threshold strategies for group member $i$, given $i$'s partners threshold strategies.[22] Formally:

$$\Psi_i(q_{-i}) = \left\{q_i \in [0,1] : \mu_i^-\left(W_i(q_i, q_{-i})\right) \leqslant q_i \leqslant \mu_i\left(W_i(q_i, q_{-i})\right)\right\}. \tag{4}$$

**Definition 1.** *The group disclosure game* ***has strategic complementarities*** *if for each $i \in N$, the mapping $\Psi_i$ is increasing in other group members' disclosure thresholds, $q_{-i}$. That is, $q'_{-i} \geqslant q_{-i}$ implies $\Psi_i(q'_{-i}) \geqslant_{sso} \Psi_i(q_{-i})$, where $\geqslant_{sso}$ indicates strong set ordering.*[23]

[21] If no disclosure is an event with measure 0 given $q$, then we let $W_i(q) = \min(\Omega_i)$.

[22] Note that we have not used the term "best response" to describe the mapping $\Psi_i$. The group disclosure game has $n+1$ players, the group members and the outside observer. Fixing all other players' strategies and beliefs, group member $i$'s best response is simply to recommend disclosure when they draw an outcome larger than the observer's (fixed) belief of no disclosure about $i$'s value. This is not the mapping that is being captured by $\Psi_i$, which instead describes $i$'s "individually rational" disclosure recommendation strategy, taking into account the effect of that strategy on the observer's belief of no disclosure, as described by $W_i(q_i, q_{-i})$.

[23] The definition of strong set ordering is in Milgrom and Shannon (1994). Consider two sets of real numbers $A$ and $B$. $A \geqslant_{sso} B$ if, for any pair $\{a, b\}$, with $a \in A$ and $b \in B$, we have $\max\{a, b\} \in A$ and $\min\{a, b\} \in B$..

## B.2 Proof of Theorem 2

This proof consists of four steps. Step 1 provides a characterization of the individual rationality mapping $\Psi_i$. Step 2 considers an environment in which the group's deliberation procedure $D$ is the consensus procedure, and argues that the group disclosure game has strategic complementarities. Step 3 generalizes that argument to show that the restricted game has strategic complementarities when the deliberation procedure is a restricted-consensus procedure. Finally, step 4 argues that, when the restricted game has strategic complementarities, the equilibrium set has extremal equilibria.

**Step 1.** Fix a strategy profile $q$. For each group member $i$, $i$'s outcome value realization $\omega_i$, and set of group members $J \in N \setminus \{i\}$, let $\phi_{q_{-i}}(J|\omega_i)$ be the probability that exactly the set $J$ of group members other than $i$ recommends "no disclosure" conditional on $i$'s value realization $\omega_i$. Note that $\phi_{q_{-i}}(J|\omega_i)$ is fully determined by $q_{-i}$, and does not depend on $q_i$. We will characterize the best response mapping $\Psi_i(\cdot)$ using condition

$$v_i = \frac{\sum_{\omega_i \geqslant v_i} \omega_i \mu_i(\omega_i) \sum_{i \neq J \subset N} C(J)\phi_{q_{-i}}(J|\omega_i) + \sum_{\omega_i < v_i} \omega_i \mu_i(\omega_i) \sum_{i \neq J \subset N} C(J \cup \{i\})\phi_{q_{-i}}(J|\omega_i)}{\sum_{\omega_i \geqslant v_i} \mu_i(\omega_i) \sum_{i \neq J \subset N} C(J)\phi_{q_{-i}}(J|\omega_i) + \sum_{\omega_i < v_i} \mu_i(\omega_i) \sum_{i \neq J \subset N} C(J \cup \{i\})\phi_{q_{-i}}(J|\omega_i)},$$

where we use notation $C(J) = 1 - D(N \setminus J)$, for all $J \subset N$. We can rewrite this condition as

$$\sum_{\omega_i \geqslant v_i} (\omega_i - v_i)\mu_i(\omega_i) \sum_{i \neq J \subset N} C(J)\phi_{q_{-i}}(J|\omega_i) = \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i) \sum_{i \neq J \subset N} C(J \cup \{i\})\phi_{q_{-i}}(J|\omega_i). \tag{5}$$

Note that the left-hand side of (5) is continuously decreasing in $v_i$ and the right-hand side is continuously increasing in $v_i$, so that there is a unique $\tilde{v}_i$ that satisfies (5). Then $\Psi_i(\cdot)$ is

$$\Psi_i(q_{-i}) = [\mu_i^-(\tilde{v}_i), \mu_i(\tilde{v}_i)], \tag{6}$$

which is a proper interval if $\tilde{v}_i$ is in the support of outcome values for group member $i$ — in which case $\mu_i^-(\tilde{v}_i) < \mu_i(\tilde{v}_i)$— and equal to a single point $\mu_i(\tilde{v}_i)$ if $\tilde{v}_i$ is not a possible realization of $i$'s outcome value.

**Step 2.** Suppose the group uses the consensus deliberation procedure, so that $C(J) = 1$ for all $J \neq \varnothing$. We can then rewrite (5) as

$$\sum_{\omega_i \geqslant v_i} (\omega_i - v_i)\mu_i(\omega_i) \left(1 - \phi_{q_{-i}}(\varnothing|\omega_i)\right) = \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i), \tag{7}$$

where we are using the fact that $\sum_{i \neq J \subset N} \phi_{q_{-i}}(J|\omega_i) = 1$. Now take two strategy profiles $q_{-i}$ and $q'_{-i}$, with $q'_{-i} \geqslant q_{-i}$. Then for each $\omega_i$, we have

$$\left(1 - \phi_{q'_{-i}}(\varnothing|\omega_i)\right) \geqslant \left(1 - \phi_{q_{-i}}(\varnothing|\omega_i)\right),$$

and therefore, for each $v_i$, the left-hand side of (7) is larger under $q'_{-i}$ than under $q_{-i}$. Consequently, the solution $\tilde{v}'_i$ to (7) under $q'_{-i}$ is larger than the solution $\tilde{v}_i$ to (7) under $q_{-i}$. This finally implies, by (6), that $\Psi_i(q'_{-i})$ is larger than $\Psi_i(q_{-i})$ in the strong set order, and so the (restricted) disclosure game under the consensus deliberation procedure has strategic complementarities — the consensus deliberation procedure belongs to set $\mathbb{D}$.

**Step 3.** Suppose now that the deliberation procedure $D$ is a restricted-consensus procedure, and suppose $I$ is the set of group members who can unilaterally choose disclosure. Remember that the restricted game is the group disclosure game for the group $N \setminus I$, with deliberation procedure $\hat{D} : \mathcal{P}(N \setminus I) \to [0, 1]$ given by $\hat{D}(J) = D(J)$ for every $J \subseteq N \setminus I$ and outcome distribution $\hat{\mu}$ with support $\times_{i \in N \setminus I} \Omega_i$ satisfying

$$\hat{\mu}\left(\hat{\omega}\right) = \mu\left(\omega_j = \hat{\omega}_j \text{ for each } j \in N \setminus I | \omega_i = \min(\Omega_i) \text{ for each } i \in I\right).$$

In the restricted game, the individual rationality mapping $\hat{\Psi}_i$ is defined, analogously to conditions (5) and (6), by $\hat{\Psi}_i(q_{-i}) = [\hat{\mu}_i^-(\tilde{v}_i), \hat{\mu}_i(\tilde{v}_i)]$, where $\tilde{v}_i$ is the unique solution to — using notation $\hat{C}(J) = 1 - \hat{D}\left[(N \setminus I) \setminus J\right]$ —

$$\sum_{\omega_i \geqslant v_i} (\omega_i - v_i)\hat{\mu}_i(\omega_i) \sum_{i \neq J \subset N \setminus I} \hat{C}(J)\phi_{q_{-i}}(J|\omega_i) = \sum_{\omega_i < v_i} (v_i - \omega_i)\hat{\mu}_i(\omega_i) \sum_{i \neq J \subset N \setminus I} \hat{C}(J \cup \{i\})\phi_{q_{-i}}(J|\omega_i). \tag{8}$$

Using the fact that the procedure is a restricted-consensus procedure, and therefore $\hat{C}(J) = 1$ for all $J \neq \varnothing$, we can rewrite (8) as

$$\sum_{\omega_i \geqslant v_i} (\omega_i - v_i)\hat{\mu}_i(\omega_i) \left[1 - (1 - \hat{C}(\varnothing))\phi_{q_{-i}}(\varnothing|\omega_i)\right] = \sum_{\omega_i < v_i} (v_i - \omega_i)\hat{\mu}_i(\omega_i). \tag{9}$$

Analogously to step 2, we then have that $\hat{\Psi}_i(q'_{-i})$ is larger than $\hat{\Psi}_i(q_{-i})$ in the strong set order when $q'_{-i} \geqslant q_{-i}$; and so the restricted game has strategic complementarities. We conclude that every deliberation procedure that is a restricted consensus procedure belongs to the set $\mathbb{D}$.

**Step 4.** We know from Theorem 1 that an equilibrium with full disclosure exists for every deliberation procedure, in which each group member $i \in N$ uses threshold recommendation strategy $q_i = 0$. This equilibrium is trivially the equilibrium with most disclosure. If $D$ is the unilateral procedure, then by Theorem 1 we also know that full disclosure is the equilibrium with least disclosure. Suppose now that $D \in \mathbb{D}$ is not the unilateral procedure. We argue that there exists an equilibrium with least disclosure.

(Case 1) First suppose $D$ is such that no group member can unilaterally choose disclosure. In this case, the restricted game corresponds to the original group disclosure game. Define $\bar{\Psi}_i(q_{-i}) = \max\left(\Psi_i(q_{-i})\right)$ to be be the largest individually rational strategy $q_i$ for group member $i$, given others use profile $q_{-i}$. Also let $\bar{\Psi}(q) = \left(\bar{\Psi}_1(q_{-1}), ..., \bar{\Psi}_n(q_{-n})\right)$, so that $\bar{\Psi} : [0,1]^n \to [0,1]^n$ is a self-map in $[0,1]^n$. Because $D \in \mathbb{D}$, $\bar{\Psi}$ is a nondecreasing map.

Consider the sequence formed by initial strategy profile $\bar{q} = (1, ..., 1)$ and $\bar{\Psi}(\bar{q})$, $\bar{\Psi} \circ \bar{\Psi}(\bar{q})$, $\bar{\Psi} \circ \bar{\Psi} \circ \bar{\Psi}(\bar{q})$, and so on. Because $\bar{\Psi}$ is a nondecreasing map, then this sequence is weakly decreasing. Moreover, because each vector in the sequence belongs to the compact space $[0,1]^n$, we know that

$$\lim_{k\to\infty} \bar{\Psi} \underbrace{\circ ... \circ}_{k \text{ times}} \bar{\Psi}(\bar{q}) := \psi$$

exists, and is the largest fixed point of $\bar{\Psi}$, and consequently also of $\Psi$. That is, if $\psi'$ is a fixed point of $\Psi$, then $\psi'_i \leqslant \psi_i$ for each $i \in N$.

Moreover, every equilibrium without full disclosure of the original group disclosure game corresponds to a fixed point of $\Psi$ (and vice-versa). Consequently $\psi$ corresponds to the "largest" equilibrium without full disclosure of the original game — that is, if $\psi'$ is a vector of threshold recommendation strategies that corresponds to an equilibrium of the group disclosure game, then $\psi'_i \leqslant \psi_i$ for each $i \in N$ —- and $\psi$ thus corresponds to the equilibrium with least disclosure.

(Case 2) Suppose instead that there is a set $I \neq \varnothing, N$ of group members who can unilaterally choose disclosure, and suppose $D \in \mathbb{D}$, so that the restricted game has strategic complementarities. By Theorem 1, we know that, in any equilibrium, each group member $i \in I$ must recommend the disclosure of every outcome realization $\omega$ with $\omega_i > \min(\Omega_i)$. Therefore, it must be that in an equilibrium with least disclosure, group member $i \in I$ uses recommendation strategy with threshold $q_i = \mu_i\left(\min(\Omega_i)\right)$.

Conditional on these recommendation strategies for each group member in $I$, an equilibrium of the original disclosure game corresponds to an equilibrium of the restricted disclosure game. Now consider the individual rationality mapping for the restricted disclosure game, $\hat{\Psi}$, as defined in step 2. Because $D \in \mathbb{D}$, we know that $\hat{\Psi}$ is an increasing self-map in $[0,1]^{n-|I|}$. Analogously to case 2, we know that $\hat{\Psi}$ must have a largest fixed point, and this largest fixed point must correspond to the equilibrium with least disclosure. $\square$.

### B.3 Proof of Proposition 1

**Proof of the first statement.** If $n = 2$, then condition (5) which characterizes the best response mapping $\Psi_i(q_{-i})$, is given by (where we let $j \neq i$):[24]

$$\sum_{\omega_i \geqslant v_i} (\omega_i - v_i)\mu_i(\omega_i) C(\{j\})\phi_{q_j}(\{j\}|\omega_i) = \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i) \left[C(\{i,j\})\phi_{q_j}(\{j\}|\omega_i) + C(\{i\})\phi_{q_j}(\varnothing|\omega_i)\right].$$

We can rewrite this expression as

$$\begin{aligned} q_j C(\{j\}) \sum_{\omega_i \geqslant v_i} (\omega_i - v_i)\mu_i\left(\omega_i | j \text{ recommends no disclosure}\right) = \\ = q_j C(\{i,j\}) \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i | j \text{ recommends no disclosure}) \\ + (1 - q_j) C(\{i\}) \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i | j \text{ recommends disclosure}). \end{aligned}$$

$$\begin{aligned} \Leftrightarrow q_j C(\{j\}) \sum_{\omega_i \in \Omega_i} (\omega_i - v_i)\mu_i\left(\omega_i | j \text{ recommends no disclosure}\right) = \\ = q_j (C(\{i,j\}) - C(\{j\}) \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i | j \text{ recommends no disclosure}) \\ + (1 - q_j)(C(\{i\}) - C(\varnothing)) \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i | j \text{ recommends disclosure}). \end{aligned}$$

$$\begin{aligned} \Leftrightarrow C(\{j\}) \sum_{\omega_i \in \Omega_i} (\omega_i - v_i)\mu_i\left(\omega_i | j \text{ recommends no disclosure}\right) = \\ = (C(\{i,j\}) - C(\{j\}) \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i | j \text{ recommends no disclosure}) \\ + \frac{(1 - q_j)}{q_j}(C(\{i\}) - C(\varnothing)) \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i | j \text{ recommends disclosure}). \end{aligned} \tag{10}$$

First note that the left-hand side of (10) is increasing in $q_j$: if $q_j$ increases, then $j$ recommends no disclosure for a weakly higher set of realizations of $\omega_j$, and because $\mu$ is such that $i$ and $j$'s values are positively correlated, $\mu_i(\omega_i | j \text{ recommends no disclosure})$ increases in the

[24]Remember from the proof of Theorem 2 in section B.2 that $\phi_{q_{-i}}(J|\omega_i)$ is the probability that exactly the set $J$ of group members other than $i$ recommends "no disclosure" conditional on $i$'s value realization $\omega_i$. And $C(J) = 1 - D(N \setminus J)$ denotes the probability that the group does not disclose after the set $J$ of group members recommends no disclosure.

likelihood ratio order after an increase in $q_i$. Consequently, the expected value of $(\omega_i - v_i)$ conditional on $j$ recommending no disclosure is increasing in $q_i$.

Second, the right-hand side of (10) is decreasing in $q_j$, through two effects. First, $(1-q_j)/q_j$ decreases. Second, if $q_j$ increases, then $j$ recommends no disclosure for a weakly higher set of realizations of $\omega_j$, and also recommends disclosure for a weakly higher set of realizations of $\omega_j$. And because $\mu$ is such that $i$ and $j$'s values are positively correlated, both $\mu_i(\omega_i|j$ recommends no disclosure) and $\mu_i(\omega_i|j$ recommends disclosure) increase in the likelihood ratio order after an increase in $q_i$. Consequently, both the summations in the right-hand side of (10) decrease after an increase in $q_j$.

To complete the proof, take $q_j, q_j'$, with $q_j \geqslant q_j'$. It must be that, if the left-hand side of (10) is larger than the right-hand side under $q_j'$, then the same holds under $q_j$. And consequently, $v_i$ that satisfies (10) under $q_j$ is weakly larger than $v_i$ that satisfies (10) under $q_j'$. (Remember from the proof of Theorem 2 that there is a unique $v_i$ that satisfies (10) for each $q_j$.) By the definition of the mapping $\Psi_i(\cdot)$ in (6), $\Psi_i(\cdot)$ is therefore increasing in $q_j$, so that the disclosure game has strategic complementarities. □

**Proof of the second statement.** Suppose the deliberation procedure is such that no group member can unilaterally choose disclosure, so that the restricted game corresponds to the original game and restricted-supermodularity corresponds to supermodularity. If the outcome distribution $\mu$ is such that outcome values are independently distributed across group members, then condition (5), which characterizes the best response mapping $\Psi_i(q_{-i})$, can be rewritten as

$$\left[\sum_{i\notin J\subseteq N} C(J)\prod_{j\in J} q_j \prod_{k\in N\setminus(J\cup\{i\})}(1-q_k)\right]\left(\sum_{\omega_i\in\Omega_i}\mu_i(\omega_i)\,(\omega_i-v_i)\right) = \tag{11}$$
$$\left[\sum_{i\notin J\subseteq N}(C(J\cup\{i\})-C(J))\prod_{j\in J} q_j \prod_{N\setminus(J\cup\{i\})}(1-q_k)\right]\left(\sum_{\omega_i<v_i}\mu_i(\omega_i)\,(v_i-\omega_i)\right).$$

Note that, if the left-hand side of (11) is larger than the right-hand side, then it must be that $\sum_{\omega_i\in\Omega_i}\mu_i(\omega_i)\,(\omega_i-v_i)\geqslant 0$ (because the right-hand side is always positive). If that is the case, then the left-hand side is increasing in $q_j$, for each $j\neq i$, since $C(J\cup\{j\})-C(J)\geqslant 0$ for each $J\subseteq N$ and

$$\frac{\partial LHS}{\partial q_j} = \left(\sum_{\omega_i\in\Omega_i}\mu_i(\omega_i)\,(\omega_i-v_i)\right)\times\left[\sum_{i,j\neq J\subseteq N}(C(J\cup\{j\})-C(J))\prod_{k\in J\setminus\{j\}} q_k \prod_{l\in N\setminus(J\cup\{i,j\})}(1-q_l)\right]\geqslant 0.$$

In turn, the right-hand side of (11) is given by

$$\frac{\partial RHS}{\partial q_j} = \left(\sum_{\omega_i < v_i} \mu_i(\omega_i)\,(v_i - \omega_i)\right) \times$$
$$\left[\sum_{i,j \neq J \subseteq N} [(C(J \cup \{i,j\}) - C(J \cup \{j\})) - (C(J \cup \{i\}) - C(J))] \prod_{k \in J \setminus \{j\}} q_k \prod_{\ell \in N \setminus (J \cup \{i,j\})} (1 - q_\ell)\right].$$

If $D$ is supermodular, then — remember that $C(J) = 1 - D(N \setminus J)$ for each $J \subseteq N$ —

$$[(C(J \cup \{i,j\}) - C(J \cup \{j\})) - (C(J \cup \{i\}) - C(J))] \leqslant 0,$$

for each $J \subset N$ with $i, j \notin J$. Consequently, the right-hand side of (11) is decreasing in $q_j$ if $D$ is supermodular.

Now take $q_{-i}, q'_{-i}$, with $q_{-i} \geqslant q'_{-i}$. It must be that, if the left-hand side of (11) is larger than the right-hand side under $q'_{-i}$, then the same holds under $q_{-i}$. And consequently, $v_i$ that satisfies (11) under $q_{-i}$ is weakly larger than $v_i$ that satisfies (11) under $q'_{-i}$. The mapping $\Psi_i(\cdot)$ is therefore increasing when $D$ is supermodular.

If the set of group members who can unilaterally choose disclosure is non-empty, so that the restricted game differs from the original game and restricted-supermodularity differs from supermodularity, then the proof follows analogously, where each piece of the argument applies to the restricted game rather than to the original game. □

# C Appendix to Section 5

## C.1 Proof of Proposition 2

Suppose disclosure is proportionally easier in procedure $D'$ than in procedure $D$. Letting $C(I) = 1 - D(N \setminus I)$ and $C'(I) = 1 - D'(N \setminus I)$ for each $I \subseteq N$, we have that, for each $I \neq \varnothing, N$, $C'(I) = \alpha C(I)$ for each $I \neq \varnothing, N$. Now consider the conditions that characterize the individual rationality mappings $\Psi$ and $\Psi'$ for procedures $D$ and $D'$, respectively — these conditions were introduced as (5) and (6) in the proof of Theorem 2.

For each $i \in N$ and $q_{-i} \in [0,1]^{n-1}$, $\Psi_i(q_{-i}) = [\mu_i^-(v_i), \mu_i(v_i)]$, where $v_i$ is the unique solution to (12) below, and $\Psi'_i(q_{-i}) = [\mu_i^-(v'_i), \mu_i(v'_i)]$, where $v'_i$ is the unique solution to (13).

$$\sum_{\omega_i \geqslant v_i} (\omega_i - v_i)\mu_i(\omega_i) \sum_{i \neq J \subset N} C(J)\phi_{q_{-i}}(J|\omega_i) = \sum_{\omega_i < v_i} (v_i - \omega_i)\mu_i(\omega_i) \sum_{i \neq J \subset N} C(J \cup \{i\})\phi_{q_{-i}}(J|\omega_i), \quad (12)$$

$$\sum_{\omega_i \geqslant v_i'} (\omega_i - v_i')\mu_i(\omega_i) \sum_{i \neq J \subset N} C'(J)\phi_{q_{-i}}(J|\omega_i) = \sum_{\omega_i < v_i'} (v_i' - \omega_i)\mu_i(\omega_i) \sum_{i \neq J \subset N} C'(J \cup \{i\})\phi_{q_{-i}}(J|\omega_i)$$

$$\Rightarrow \sum_{\omega_i \geqslant v_i'} (\omega_i - v_i')\mu_i(\omega_i) \sum_{i \neq J \subset N} C(J)\phi_{q_{-i}}(J|\omega_i) = \tag{13}$$

$$= \sum_{\omega_i < v_i'} (v_i' - \omega_i)\mu_i(\omega_i) \left[\frac{1}{\alpha}\phi_{q_{-i}}(N|\omega_i) + \sum_{i \neq J \subsetneq N} C(J \cup \{i\})\phi_{q_{-i}}(J|\omega_i)\right].$$

From (12) and (13), we can see that, if $v_i = v_i'$, then the left-hand side of the two equations are equal to each other, whereas the right-hand side of (13) is larger. Consequently, it must be that the solution $v_i$ to (12) is weakly larger than the solution $v_i'$ to (13). And consequently, for each $i$ and each $q_{-i}$, $\Psi_i(q_{-i})$ is a weakly larger set than $\Psi'_{-i}(q_{-i})$ (in the strong set order).

Now let $\bar{\Psi}_i(q_{-i}) = \max(\Psi_i(q_{-i}))$. Also let $\bar{\Psi}(q) = \left(\bar{\Psi}_1(q_{-1}), ..., \bar{\Psi}_n(q_{-n})\right)$. And define $\bar{\Psi}'$ analogously, for deliberation procedure $D'$. Remember from the proof of Theorem 2 that the equilibrium with least disclosure under procedures $D$ and $D'$ are characterized by thresholds

$$\psi = \lim_{k \to \infty} \bar{\Psi} \underbrace{\circ ... \circ}_{k \text{ times}} \bar{\Psi}(\bar{q}) \text{ and } \psi' = \lim_{k \to \infty} \bar{\Psi}' \underbrace{\circ ... \circ}_{k \text{ times}} \bar{\Psi}'(\bar{q}),$$

where $\bar{q} = (1, ..., 1)$. Because both $\bar{\Psi}$ and $\bar{\Psi}'$ are increasing mappings, and moreover $\bar{\Psi}(q) \geqslant \bar{\Psi}'(q)$ for each $q$, it must be that $\psi \geqslant \psi'$. Finally, because $\psi \geqslant \psi'$, and because $D'(I) \geqslant D(I)$ for each $I \subseteq N$, it must be that there is weakly more disclosure in the equilibrium with least disclosure under $D'$ than in the equilibrium with least disclosure under $D$. □

## C.2 Proof of Proposition 3

The proof of this proposition relies on two lemmas:

**Lemma 1.** *The equilibrium with least disclosure is a strict equilibrium for almost all deliberation procedures in $int(\mathbb{D})$.*

*Proof.* Remember that the set of possible deliberation procedures for group $N$ is a compact and convex subset of the vector space $2^{|N|-2}$, defined by $D(I) \in [0, 1]$ for each $I \subseteq N$, with $I \neq \varnothing, N$, and the monotonicity condition $I \subseteq J \Rightarrow D(I) \leqslant D(J)$. In this proof, we will use the Lebesgue measure in dimension $2^{|N|-2}$, which we will denote by $\lambda$.

First, for any $D \in int(\mathbb{D})$, from the construction of the equilibrium with least disclosure in the proof of Theorem 2 — as the largest fixed point of the mapping $\bar{\Psi}$ — it must be that the equilibrium with least disclosure is a pure-strategy equilibrium. That is, one in which the profile $x$ of disclosure recommendation strategies is such that, for each $i \in N$, $x_i$ is a pure threshold recommendation strategy: for each $i \in N$, there exists $\hat{\omega}_i \in \Omega_i$ such that

- $\omega_i \leqslant \hat{\omega}_i \Rightarrow x_i(\omega) = 0$,
- and $\omega_i > \hat{\omega}_i \Rightarrow x_i(\omega) = 1$.

Note that, because $\Omega$ is a finite space of possible outcomes, the set of such pure strategy profiles is finite. Fix one such strategy profile, defined by the vector of thresholds $\hat{\omega} \in \Omega$. If such strategy profile is an equilibrium, that equilibrium is *not strict* if there is some group member — say group member $i$ — such that

$$\mathbb{E}(\omega_i | \text{ no disclosure}) = \hat{\omega}_i. \tag{14}$$

We want to express that equality as a function of the deliberation procedure $D$. To that end, we use notation $L(\omega) = \{j \in N : \omega_j \leqslant \hat{\omega}_j\}$ to express the set of group members for whom a given outcome $\omega$ is "below threshold." We can then write (14) as

$$\sum_{I \subseteq N} \sum_{\omega \in \Omega} \mu(\omega) \mathbb{1} \{L(\omega) = I\} (1 - D(I)) \omega_i = \sum_{I \subseteq N} \sum_{\omega \in \Omega} \mu(\omega) \mathbb{1} \{L(\omega) = I\} (1 - D(I)) \hat{\omega}_i. \tag{15}$$

Condition (15) is a linear equation with $2^{|N|} - 2$ variables, corresponding to $D(I)$ for each $I \subseteq N$, with $I \neq \varnothing, N$. Let $\mathcal{G}(\hat{\omega}, i)$ be the set of deliberation procedures for which (15) is satisfied for group member $i$, given threshold strategy $\hat{\omega}$. Because (15) is an equality condition, it must be that the set $\mathcal{G}(\hat{\omega}, i)$ for which it is satisfied has dimension at most $2^{|N|} - 3$, and therefore $\lambda(\mathcal{G}(\hat{\omega}, i)) = 0$. This is true for every $\hat{\omega} \in \Omega$ and every $i \in N$ and, because both $\Omega$ and $N$ are finite sets,

$$\lambda\left(\cup_{\hat{\omega} \in \Omega, i \in N} \mathcal{G}(\hat{\omega}, i)\right) = 0.$$

Consequently, there must be at most a measure $0$ set of deliberation procedures $D \in \mathbb{D}$ for which the equilibrium with least disclosure is not strict. □

To state Lemma 2, we introduce the following notation. If $D \in \mathbb{D}$ is such that the equilibrium with least disclosure is a strict equilibrium, then it must be that the profile of pure threshold recommendation strategies in that equilibrium is determined by thresholds $\bar{\omega} = \omega^{ND}$. Fixing those thresholds, we let $H(\omega) = \{i \in N : \omega_i > \bar{\omega}_i\}$ be the set of group members for which realization $\omega$ is "above threshold." Moreover, with some abuse of notation, for any given set

$I \subseteq N$, we let $\mu(H(\omega) = I)$ be the probability that an outcome $\omega$ realizes which is an "above threshold" realization for exactly group members $I$.

**Lemma 2.** *Fix a starting deliberation procedure $D \in \mathbb{D}$ such that the equilibrium with least disclosure is a strict equilibrium. For each $i \in N$, the gradient $\nabla\bar{\omega}_i = \left(\frac{\partial\bar{\omega}_i}{\partial D(I)}\right)_{I \subseteq N}$ exists, and for each $J \subseteq N$ with $J \neq \varnothing, N$,*

$$\frac{\partial\bar{\omega}_i}{\partial D(J)} = \frac{\sum_{\omega\in\Omega} \mu(H(\omega) = J)}{\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))} \left[\bar{\omega}_i - \mathbb{E}\left(\omega_i | H(\omega) = J\right)\right]. \tag{16}$$

*Proof of Lemma.* We can write $\bar{\omega}_i$ as

$$\bar{\omega}_i = \frac{\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))\mathbb{E}(\omega_i | H(\omega) = I)}{\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))}, \tag{17}$$

Now note that, because the equilibrium is strict, small variations in the deliberation procedure $D$ only lead to small variations in the observer's no disclosure beliefs, and therefore do not change group members' individually rational strategies. Therefore the change in $\bar{\omega}_i$ can be computed only as its "direct effect," as follows.

$$\begin{aligned}\frac{\partial\bar{\omega}_i}{\partial D(J)} =& \frac{-\mu(H(\omega) = J)\mathbb{E}(\omega_i | H(\omega) = J)}{\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))} \\ &+ \mu(H(\omega) = J)\frac{\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))\mathbb{E}(\omega_i | H(\omega) = I)}{\left[\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))\right]^2} = \\ =& \frac{\mu(H(\omega) = J)}{\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))} \left[\bar{\omega}_i - \mathbb{E}\left(\omega_i | H(\omega) = J\right)\right],\end{aligned}$$

where the last equality used the expression for $\bar{\omega}_i$ in (17). □

Back to the proof of the proposition. By Lemmas 1 and 2, we know that the gradients exist for almost all deliberation procedures $D \in int(\mathbb{D})$. Now suppose $v$ is a direction that increases group member $i$'s relative power. Let $m = \min\left\{\frac{v_I}{1-D(I)} : i \in I \subsetneq N\right\}$ and $M = \max\left\{\frac{v_I}{1-D(I)} : i \notin I \subsetneq N\right\}$, so that $m \geqslant M$. Then, using equation (16), we have

$$\nabla\bar{\omega}_i \cdot v = \sum_{J \subsetneq N} \frac{\mu(H(\omega) = J)(1 - D(J))}{\sum_{I \subsetneq N} \mu(H(\omega) = I)(1 - D(I))} \left[\bar{\omega}_i - \mathbb{E}\left(\omega_i | H(\omega) = J\right)\right] \frac{v_J}{(1 - D(J))}$$

$$\leqslant m\left[\sum_{i\in J\subsetneq N}\frac{\mu(H(\omega)=J)(1-D(J))}{\sum_{I\subsetneq N}\mu(H(\omega)=I)(1-D(I))}\left(\bar{\omega}_i-\mathbb{E}\left(\omega_i|H(\omega)=J\right)\right)\right]$$

$$+M\left[\sum_{i\notin J\subsetneq N}\frac{\mu(H(\omega)=J)(1-D(J))}{\sum_{I\subsetneq N}\mu(H(\omega)=I)(1-D(I))}\left(\bar{\omega}_i-\mathbb{E}\left(\omega_i|H(\omega)=J\right)\right)\right]$$

$$\leqslant m\left[\sum_{J\subsetneq N}\frac{\mu(H(\omega)=J)(1-D(J))}{\sum_{I\subsetneq N}\mu(H(\omega)=I)(1-D(I))}\left(\bar{\omega}_i-\mathbb{E}\left(\omega_i|H(\omega)=J\right)\right)\right]$$

$$=m\left[\bar{\omega}_i-\sum_{J\subseteq N}\frac{\mu(H(\omega)=J)(1-D(J))\mathbb{E}\left(\omega_i|H(\omega)=J\right)}{\sum_{I\subseteq N}\mu(H(\omega)=I)(1-D(I))}\right]=0.$$

The inequalities follow from (2) — the definition of a direction that increases $i$'s relative power — and the fact that $\bar{\omega}_i \leqslant \mathbb{E}(\omega_i|H(\omega)=J)$ if $i\in J$ and $\bar{\omega}_i \geqslant \mathbb{E}(\omega_i|H(\omega)=J)$ if $i\notin J$. The last equality follows from the definition of $\bar{\omega}_i$ in (17). To show that $\nabla\bar{\omega}_i\cdot v\geqslant 0$ if $v$ is a direction that decreases $i$'s relative power, we can use analogous steps. □

# D Appendix to Section 6

## D.1 Proof of Theorem 3

Let $I$ be the set of group members who can unilaterally choose disclosure.

**Case 1.** If $I=N$, then Theorem 1 implies that an equilibrium with full disclosure exists in which "no disclosure" happens on path if and only if each group member draws their worst possible value. This assessment is satisfies sequential consistency, and so Theorem 3 holds trivially in that case.

**Case 2.** If $I\neq\varnothing$ and $I\neq N$, by Theorem 1, we know that an equilibrium without full disclosure exists in which

$$\omega_i^{ND}\begin{cases}=\min(\Omega_i),\text{ if } i\in I\\>\min(\Omega_i),\text{ if } i\notin I.\end{cases}$$

Consider the full-disclosure assessment made up of those beliefs and strategies $x_i(\omega)=1$ for all $\omega$, if $i\in I$ and $x_j(\omega)=1$ if $\omega_j>\omega_j^{ND}$ and $x_j(\omega)=0$ otherwise, if $j\notin I$. For belief consistency, take the following sequence of completely mixed strategy profiles: for $i\in I$, $x_i^k(\omega)=1-1/k$ if $\omega_i=\min(\Omega_i)$ and $x_i^k(\omega)=1-1/k^2$ if $\omega_i\neq\min(\Omega_i)$; and for $j\notin I$,

$x_j^k(\omega) = 1 - 1/k$ if $\omega_j \leqslant \omega_j^{ND}$ and $x_j^k(\omega) = 1/k$ if $\omega_j > \omega_j^{ND}$.

Given these profiles, if an outcome $\omega$ is such that $\omega_i = \min(\Omega_i)$ for every $i \in I$, letting $L(\omega) = \{j \in N \setminus I : \omega_j \leqslant \omega_j^{ND}\}$ and $H(\omega) = \{j \in N \setminus I : \omega_j > \omega_j^{ND}\}$, then

$$\mathbb{P}(ND, \omega) = \frac{\mu(\omega)}{k^{|I|}} \left[ \sum_{J \subset N \setminus I} \frac{1}{k^{|J|}} \left(1 - \frac{1}{k}\right)^{N-|I|-|J|} [1 - D((J \cap L(\omega)) \cup ((N \setminus J) \cap H(\omega))] \right]$$

And so

$$\lim_{k\to\infty} \frac{\mathbb{P}(ND, \omega)}{\mathbb{P}(ND)} = \frac{\mu(\omega)\,[1 - D(H(\omega))]}{\sum_{\omega'} \mu(\omega')\,[1 - D(H(\omega'))]},$$

which is the same distribution of outcomes conditional on no disclosure that arises in the equilibrium without full disclosure that we started with. We thus conclude that our starting beliefs of no disclosure are consistent with the constructed sequence of strategy profiles, and so our assessment has full disclosure and satisfies sequential consistency.

**Case 3.** Finally, let $I = \varnothing$, so that no group member can unilaterally choose disclosure. Suppose by way of contradiction that an equilibrium with full disclosure exists, with belief profile $\omega^{ND}$, which satisfies sequential consistency. Because the equilibrium has full disclosure, it must be that there exists a subset $\hat{I} \subset N$ of group members, with $D(\hat{I}) = 1$, such that, for each $i \in \hat{I}$,

$$\omega_i^{ND} = \min(\Omega_i), \text{ and } x_i(\omega) = 1 \text{ for all } \omega \in \Omega.$$

And for each $i \in N \setminus \hat{I}$,

$$\omega_i^{ND} > \min(\Omega_i), x_i(\omega) = 1 \text{ if } \omega_i \leqslant \omega_i^{ND} \text{ and } x_i(\omega) = 0 \text{ if } \omega_i > \omega_i^{ND}.$$

Now consider any sequence of completely mixed strategy profiles that converge to this profile $x$. We represent these as follows: for each group member $i \in \hat{I}$, $\epsilon_i^k(\omega_j)$ is $i$'s "error" relative to the assessment for outcomes with own-value $\omega_i$, with $\lim_{k\to\infty} \epsilon_i^k(\omega_i) = 0$, so that

$$x_i^k(\omega) = \epsilon_i^k(\omega_i).$$

And for each group member $i \in N \setminus \hat{I}$, again $\epsilon_i^k(\omega_i)$ is $i$'s "error" relative to the assessment for outcomes with own-value $\omega_i$, with $\lim_{k\to\infty} \epsilon_i^k(\omega_i) = 0$, so that

$$x_i^k(\omega) = 1 - \epsilon_i^k(\omega_i), \text{ if } \omega_i \leqslant \omega_i^{ND}, \text{ and } x_i^k(\omega) = \epsilon_i^k(\omega_i), \text{ otherwise.}$$

And define notation

$$\epsilon_J^k(\omega) = \prod_{j \in J} \epsilon_j^k(\omega) \text{ and } \eta_J^k(\omega) = \prod_{j \in J}(1 - \epsilon_j^k(\omega)),$$

to be the probabilities that all group members in $J$ "err" and "do not err" relative to the assessment, respectively. Consider outcome $\underline{\omega}$ with $\underline{\omega}_i = \min(\Omega_i)$ for each $i \in N$. We use two claims:

**Claim 2.** $\lim_{k\to\infty} \frac{\mathbb{P}(ND,\underline{\omega})}{\mathbb{P}(ND)} > 0$.

*Proof of Claim.* if the beliefs conjectured in our assessment are consistent, there must be some $\hat{\omega}$ with $\hat{\omega}_i = \min(\Omega_i)$ for each $i \in \hat{I}$ such that $\lim_{k\to\infty} \frac{\mathbb{P}(ND,\hat{\omega})}{\mathbb{P}(ND)} > 0$. And moreover, for each $k$, $\mathbb{P}(ND, \underline{\omega}) \geqslant \mathbb{P}(ND, \hat{\omega})$, and therefore $\lim_{k\to\infty} \frac{\mathbb{P}(ND,\underline{\omega})}{\mathbb{P}(ND)} \geqslant \lim_{k\to\infty} \frac{\mathbb{P}(ND,\hat{\omega})}{\mathbb{P}(ND)} > 0$. □

**Claim 3.** *There exists some $\hat{\omega}$ such that $\hat{\omega}_i > \min(\Omega_i)$ for some $i \in \hat{I}$ and $\hat{\omega}_j = \underline{\omega}_j$ for all $j \neq i$ such that* $\lim_{k\to\infty} \frac{\mathbb{P}(ND,\hat{\omega})}{\mathbb{P}(ND,\underline{\omega})} > 0$.

*Proof of Claim.* We can write the probability of outcome $\underline{\omega}$ not being disclosed as

$$\mathbb{P}(ND, \underline{\omega}) = \mu(\underline{\omega}) \left[ \sum_{J \subseteq N} \epsilon_J^k(\underline{\omega}) \eta_{N\setminus J}^k(\underline{\omega}) \left[ 1 - D((\hat{I} \setminus J) \cup (J \setminus \hat{I})) \right] \right].$$

Now define a minimal effective error to be $E \subseteq N$ such that

$$D((\hat{I} \setminus E) \cup (E \setminus \hat{I})) < 1$$

$$\text{and } \lim_{k\to\infty} \frac{\epsilon_J^k(\underline{\omega})}{\epsilon_E^k(\underline{\omega})} < \infty \text{ for all } J \text{ such that } D((\hat{I} \setminus J) \cup (J \setminus \hat{I})) < 1.$$

Because the deliberation procedure is such that no group member can unilaterally choose disclosure, any minimal effective error $E$ is such that $E \setminus \hat{I} = \varnothing$ and $\hat{I} \setminus E \neq \varnothing$. To see this, suppose by contradiction that a minimal effective error $E$ is such that $E \setminus \hat{I} \neq \varnothing$. Then consider the set $E' = E \cap \hat{I}$: first note that $D((\hat{I} \setminus E') \cup (E' \setminus \hat{I})) = D(\hat{I} \setminus E) \leqslant D((\hat{I} \setminus E) \cup (E \setminus \hat{I})) < 1$; and second, because $E' \subsetneq E$, $\lim_{k\to\infty} \frac{\epsilon_{E'}^k(\underline{\omega})}{\epsilon_E^k(\underline{\omega})} = \infty$. Together, these facts contradict the assumption that $E$ is a minimal effective error. Next suppose by contradiction that a minimal effective error $E$ is such that $E \setminus \hat{I} = \varnothing$, but $\hat{I} \setminus E = \varnothing$; that is, $E = \hat{I}$. Because no group member can unilaterally choose disclosure, there is a set $E' \subsetneq \hat{I}$ such that $D(\hat{I} \setminus E') < 1$. This, along with the fact that $E'$ is a strict subset of $\hat{I}$ imply that $E = \hat{I}$ is not a minimal effective error.

Fix $E$ to be a minimal effective error, and consider $\hat{\omega}$ such that $\hat{\omega}_i > \min(\Omega_i)$ for some $i \in \hat{I} \setminus E$ and $\hat{\omega}_j = \underline{\omega}_j$ for all $j \neq i$. Then we write

$$\mathbb{P}(ND, \hat{\omega}) = \mu(\hat{\omega})\epsilon^k_E(\hat{\omega})\eta^k_{N\setminus E}(\underline{\omega})\left[1 - D(\hat{I} \setminus E)\right]$$
$$+ \mu(\hat{\omega}) \sum_{J \subseteq N, J \neq E} \epsilon^k_J(\hat{\omega})\eta^k_{N\setminus J}(\hat{\omega})\left[1 - D((\hat{I} \setminus J) \cup (J \setminus \hat{I}))\right].$$

Because $i \notin E$, it must be that $\epsilon^k_E(\hat{\omega}) = \epsilon^k_E(\underline{\omega})$, and so $\lim_{k\to\infty} \frac{\mathbb{P}(ND,\hat{\omega})}{\epsilon^k_E(\underline{\omega})} > 0$. Moreover, because $E$ is a minimal effective error, we know that $\lim_{k\to\infty} \frac{\mathbb{P}(ND,\underline{\omega})}{\epsilon^k_E(\underline{\omega})} < \infty$. We thus conclude that $\lim_{k\to\infty} \frac{\mathbb{P}(ND,\hat{\omega})}{\mathbb{P}(ND,\underline{\omega})} > 0$. □

Combining the two claims, we know that there exists some $\hat{\omega}$ such that $\hat{\omega}_i > \min(\Omega_i)$ for some $i \in \hat{I}$ and $\hat{\omega}_j = \underline{\omega}_j$ for all $j \neq i$ such that

$$\lim_{k\to\infty} \frac{\mathbb{P}(ND, \hat{\omega})}{\mathbb{P}(ND)} = \left(\lim_{k\to\infty} \frac{\mathbb{P}(ND, \hat{\omega})}{\mathbb{P}(ND, \underline{\omega})}\right)\left(\lim_{k\to\infty} \frac{\mathbb{P}(ND, \underline{\omega})}{\mathbb{P}(ND)}\right) > 0,$$

and therefore consistency implies that $\omega^{ND}_i > \min(\Omega_i)$ for some $i \in \hat{I}$, which contradicts that our original assessment satisfies sequential consistency. We conclude that a full disclosure equilibrium that satisfies sequential consistency does not exist. □

# E Detailed Algebra for the Examples

## E.1 Example 4.1.1

There are two group members, and the deliberation procedure and distribution of outcome values are symmetric. Specifically, let $D(0,0) = 0$, $D(1,1) = 1$, and $D(1,0) = D(0,1) = \delta < 1$. And let the set of possible outcome values be $\Omega = \Omega_1 \times \Omega_2$, with $\Omega_1 = \Omega_2 = \{1, 2, 11\}$. Outcomes $\omega = (1,2)$ and $\omega = (2,1)$ occur with probability $4/15$ each, while every other possible outcome occurs with probability $1/15$. This outcome distribution is represented in the left panel of Figure 4.

*Case 1.* Low values of $\delta$: $\delta \leqslant 12/17$. When $\delta$ is low enough, there is a unique equilibrium without full disclosure, in which each group member recommends disclosure if and only if their own realized value is 11. Aggregating these individual recommendations we obtain the probability of non-disclosure for each outcome. When the realized outcome is $(2,2)$, for instance,

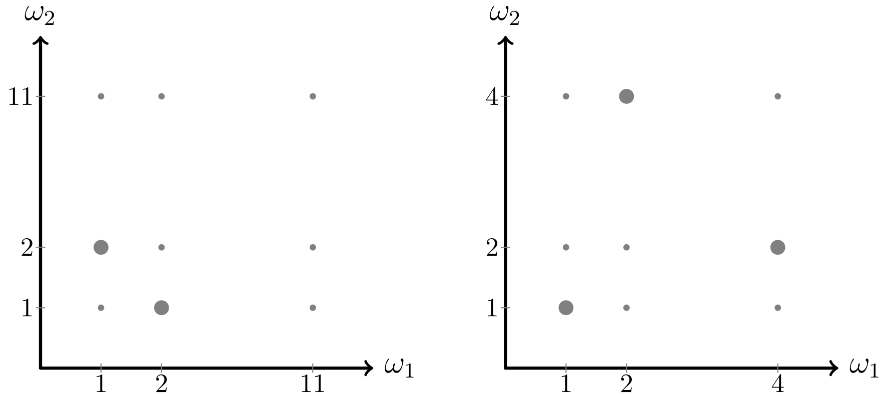


**Figure 4:** Representation of the distribution of outcome values in Example 4.1.1 (left panel) and Example 4.1.2 (right panel). Dot sizes represent the probability of each outcome realization.

the outcome is not disclosed and when it is $(2, 11)$ it is only disclosed with probability $\delta$. We then obtain that for each $i \in \{1, 2\}$, the equilibrium condition

$$\omega_i^{ND} = \mathbb{E}(\omega_i | \text{ no disclosure }) = \frac{15 + 25(1-\delta)}{10 + 4(1-\delta)} \in [2, 11],$$

holds because $\delta \leqslant 12/17$. These beliefs in case of no disclosure justify the equilibrium disclosure recommendation strategies.

*Case 2.* High values of $\delta$: $\delta \geqslant 3/4$. There is a unique equilibrium without full disclosure, in which each group member recommends disclosure if and only if their own realized value is either 2 or 11. Aggregating these individual recommendations, we find that for each $i \in \{1, 2\}$, the equilibrium condition,

$$\omega_i^{ND} = \mathbb{E}(\omega_i | \text{ no disclosure }) = \frac{1 + 24(1-\delta)}{1 + 10(1-\delta)} \in [1, 2],$$

holds in the range, as $\delta \geqslant 3/4$. Again, these beliefs of no disclosure can justify the equilibrium disclosure recommendation strategies.

*Case 3.* Intermediate $\delta$ values: $\delta \in (12/17, 3/4)$. In this case, there exist only two pure-strategy equilibria without full disclosure, which are both *asymmetric*.[25] In each of the two asymmetric equilibria, one group member (group member 1, say) recommends no disclosure if and only if their outcome value is 1, and one group member (say, group member 2) recommends no dis-

[25]There exists also a mixed-strategy equilibrium which is symmetric. This symmetric equilibrium cannot be ranked with the two asymmetric equilibria in terms of the "amount of disclosure."

closure if and only if their outcome value is either 1 or 2. Aggregating these recommendations according to the deliberation procedure, we obtain the no-disclosure beliefs. For group member 1, we have

$$\omega_1^{ND} = \mathbb{E}(\omega_1 | \text{ no disclosure }) = \frac{5 + 33(1 - \delta)}{5 + 8(1 - \delta)},$$

which satisfies the equilibrium condition $\omega_1^{ND} \in (1, 2)$, because $\delta \in (12/17, 3/4)$. As for group member 2, we have

$$\omega_2^{ND} = \mathbb{E}(\omega_2 | \text{ no disclosure }) = \frac{9 + 20(1 - \delta)}{5 + 8(1 - \delta)},$$

which satisfies the equilibrium condition $\omega_2^{ND} \in (2, 3)$, because $\delta \in (12/17, 3/4)$. These beliefs of no disclosure in turn justify each individual's disclosure recommendation strategy. We can also check from the calculations in cases 1 and 2 that no pure-strategy symmetric equilibrium without full disclosure exists for this range of $\delta$.

### E.1.1 Example 4.1.2

The group has two group members, and uses the deliberation procedure the consensus procedure: $D(0, 0) = 0$, $D(1, 1) = 1$, and $D(1, 0) = D(0, 1) = 0$. The set of possible outcome values is $\Omega = \Omega_1 \times \Omega_2$, with $\Omega_1 = \Omega_2 = \{1, 2, 4\}$. Outcomes $\omega = (1, 1)$, $\omega = (2, 4)$ and $\omega = (4, 2)$ occur with probability $4/18$ each, while every other possible outcome occurs with probability $1/16$. This outcome distribution is represented in the right panel of Figure 4.

In this environment, we have two equilibria without full disclosure, which are both symmetric and ranked in terms of the "amount of disclosure." In the first equilibrium, each group member recommends no disclosure if and only if they draw an outcome value of 1. We can check that, aggregating these recommendations according to the consensus procedure, the beliefs of no disclosure are, for each $i = 1, 2$,

$$\omega_i^{ND} = \mathbb{E}(\omega_i | \text{ no disclosure }) = \frac{12}{8} = 3/2,$$

which justifies the conjectured strategies. Suppose instead that each group member recommends no disclosure if and only if their drawn outcome value is either 1 or 2. This pair of strategies induces beliefs of no disclosure equal to

$$\omega_i^{ND} = \mathbb{E}(\omega_i | \text{ no disclosure }) = \frac{35}{17},$$

for each $i = 1, 2$. Again, these beliefs justify the conjectured strategy. In this second equilib-

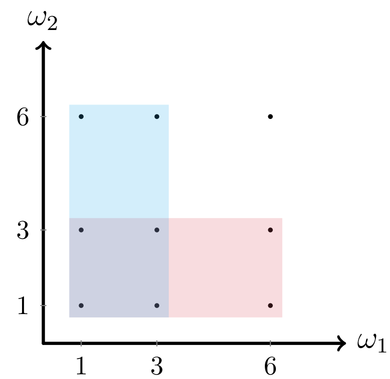


**Figure 5:** Conjectured equilibrium in which each group member recommends disclosure if and only if $w_i = 6$. The blue (pink) region indicates outcomes for which group member 1 (group member 2) recommends no disclosure. The space of outcomes is divided into four parts, corresponding to different disclosure probabilities.

rium, all outcomes in which at least one group member has a value of 1 or 2 are not disclosed; it therefore induces strictly less disclosure than the first equilibrium, in which only outcomes in which at least one group member drew a value of 1 are not disclosed.

## E.2 Example 5.1.1

In example 5.1.1, we consider a symmetric environment with two group members. The set of possible outcome values is $\Omega = \Omega_1 \times \Omega_2$, with $\Omega_1 = \Omega_2 = \{1, 3, 6\}$. Outcomes are uniformly distributed over the set $\Omega$. We know from Proposition 1 that, in this case, for any deliberation procedure, the group disclosure game has an equilibrium with least disclosure. Below, we show that there are four regions of the space of deliberation procedures — depicted in Figure 2 — that yield different equilibria with least disclosure.

**Case 1. Both group members recommend disclosure if and only if $w_i = 6$.** Figure 5 represents the conjectured equilibrium. There are four regions of the outcome space: the 4 points in the southwest corner are not disclosed since neither group member is in favor of disclosing it. The two points in the northwest corner are not disclosed with probability $1 - D(0, 1)$, as group member 2 is in favor of disclosing it (her outcome is 6) and member 1 is not. The two outcomes in the southeast corner are not disclosed with probability $1 - D(1, 0)$, as group member 1 is in favor of disclosing it and member 2 is not. The point in the northeast corner is disclosed with probability 1. Given these disclosure probabilities for each outcome, we can calculate the relevant mathematical objects. We begin with the probability of non-disclosure:

$$Prob^{ND} = 1 \times \frac{1}{9} \times 4 + (1 - D(0,1)) \times \frac{1}{9} \times 2 + (1 - D(1,0)) \times \frac{1}{9} \times 2.$$

We can use this to obtain the no-disclosure belief for player 1:

$$w_1^{ND} = \frac{1 \times \frac{1}{9} \times (1+3+1+3) + (1 - D(0,1)) \times \frac{1}{9} \times (1+3) + (1 - D(1,0)) \times \frac{1}{9} \times (6+6)}{Prob^{ND}},$$

which can be simplified to:

$$w_1^{ND} = \frac{8 + 4(1 - D(0,1)) + 12(1 - D(1,0))}{4 + 2(1 - D(0,1)) + 2(1 - D(1,0))} = 2 + \frac{4(1 - D(1,0))}{2 + (1 - D(0,1)) + (1 - D(1,0))}.$$

Symmetrically, for member 2:

$$w_2^{ND} = 2 + \frac{4(1 - D(0,1))}{2 + (1 - D(0,1)) + (1 - D(1,0))}.$$

For this candidate to be an equilibrium, we must have $w_i^{ND} \in [3,6)$ for both players. That implies the following system of inequalities:

$$4(1 - D(1,0)) \geq 2 + (1 - D(0,1)) + (1 - D(1,0))$$
$$4(1 - D(0,1)) \geq 2 + (1 - D(0,1)) + (1 - D(1,0))$$

This system can be simplified to

$$D(1,0)) \geq 3D(0,1)$$
$$D(0,1)) \geq 3D(1,0),$$

which can only be satisfies for positive $D(0,1)$ and $D(1,0)$ if both are zero. Hence, the only disclosure procedure that can sustain such equilibrium is the consensus procedure. Note that this is not a strict equilibrium. Indeed, both group members are indifferent between disclosing or not when their outcome is 3, but their strategy dictates that they do not disclose such outcomes.

**Case 2. Both group members recommends disclosure if and only if $w_i \in \{3,6\}$.** Figure 6 represents the conjectured equilibrium. Once more, the individual recommendations define 4 regions. The single point in the southwest corner is not disclosed since neither group member is in favor of disclosing it. The two points in the northwest corner are not disclosed with probability $1 - D(0,1)$, as group member 2 is in favor of disclosing it and member 1 is not. The two outcomes in the southeast corner are not disclosed with probability $1 - D(1,0)$, as

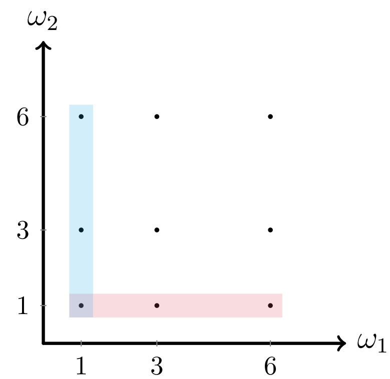


**Figure 6:** Conjectured equilibrium in which each group member recommends disclosure if and only if $w_i \in \{3,6\}$. The blue (pink) region indicates outcomes for which group member 1 (group member 2) recommends no disclosure. The space of outcomes is divided into four parts, corresponding to different disclosure probabilities.

group member 1 is in favor of disclosing it and member 2 is not. The four outcomes in the northeast corner are disclosed with probability 1. Given these disclosure probabilities for each outcome, we can calculate the relevant mathematical objects. We begin with the probability of non-disclosure:

$$Prob^{ND} = 1 \times \frac{1}{9} \times 1 + (1 - D(0,1)) \times \frac{1}{9} \times 2 + (1 - D(1,0)) \times \frac{1}{9} \times 2.$$

We can use this to obtain the no-disclosure belief for player 1:

$$w_1^{ND} = \frac{1 \times \frac{1}{9} \times (1) + (1 - D(0,1)) \times \frac{1}{9} \times (1+1) + (1 - D(1,0)) \times \frac{1}{9} \times (3+6)}{Prob^{ND}},$$

which can be simplified to:

$$w_1^{ND} = \frac{1 + 2(1 - D(0,1)) + 9(1 - D(1,0))}{1 + 2(1 - D(0,1)) + 2(1 - D(1,0))} = 1 + \frac{7(1 - D(1,0))}{1 + 2(1 - D(0,1)) + 2(1 - D(1,0))}.$$

Symmetrically, for member 2:

$$w_2^{ND} = 1 + \frac{7(1 - D(0,1))}{1 + 2(1 - D(0,1)) + 2(1 - D(1,0))}.$$

For this candidate to be an equilibrium, we must have $w_i^{ND} \in [1,3]$ for both players. That implies the following system of inequalities:

$$7(1-D(1,0)) \leq 2+4(1-D(0,1))+4(1-D(1,0))$$
$$7(1-D(0,1)) \leq 2+4(1-D(0,1))+4(1-D(1,0))$$

This system can be simplified to

$$D(1,0)) \geq -1+\frac{4}{3}D(0,1)$$
$$D(0,1)) \geq -1+\frac{4}{3}D(1,0).$$

These two inequalities, paired with the fact that $D(0,1)$ and $D(1,0)$ are both positive and smaller than one, define the white region of Figure 3.

**Case 3. Group member 1 recommends disclosure if and only if $w_1 = 6$ and group member 2 recommends disclosure if and only if $w_2 \in \{3,6\}$.** Figure 7 represents the conjectured equilibrium. The two outcomes in the southwest corner are not disclosed since neither group member is in favor of disclosing it. The outcome in the northwest corner is not disclosed with probability $1-D(0,1)$, as group member 2 is in favor of disclosing it and member 1 is not. The four outcomes in the southeast corner are not disclosed with probability $1-D(1,0)$, as group member 1 is in favor of disclosing it and member 2 is not. The two outcomes in the northeast corner are disclosed with probability 1. Given these disclosure probabilities for each outcome, we can calculate the relevant mathematical objects. We begin with the probability of non-disclosure:

$$Prob^{ND} = 1\times\frac{1}{9}\times 2+(1-D(0,1))\times\frac{1}{9}\times 1+(1-D(1,0))\times\frac{1}{9}\times 4.$$

We can use this to obtain the no-disclosure belief for players 1 and 2:

$$w_1^{ND} = \frac{1\times\frac{1}{9}\times(1+1)+(1-D(0,1))\times\frac{1}{9}\times(1)+(1-D(1,0))\times\frac{1}{9}\times(3+6+3+6)}{Prob^{ND}}$$
$$w_2^{ND} = \frac{1\times\frac{1}{9}\times(1+3)+(1-D(0,1))\times\frac{1}{9}\times(6)+(1-D(1,0))\times\frac{1}{9}\times(1+3+1+3)}{Prob^{ND}}$$

which can be simplified to:

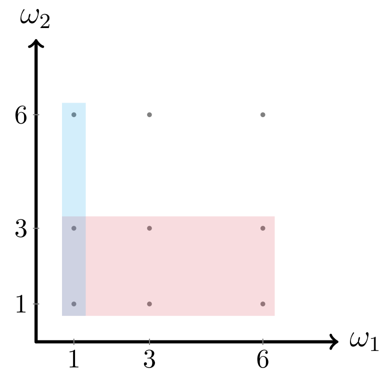


**Figure 7:** Conjectured equilibrium in which group member 1 recommends disclosure if and only if $w_1 = 6$ and group member 2 recommends disclosure if and only if $w_2 \in \{3, 6\}$. The blue (pink) region indicates outcomes for which group member 1 (group member 2) recommends no disclosure. The space of outcomes is divided into four parts, corresponding to different disclosure probabilities.

$$
\begin{aligned}
w_1^{ND} &= \frac{2 + (1 - D(0,1)) + 18(1 - D(1,0))}{2 + (1 - D(0,1)) + 4(1 - D(1,0))} = 1 + \frac{14(1 - D(1,0))}{2 + (1 - D(0,1)) + 4(1 - D(1,0))} \\
w_2^{ND} &= \frac{4 + 6(1 - D(0,1)) + 8(1 - D(1,0))}{2 + (1 - D(0,1)) + 4(1 - D(1,0))} = 2 + \frac{4(1 - D(0,1))}{2 + (1 - D(0,1)) + 4(1 - D(1,0))}
\end{aligned}
$$

For this candidate to be an equilibrium, we must have $w_1^{ND} \in [1, 3]$ and $w_2^{ND} \in [3, 6]$. That implies the following system of inequalities:

$$
\begin{aligned}
7(1 - D(1,0)) &\leq 2 + (1 - D(0,1)) + 4(1 - D(1,0)) \\
4(1 - D(0,1)) &\geq 2 + (1 - D(0,1)) + 4(1 - D(1,0))
\end{aligned}
$$

This system can be simplified to

$$
\begin{aligned}
D(1,0) &\geq \frac{2}{3} D(0,1) \\
D(0,1) &\leq -1 + \frac{4}{3} D(1,0).
\end{aligned}
$$

Of these two inequalities, note that only the second one has any bite. The second one paired with the fact that $D(0,1)$ and $D(1,0)$ are both positive and smaller than one, define the blue region of Figure 3. Finally, we do not present here the pink region as this is just the symmetric calculation from the blue region.