# An experimental analysis of multidimensional cheap talk ☆

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### A B S T R A C T

We design experimental games that capture the logic of Battaglini's (2002) construction of fully revealing equilibrium in multidimensional cheap talk. Two senders transmit information to a receiver over a $2 \times 2$ state space. Despite overall misaligned interests, full revelation is achieved in equilibrium by having the senders truthfully reveal along distinct dimensions. Our experimental findings confirm that more information can be extracted with two senders in a multidimensional setting. The extent to which information is transmitted depends on whether dimensional interests are aligned between a sender and the receiver, the sizes of the message spaces, and the specification of out-of-equilibrium beliefs. While inducing interest alignment on the relevant dimensions and restricting the message spaces facilitated equilibrium play and information transmission, having a fully revealing equilibrium that is supported by implausible beliefs reduced the instances in which the equilibrium was played.

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## 1. Introduction

A defining hallmark of modern economies is the extensive specialization that occurs not only in physical production but also in the more intangible domain of decision making and information provision. Comparative advantage not only dictates that decision makers delegate knowledge acquisition to experts but also guides different experts to specialize in offering advice on distinct issues. When conflicts of interests are present, strategic considerations may provide yet another reason for decision makers to consult different experts. In seeking advice from an interested advisor on the potential impacts of a

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bill, a legislator may obtain impartial advice only in certain areas, creating the need for her to consult another advisor who might be forthright in a different manner. In a seminal paper on multidimensional cheap talk, Battaglini (2002) provides a strategic argument for otherwise equally informed experts to specialize in giving advice on different dimensions.[1]

The theory of multidimensional cheap talk contrasts sharply with its unidimensional counterpart. In the canonical cheap-talk model of Crawford and Sobel (1982), unless interests are perfectly aligned between the sender and the receiver, only partial information can be transmitted.[2] The picture changes drastically when one more sender is introduced and the uncertainty becomes multidimensional. Battaglini (2002) shows that with two senders and for a multidimensional (unbounded) state space, a fully revealing equilibrium exists even when the senders are arbitrarily biased. The key insight of the equilibrium construction is that, by having one sender truthfully reveal along one dimension, an incentive is created for the other sender to truthfully reveal along the other dimension. By combining the information from the two senders, the receiver fully identifies the state.[3]

We experimentally investigate the key insight of Battaglini's (2002) equilibrium construction. In particular, we address three research questions. First, we explore under what circumstances the theoretical prediction that more information can be extracted with two senders in a multidimensional setting will be verified in the lab, and whether the information transmission will be conducted in strategies consistent with the logic of Battaglini's (2002) equilibrium. Second, we investigate how, in an experimental setting, the size of the message spaces may affect the extent of information transmission. Finally, we explore how the empirical performance of an equilibrium may depend on the specification of out-of-equilibrium beliefs, which, unlike the case with one sender, is an important issue in cheap talk with multiple senders.[4]

We create simple discrete environments to address our research questions. Two senders, Sender 1 (he) and Sender 2 (he), send simultaneous messages to a receiver (she) regarding a 2 (horizontal dimension) × 2 (vertical dimension) state space. The receiver chooses among four actions. Each sender has available four costless messages framed as non-binding action recommendations. Interests are overall misaligned: the players' ideal actions differ. However, each sender and the receiver share a common ranking of the relevant actions assuming that the senders' influences on the receiver are limited to distinct dimensions. Such a payoff structure supports a fully revealing equilibrium in which Sender 1 truthfully reveals along the horizontal dimension and Sender 2 along the vertical dimension.

We consider treatment variations in which the message spaces become binary and in which the common interest between a sender and the receiver is along a diagonal of the state space matrix. One-sender control games are also included. To address the issue of out-of-equilibrium beliefs, we design a game by eliminating a state so that only three states remain. Following Ambrus and Takahashi (2008), out-of-equilibrium messages arise in the game as messages that indicate a "state" outside of the state space, i.e., the eliminated state. The corresponding fully revealing equilibrium is supported by out-of-equilibrium beliefs that are implausible according to the robustness criterion advanced by Battaglini (2002).[5]

Our simple discrete design provides an environment that is relatively easy for subjects to comprehend. To take advantage of such a simple design, however, we need to depart from certain aspects of Battaglini's (2002) model. In particular, in his model a dimension of common interest between a sender and the receiver is endogenous (i.e., it is an equilibrium phenomenon), whereas in our case it arises from the payoff structure of the game. Despite this departure from Battaglini (2002), we nevertheless preserve the key logic of his equilibrium in which one sender reveals along one dimension of common interest.

In our findings from the four-message games, high adherence to fully revealing equilibrium was observed when a sender's and the receiver's interests are aligned on a dimension regardless of the other sender's behavior. Sender 1s revealed on the horizontal dimension and randomized on the vertical dimension, and vice versa for Sender 2s. Receivers

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[1] Cheap-talk models have been a theoretical arena for studying the strategic interactions between experts and decision makers. Other than the interactions between legislators and advisors (Gilligan and Krehbiel, 1989; Krishna and Morgan, 2001b), they have shed light on, for example, the interactions between stock analysts and investors (Morgan and Stocken, 2003) and between doctors and patients (Kőszegi, 2006).

[2] This informational property of the equilibrium survives modeling variations within the single-sender-single-dimension environment. It is invariant to, for example, the introduction of an additional round of communication (Krishna and Morgan, 2004), noise in the communication channel (Blume et al., 2007), and a mediator (Goltsman et al., 2009; Ivanov, 2010).

[3] For an analysis of multiple senders with unidimensional or discrete state spaces, see Gilligan and Krehbiel (1989), Austen-Smith (1993), and Krishna and Morgan (2001a, 2001b). Battaglini (2002) revisits the problem with more complete characterizations. Ambrus and Lu (2014) and Lu (2015) further investigate robust equilibria in such an environment. For an analysis of multidimensional state spaces with a single sender, see Levy and Razin (2007) and Chakraborty and Harbaugh (2007, 2010). For papers that introduce additional receivers, see Farrell and Gibbons (1989) and Goltsman and Pavlov (2011).

[4] When there is only one sender, out-of-equilibrium messages arise only as unused messages, which can be disregarded without any impact on equilibrium outcomes. With two senders, out-of-equilibrium messages can arise when they convey inconsistent information. Even when the senders reveal along different dimensions, as in Battaglini's (2002) construction, so that there will be no inconsistent information, Ambrus and Takahashi (2008) point out that out-of-equilibrium messages can still emerge: if the state space is bounded, after a deviation the messages may indicate a "state" outside of the state space. (Intuitively, when one investment advisor advocates strongly for stocks and another strongly for bonds, investors are likely to raise question if there does not exist economic condition that warrants heavy investments in both.) Accordingly, the specification of out-of-equilibrium beliefs is an indispensable part of the characterizations of cheap-talk equilibria with multiple senders. This further leads to the robustness inquiry of what equilibria can only be supported by implausible beliefs. While "implausibility" in this regard is based on theoretical consideration, an experimental study that investigates this issue may inform the theory by exploring whether the theoretical notion has empirical appeal supported by layman's intuition.

[5] For a few findings on robustness in the theoretical literature, see Battaglini (2004) who shows that the fully revealing equilibrium under an unbounded state space is robust to noise in the senders' observations; under a different information structure, Levy and Razin (2007) show that it is not; Ambrus and Takahashi (2008) show that imposing the so-called "diagonal continuity" drastically reduces the possibility of full revelation under a bounded state space; Kim (2010) proposes yet another criterion—"outcome-robustness"—and shows that no fully revealing equilibrium studied in Levy and Razin (2007) survives.