Centralized vs. Decentralized Management: An Experimental Study

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Abstract: We introduce a new game to the experimental literature and use it to study how behavioral phenomena affect the tradeoffs between centralized and decentralized management. Our game models an organization with two divisions and one central manager. Each division must choose or be assigned a product. Ignoring asymmetric information, the underlying game is an asymmetric coordination game related to the Battle of the Sexes. In equilibrium, the divisions coordinate on identical products. Each division prefers an equilibrium where the selected products are closest to its local tastes while central management prefers the efficient equilibrium, determined by a randomly state of the world, which maximizes total payoffs. The state of the world is known to the divisions, but the central manager only learns about it through messages from the divisions who have incentives to lie. Contrary to the theory, overall performance is higher under centralization, where the central manager assigns products to divisions after receiving messages from the divisions, than under decentralization where the divisions choose their own products. Underlying this, mis-coordination is common under decentralization and divisions fail to use their information when they do coordinate. Mis-coordination is non-existent under centralization and there is a high degree of truth-telling by divisions as well. Performance under centralization is depressed by persistent sub-optimal use of information by center managers.

Keywords: Coordination, Experiments, Organizations, Asymmetric Information

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1. Introduction: A central question in the economics of organizations is whether organizations should be centrally managed or divisions should operate independently. This is an old question in economics, dating back to debates about whether an economy should be centrally managed as in a socialist economy or decentralized as under capitalism.[1] There is a long history of theory papers looking at the tradeoffs between centralization and decentralization within firms and recent years have seen a new burst of research, both theoretical and empirical, on this issue.[2] At the heart of the matter is whether a firm should be more concerned about coordination problems between its divisions or the difficulties associated with information transmission from its divisions to central management.

One of the primary advantages of large firms is the ability to take advantage of economies of scale. This advantage is reduced if the firm must produce many variants of its basic product rather than a single or small number of varieties. Left on their own, divisions may choose to sell products which are inefficiently differentiated. This is precisely the outcome documented by Thomas (2011). She studies two multinational producers of laundry detergent in Europe which operate in a decentralized way. Her main conclusion is that decentralization leads to products being, from the perspective of central management, excessively differentiated between countries leading to inefficiently high costs.

Centralization allows a firm to control its divisions' product choices, limiting inefficient differentiation across divisions, but this enforced coordination comes at a cost. Divisions often have valuable information about market conditions. If they are asked to transmit this information to central management as an initial step in the centralized choice of products, divisions typically have a strong incentive to distort their information for strategic reasons and this may lead to the coordinated choice for all divisions but on the wrong product. The choice of whether or not to centralize involves weighing the benefits of coordination versus the costs of distorted information.

This paper presents the results of laboratory experiments that shed light on how behavioral phenomena affect the tradeoffs between centralization and decentralization. We design a new game which allows us to study some of the crucial issues involved. Our experiments are not intended to test any particular theory, but instead focus on how the interplay of several phenomena affect the centralization vs. decentralization trade-off. The results of our experiments show whether centralized or decentralized management is preferable in our case. However, we are less interested in the bottom line than in understanding how it comes about. We focus on three behavioral issues some of which have been

[1] See Lange and Taylor (1938) and Hayek (1945).

[2] See Mookherjee (2006) for a good survey of the older theoretical literature on centralization versus decentralization. Prominent examples of the more recent theory literature include Hart and Moore (2005), Alonso, Dessein, and Matuouschek (2008a, 2008b and 2015), Rantakari (2008), Hart and Holmstrom (2010), Dessein, Garicano, and Gertner (2010). For recent empirical studies using observational data see Thomas (2011) and McElheran (2014).

shown to be important in other contexts and that play a central role in the comparison between centralization and decentralization:

(1) The first issue is to what extent under decentralization divisions will successfully coordinate on the efficient (i.e. total surplus maximizing) equilibrium in an environment with multiple equilibria. In the theoretical analysis of the centralization-decentralization trade-off, it is not an indispensable feature of the analysis to assume coordination on the efficient equilibrium, but it is typically used to sharpen the the theoretical predictions. In particular, in a prominent paper Alonso et al. (2008) write: “We believe that it is reasonable to assume that the organization is able to coordinate on the equilibrium that maximizes the expected overall profits, and we focus on this equilibrium for the rest of the analysis (p. 158).” From our point of view, the degree of successful coordination is an empirical issue and our laboratory experiments provide data on it.

(2) The second issue is whether, when transmitting information about the state of the world in the case of centralized management, divisions will choose the messages which maximize their expected payoffs rather than telling the truth. The standard self-interest assumption proposes that divisions will lie whenever it is in their interest. However, previous experimental work on various issues shows that participants in experiments do not always lie. If this also occurs in our environment it will affect tha comparison between centralization and decentralization.

(3) The third issue is whether firms will optimally extract information from the messages sent by their divisions. The classical assumption of perfect rationality prescribes the optimal use of information, but again it is an empirical question to what extent this occurs and our experiments make it possible to carefully study this problem.

Going into detail, our experiments are based on a simple new game of a firm with a central manager and two division managers. The firm has to decide what variety of a product to sell through each of its divisions. This decision can either be made directly by the central manager (centralization) or delegated to the division managers (decentralization). Division profits are a function of what products are sold by *both* divisions and the central manager’s profit equals the sum of the two divisions’ profits.

Division profits (and firm profits by extension) are affected by economies of scale and consumer tastes. Economies of scale lead to lower costs when the products sold by the two divisions are the same than when they are different. Intuitively, a large firm that sells only one product can cut costs by taking advantage of its purchasing power or using large scale centralized production. These cost saving advantages disappear if each division’s products require a different set of inputs or small scale production, creating an incentive to coordinate the divisions’ product choices. Demand for the divisions’ products depends on consumer tastes. Some elements of consumer tastes are constant while others vary. For example, consider an American restaurant chain selling food through two divisions, North and South.

American tastes have been changing over time in favor of healthier foods. This has happened across the entire country and would affect both divisions. The nation-wide trend towards healthier food is an example of varying tastes. These varying tastes are global in the sense that they affect both divisions equally. The constant part of tastes consists in the northern regions of the US consistently having a different taste for food than the southern regions. Even though tastes have changed throughout the country, persistent differences between regions have remained. This is an example of local tastes.

Global tastes can change over time and in our model they are assumed to be stochastic. Division managers are considered to be closer to the market and know the realized state of the world while the central manager only knows the *ex ante* distribution over states. In contrast, local tastes are constant and known by all three players. Under centralization, central managers want the divisions to share their information but persistent differences in local tastes complicate this since each division has an incentive to bias its reports to central management in favor of its local tastes.

Our model incorporates the preceding features in a fashion designed to confront subjects with challenging tradeoffs while keeping the environment relatively simple. Under decentralization the division managers choose products independently from each other while central management is a passive bystander. The model is constructed so decentralization yields a game between the divisions with multiple equilibria, resembling the Battle of the Sexes (BOS). For all states of the world, all equilibria involve division managers choosing identical products, due to the strength of the economies of scale. Both divisions prefer product choices which are closer to their local tastes, leading to diametrically opposed preferences over the set of equilibria. For each state of the world there is an efficient equilibrium which maximizes total profits. The product jointly chosen in the efficient equilibrium changes with the state of the world, coming closer to the local tastes of one division or the other depending on current global tastes. For most states of the world, the efficient equilibrium yields a higher profit to one division than the other. An important difference from the BOS is that in our games there always exists an equilibrium that yields both divisions identical payoffs but generally does not maximize total profits.

Under centralization division managers do not make product choices. Rather, division managers independently make non-verifiable reports about the state of the world (i.e. global tastes) to the central manager, who then chooses a product for each division. Given the importance of economies of scale in our set-up, the central manager should always choose the same product for both divisions regardless of beliefs of what the true state of the world is. The central manager could always maximize total profits *if he knew the state of the world.* However, the game is constructed so the only equilibria under centralization are babbling equilibria in which the division managers' incentives to distort their reports are so strong that they reveal no useful information to the central manager.

The model is designed to emphasize the relative strengths and weaknesses of decentralization and centralization. With decentralization there is no asymmetric information but the divisions face a difficult coordination problem. Under centralization, the central manager can force coordination but is not expected to benefit from the private information of division managers since the models is constructed so the *only* type of equilibria are babbling equilibria.[3] Theory suggests that the maximum total profits consistent with an equilibrium are higher for decentralization. Empirically, the relative performance of decentralization and centralization depends on the relative severity of the coordination problems in the former case and the informational problems in the latter.

Contrary to the theoretical prediction, our data features substantially higher total profits under centralization. This holds true whether we use a strangers matching or a partners matching, and remains true as subjects gain experience. Underlying this difference in profits is the fact that coordination is extremely difficult under decentralization. Experience and fixed matching eases the coordination problem, but never to the point that coordination approaches the levels achieved under centralization. Even when coordination does occur under decentralization, the most common outcome is to coordinate on an equilibrium where actions don't vary with the state of the world. This equalizes payoffs and simplifies coordination since the equilibrium is not state-dependent, *but eliminates the informational advantages of decentralization.*

Payoffs under centralization are no better than expected for the babbling equilibrium, but central and division managers are *not* playing a babbling equilibrium where messages are uninformative and central managers chose the same products regardless of what messages they receive. We observe a sizeable degree of truth-telling by division managers, and central managers respond positively to the messages sent by the divisions. However, central managers make systematic mistakes in using the information contained in the divisions' messages. As an especially common example, suppose a central manager receives a pair of messages where each division manager claims the state is the most favorable towards him (but not the other division manager). Such pairs of messages are completely uninformative and the central manager's best response is to play according to the babbling equilibrium. About two thirds of central managers do *not* play optimally in this case, acting as if one division manager's message is more informative than the other. This mistake cannot be explained by repeated interactions, social preferences, or inexperience. Errors in central managers' use of messages almost perfectly counter-balance the benefits of receiving useful information. If central managers used the information they receive more efficiently, centralization would outperform decentralization even more strongly.

[3] This is not a generic property of this class of games (Battaglini, 1992).

Coordination failure, biases toward truth-telling, and poor extraction of information from signals have all been studied independently from each other in the experimental literature (see Section 2 for a summary of the relevant literature). Rather than being interested in these phenomena for their own sake, our goal is to understand the performance of organizations under centralization and decentralization. These behavioral phenomena are relevant for our study because they systematically shift the observed outcomes away from the theoretical predictions. That said, these phenomena manifest themselves in our experiments in ways that differ from what has been observed in previous work. Under decentralization, performance is limited not just by coordination failure, but also by a strong tendency to coordinate on always playing the same equilibrium regardless of the state of the world. If the primary advantage of decentralization is the ability to use divisions' information, use of an equilibrium that does not respond to the state of the world eliminates this advantage. Along a different dimension, the failure of central managers to correctly process information under centralization resembles results reported by Vespa and Wilson (2015), but is more extreme. Vespa and Wilson receivers fail to fully extract information from senders' signals for cases where it is relatively difficult to infer the correct course of action. In our data, CMs get it wrong even in cases where the best response is rather obvious.

The most closely related experimental papers to ours are Evdokimov and Garfagnini (2015) and Hamman and Martínez-Carrasco (2015). These are described in more detail in Section 2. Both papers test specific predictions of existing theories comparing centralization and decentralization. They generally find support for the comparative statics predicted by the models. Our paper does not focus on testing any specific prediction of an existing theory but rather focuses on the behavioral assumptions underlying the theories. We feel our work has implications for many models of centralization and decentralization.

Centralization works far better than decentralization in our experimental environment, but it would be obviously excessive to claim this is a universal result. The game in our experiment is designed to generate stark tradeoffs that put stress on the theoretical predictions. While we don't expect the ranking of centralization over decentralization to generalize to all settings, we do think the behavioral phenomena underlying this ranking are rather general. Because coordination in asymmetric games is difficult and because individuals with an incentive to lie often opt for the truth, we anticipate that centralization will generally perform better than standard theory might lead one to expect.

2. Related Empirical Literature: The study with observational data that most closely relates to our work is Thomas (2011). She presents a detailed empirical analysis of two large multinational companies in the laundry detergents industry in Western Europe. The central variable of the analysis is the product-range. In both companies product-range decisions were made in a decentralized way at the brand-country level by local managers. The results show that the organizational form leads to product-range variation exceeding the optimal firm-level response to local conditions. The paper finds that too many products are being produced in this industry, as a result of mis-coordination between local managers, but cannot investigate how companies would fare under centralization.[4] Less related, there exist studies with observational dealing with coordination problems (see Ichniowski et al., 1997 and Knez and Simester, 2002). We are not aware of any research involving observational data that deals with the issue of truth-telling or with information processing of the kind we study in our experiments.

There is a rich laboratory experiments literature dealing with coordination, issues of truth-telling and information processing in isolation. For a general discussion of experiments related to coordination problems see Camerer (2003) and for surveys of experimental work on organizational issues see Camerer and Weber (2012) and Kriss and Weber (forthcoming). The paper from the experimental literature on coordination most closely related to our current work is Cooper *et al* (1989). They study the effect of communication in BOS games. Without communication, coordination is quite difficult in these games due to the lack of a focal equilibrium. Subjects do a bit better than the symmetric mixed strategy equilibrium, but are still far from efficiency. With one-way communication, coordination rates are quite high as the sender can call for her preferred equilibrium and the receiver generally follows. Two way communication is less effective, even with repetition. If a pair sends messages that agree on an equilibrium, this equilibrium is generally played, but there are numerous cases where each calls for their preferred equilibrium and play akin to the mixed strategy equilibrium results. Our environment is more complicated that the simple BOS games studied by Cooper *et al*, although the presence of a symmetric equilibrium somewhat offsets this. We also observe that coordination is quite difficult and conjecture that the Cooper *et al* communication results would extend to our setting, indicating that communication among divisions would not be a cure-all for decentralization.

There is also a large literature on truth-telling. For a recent discussion of lie aversion, see Erat and Gneezy, 2012 and the references therein. The most striking finding from this literature is the unwillingness of many subjects to tell a lie even when doing so is Pareto improving (Erat and Gneezy, 2012). Studies of cheap talk games find a similar bias towards telling the truth (Cai and Wang, 2006; Sanchez-Pages and Vorsatz, 2007), although in this case truthfulness could stem from either an aversion to lying or a failure to grasp the strategic benefits of distorting one's message.

Finally, information processing of various types has also been studied with lab experiments in various environments. Notable examples where subjects fail to correctly process information are experiments looking at individual decision making where subjects fail to correctly apply Bayes' Rule (e.g.

[4] For a related study see McElharan (2014).

Grether, 1980; Charness and Levin, 2005). In strategic settings, the paper most closely related to ours is the work by Vespa and Wilson described above. They examine variations of the cheap-talk model proposed by Battaglini (2002). Their experimental environment differs in one critical aspect from ours since, in keeping with Battaglini, they study games where messages should fully reveal the state of the world in equilibrium. We wanted to make the informational problems under centralization as severe as possible, and so designed a game where messages were not fully revealing (or even informative) in equilibrium due to a lack of common interest between the divisions. Nonetheless, their results have an obvious relationship to our experiments. They study three different games. In the two where it is relatively difficult (but possible) to infer the state of the world from sender's messages, receivers perform poorly at extracting information. The failure to extract information is even more severe in our experiments, as central managers often do poorly even when the information extraction problem is rather simple.

. The two most closely related experimental papers to ours are Evdokimov and Garfagnini (2015) and Hamman and Martínez-Carrasco (2015). The first of these papers provides a direct experimental test of the theoretical models of Alonso et al. (2008) and Rantakari (2008) in an experimental environment with two divisions and one central manager. The focus is on comparing the quality of horizontal communication between divisions with that of vertical communication between the divisions and central management and allowing for two different levels of incentives of coordination. The results are largely in line with theoretical predictions: the quality of horizontal communication is significantly higher than that of vertical communication and divisions' actions are more coordinated when the importance of coordination is high. They do find some departures from the theoretical predictions, as centralized (decentralized) organizations are less (more) coordinated than expected. While the setup is close to ours, the focus is quite different. Evdokimov and Garfagnini are largely focused on theory testing, while we are more concerned with the behavioral assumptions underpinning the theory.

Hamman and Martínez-Carrasco (2015) examine decentralization in the context of a more complex environment involving task selection. Central management first chooses what type of workers to hire, homogenous or heterogeneous, and then chooses either to keep decision making rights over task assignment (centralization) or delegates task assignment to workers (decentralization). They find that, consistent with their theory, decentralization is more common as task uncertainty grows. In other words, decentralization increases as the informational advantage of the workers grows. They also find a persistent tendency to choose centralization too frequently, driven by a tendency to overreact to bad decisions by the workers. While the environment studied by Hamman and Martínez-Carrasco is rather different than what we study, the endogenous choice of structures is an important contribution. We would be curious to know whether similar biases occur in our setup.

3. Experimental Design and Procedures: The games played in our experiments are not directly based on any model in the literature and our intent is neither to test any specific theory in the literature nor to mimic some specific real world setting. Instead, our goal is to examine how subjects handle the tradeoffs between centralization and decentralization with a focus on the behavioral aspects of their decision making. We made a number of design choices intended to yield a relative simple game with extreme features that accentuate the tradeoffs between centralization and decentralization.

(Table 1 about here)

3.1. The Game and Hypotheses: There are three players in the game, a central manager (CM) and two division managers (D1 and D2). G denotes the state of the world: G ∈ {1, 2, 3, 4, 5}, which is meant to represent overall market conditions. The states of the world give rise to the five payoff tables represented in Table 1. As standard nomenclature, we refer to states of the world by the game induced (e.g. Game 1 for G = 1) and rows and columns by their number (e.g. R1 for the first row, C3 for the third column). In each cell the three numbers correspond to the payoffs of D1 (π_{D1}), D2 (π_{D2}), and CM (π_{CM}). Payoffs are a function of the state of the world G, the row number R and the column number C. Equations 1a, 1b, and 1c give the payoff functions for D1, D2, and CM respectively.

$$\pi_{D1} = 54 - 7|R - 5| - 4|R - G| - 14|R - C| \quad \textbf{(Eq. 1a)}$$

$$\pi_{D2} = 54 - 7|C - 1| - 4|C - G| - 14|C - R| \quad \textbf{(Eq. 1b)}$$

$$\pi_{CM} = \pi_{D1} + \pi_{D2} \quad \textbf{(Eq. 1c)}$$

The choices of rows and columns represent business decisions, specifically the choice of what products to sell at two different locations. The row is the product chosen by D1 (or chosen for them by CM) and the column is likewise the product for D2. Choosing a row and a column with the same number represents standardization of product choices, whereas rows and columns with different numbers correspond to more disparate product choices between the two divisions.

As an example of how the payoff tables and functions work, suppose D1 chooses R1 and D2 chooses R2 for Game 1. This is the efficient (i.e. total surplus maximizing) equilibrium for Game 1 but is also the least preferred equilibrium for D1, obtaining a payoff of 28. If D1 deviates to choosing R2 instead of R1, the player loses 14 for ceasing to be coordinated with the other division, loses another 4 for moving away from efficiency but gains 7 from moving closer to his preferred choice R5. The total loss is 11, the difference between 26 and 15.

$$\pi_D = k_1 - k_2 * adaptation\ loss - k_3 * state\ loss - k_4 * coordination\ loss \quad \textbf{(Eq. 2)}$$

The division payoffs are better understood through Equation 2 rather than Equations 1a and 1b. Division payoffs equal a constant minus three types of losses. Adaption losses, given by the first term in the payoff function, are the losses due to deviations from local tastes. Divisions face diametrically opposed local tastes, with R5 most preferred by D1 and C1 most preferred by D2. Local tastes are do *not* depend on the state of the world and are therefore known by all three players. The second term in the division payoff functions represents the "state losses", the losses incurred by deviating from global tastes. Global tastes depend on the state of the world. Both divisions are assumed to know the state of the world, but CM only knows the *ex ante* distribution over states. The last term represents the coordination loss, the loss from not choosing the same product as the other divisions. Intuitively, division costs are lowest when they can take advantage of economies of scale by standardizing. We assume $k_4 > k_2 > k_3$. In other words, losses from mis-coordination are greater than losses from not adapting to local conditions, which in turn are larger than losses from not responding to global conditions. Together, these assumptions make all five games into coordination games where the two divisions have diametrically opposed interests.[5]

CM's payoff is the sum of the divisions' payoffs. In other words, central management seeks to maximize total firm profits. This need not be interpreted as benevolence on the part of central management, but instead can represent a setting where the rewards of division managers largely depend on how their division does while central management is concerned with profits across the entire firm.

The payoff functions in Equations 1a, 1b, and 1c are similar to those used in Alonso *et al*'s (2008a) model, but differ is several important ways. First, the state loss present in Equations 1a and 1b is not part of the Alonso *et al* model.[6] Local tastes are stochastic in their model rather than being fixed and known in ours. These differences have the effect of making the experimental environment simpler, as the central manager's uncertainty is over a single dimension rather than two and there is no asymmetric information between D1 and D2. Second, the functional form of adaption and coordination losses in Equations 1a and 1b are absolute values of differences rather than squared differences as used by Alonso *et al*. This sharpens the incentives to coordinate for the divisions. Rather than shading their choices away from local tastes and towards the other division's choice, divisions in our model want to do exactly the same thing as the other division. Finally, we assume each division manager is solely concerned with their own division's profits rather than a weighted average over divisions. This simplifies the game and sharpens the incentives faced by division managers. If this was a theory paper, the Alonso *et al* model

[5] If adaption losses are higher than the sum of coordination and state losses ($k_2 > k_3 + k_4$, it becomes a dominant strategy for each division to perfectly conform to local tastes. For less extreme cases ($k_3 + k_4 > k_2 > k_4$), there are multiple equilibria but some choices become dominated implying that the subgames no longer have five equilibria and in some cases have a unique equilibrium. If state losses are larger than adaption losses ($k_3 > k_2$), the divisions preferences over equilibria will be aligned.

[6] See Equations 1 and 2 in Alonso *et al*.

would clearly be the richer model with more interesting theoretical properties. Our payoff functions were chosen from an experimenter's point of view. We wanted to simplify the game and confront subjects with sharp tradeoffs.[7]

Before players take any actions, the state of the world (and hence the payoff table) is randomly determined *with all states being equally likely*. Recall that D1 and D2 are informed about the state of the world (there is no asymmetric information between D1 and D2) while CM is uninformed beyond the initial distribution of states. This represents a situation where both divisions know the general business conditions in the field, while central management does not. Under decentralization, D1 chooses a row, D2 chooses a column, and CM is a passive bystander. Ignoring the payoff for CM, all five games are coordination games with five pure strategy Nash equilibria: (R1,C1), (R2, C2), (R3,C3), (R4,C4), and (R5,C5). For convenience, we refer to these as Equilibrium 1, Equilibrium 2, etc. In each of the five games there is a tension similar to battle-of-the-sexes (BOS), since D1 prefers Equilibrium 5 with Equilibrium 1 being his least preferred equilibrium, while for D2 it is the other way around.[8] From previous research (Cooper et al., 1989) it is known that coordination in the BOS game is difficult to achieve. Unlike a standard BOS game, our game has a relatively easy way to coordinate and achieve equal payoffs since Equilibrium 3 yields the same payoff to both divisions in all five games. Except for Game 3, this equilibrium does not maximize total surplus (the sum of the divisions' payoffs). For all five games there is an equilibrium that maximizes total surplus over all possible outcomes. This is always equivalent to the game number (i.e. Equilibrium 1 in Game 1, Equilibrium 2 in Game 2, etc.). Intuitively, divisions standardize products in any equilibrium and standardize on the product that matches global tastes in the surplus maximizing equilibrium. The efficient equilibrium, where the divisions play the surplus maximizing equilibrium in each state of the world, is procedurally fair (equalizes expected payoffs under the veil of ignorance about the state of the world). Once the state of the world is known, the efficient equilibrium yields asymmetric payoffs for all games except Game 3. By construction, the efficient equilibrium also maximizes the central manager's payoff. Therefore, CM always prefers a different equilibrium than at least one of the divisions, and prefers a different equilibrium than either division in Games 2 – 4. Other than Game 3, equalizing payoff across divisions and maximizing surplus also point to different equilibria.

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[7] Having five possible product choices (rather than three) for each division makes the game more complex, but also has distinct advantages. First, having five choices makes it less likely that an efficient choice will emerge by chance. Under centralization, having five also lets us observe partial responses to messages (i.e. CMs can split the difference between moving to a corner and staying in the center.)

[8] Strictly speaking the battle-of-the-sexes is an anti-coordination game, where, in equilibrium, players do not choose the same action. In contrast our game is a coordination game with equilibria with asymmetric payoffs.

It is consistent with equilibrium for the divisions to always maximize total surplus, but there are many pure strategy equilibria that lead to lower payoffs. Achieving maximum surplus relies critically on the ability of divisions to coordinate on the efficient equilibrium. Looking at Table 1, notice that if one division selects the choice corresponding to the efficient equilibrium and the other division misses it by *only one level*, then average surplus drops from 80 in the efficient equilibrium to either 41 or 55. This is comparable to always coordinating on the worst possible pure strategy equilibrium which yields an expected payoff of 54.4. The payoff table is set up to favor successful coordination given the large losses caused by coordination failure.

Under *centralization* the two divisions do not choose rows and columns directly. After being informed about the state of the world (i.e. Game 1, Game 2, etc.) each division independently sends a message to the CM indicating what state of the world has been selected. There is no requirement that these messages be truthful, a point which is emphasized in the instructions.[9] After receipt of the two messages the CM then chooses both a row and a column. The CM has no knowledge about which game has been selected beyond the initial distribution over states of the world and whatever information she gleans from the divisions' messages. With centralization, the main difficulty in achieving efficiency is not achieving coordination. The CM can directly enforce coordination and has clear incentives to choose a row and column corresponding to a pure strategy Nash equilibrium.[10] Unlike decentralization where asymmetric information plays no role, asymmetric information is the central barrier to achieving efficiency under centralization. Conditional on enforcing coordination, Equations 1a and 1b are constructed so the sum of adaptive losses across D1 and D2 is a constant. This implies that CM does not care about local tastes, but the divisions do. Given their opposing interests, the divisions have no incentive to be truthful with the CM. If both DMs always report the game where the efficient equilibrium is most efficient to them (Game 5 for D1, Game 1 for D2), the best the CM can do is to choose R3/C3. Any benefits from the private information of the divisions are lost and the CM generally will not choose the surplus maximizing equilibrium given the state of the world.

More formally, we can prove the following theorem. Given that the CM must choose the same row and column in any Perfect Bayesian equilibrium (PBE), we refer to the CM as choosing a single action in response to the divisions' messages. Note that the theory assumes messages are cheap talk, with the divisions' incurring no cost, pecuniary or psychological, for sending false messages.

[9] The instructions state " … [D1 and D2] will separately send messages to [CM] saying which game has been selected. This message can be truthful or not."

[10] It is trivial to prove that the CM's best response for any beliefs over states of the world must involve setting the row and column equal to each other (i.e. coordinating). See Appendix A for proof.

Theorem: There does not exist a pure strategy PBE where the CM chooses different actions for two different states of the world. This implies that the only pure strategy PBE are babbling equilibria where R3 and C3 are always chosen.

The theoretical results suggest a pair of hypotheses about the experimental data. First, there is an equilibrium under decentralization where maximum total surplus is achieved. No such equilibrium exists with centralization. If we assume subjects play the surplus maximizing equilibrium subject to treatment, decentralization will yield the highest possible surplus and outperform centralization. Of course, it must be stressed that existing experimental evidence suggests that achieving coordination under decentralization, let alone the surplus maximizing equilibrium, may be very difficult.

H1: *Total surplus will be greater under decentralization than with centralization.*

The theorem above implies that messages under centralization will contain no useful information. The best case scenario is that play converges to the babbling equilibrium. Once again, existing experimental results should give us pause. While our setup differs from many of the existing experiments, especially since there is more than one sender, the general finding that individuals are reluctant to tell lies which benefit them and harm others is likely to apply in our experiments.

H2: *In the Centralization treatment, messages from the divisions will contain no useful information about the state of the world. Total surplus will not exceed the expected payoff from a babbling equilibrium.*

In summary, all three players want coordination. The divisions know the global ideal but want coordination at what is best for them, regardless of what is best for the firm as a whole. Central management wants coordination at the most efficient equilibrium, which is determined by global tastes, but does not know what global tastes are. We feel that this is a rather natural simple representation of the tension between divisions and center in organizations. Under decentralization, efficiency can be achieved only if the divisions can coordinate on equilibria that are not their preferred option. Under centralization, efficiency cannot be achieved in equilibrium because divisions will distort their information. But if they did share their information with central management, coordination is trivial. This is the central tension in our experiment. If the problems of coordination are particularly bad, decentralization will do relatively badly. If the difficulties of sharing information are more severe, the scales are tipped toward decentralization.

3.2 Experimental Design: In all treatments, participants were assigned the role of CM, D1 or D2 at the beginning of the session and these roles remained constant throughout the session. In treatments with decentralized decision-making the participants in the CM role were pure observers. We did this to keep the possible influence of other-regarding preferences constant across treatments. Subjects played a total of 18 rounds in all treatments.

We used a 2x2 experimental design. In addition to the variation between centralization and decentralization, we also varied the type of matching between an almost perfect strangers protocol and partners matching. With almost perfect strangers matching, groups changed from round to round. Participants were told that they would play an initial block of nine rounds in which they were re-matched with two new players in each round. This was done in such a way that none of the participants met another person twice in the nine round block (a point which the instructions stressed). At no time were participants informed about the identity of the other two people in their group. After the first nine round block was over subjects were informed that there would be an additional nine round block of the same game in which matchings would made as in the first nine round block – i.e. they would not met any other subject more than once in the nine round block. Playing two blocks allowed participants to gain experience with the game although it necessitated playing each other more than once.

With fixed matching, participants were matched with same two other subjects throughout the entire experiment. At the beginning of the session, they were only told that the matching would be fixed for the first nine round block (they were given no information about the second block). After the first block was over, subjects were informed that there would be an additional nine rounds of the same game using the same groups as in the first nine rounds.

Comparing the two types of matching gives us two different views of the problem. With the strangers matching we are as close to the one shot game as possible. This largely eliminates any repeated game effects, but makes it relatively difficult to learn how to coordinate and, arguably, is less realistic (presumably central managers and division managers within a firm interact repeatedly). The partner matching should make coordination easier. In theory the set of (subgame perfect) equilibrium outcomes is not expanded with partner matching, but it does become possible to engage is strategic teaching in the decentralized game.[11] These variations give rise to our four treatments.

We conducted five sessions for each of the treatments with strangers matching and three sessions for each of the treatments with fixed matching. Fewer sessions are needed with the fixed matching since

[11] Strategic teaching refers to attempts to alter others' future choices by manipulating their learning processes. For experimental evidence of strategic teaching see Terracol and Vaksmann (2009), Hyndman et al. (2009), Fehr et al. (2012) and Hyndman et al. (2012).

each session generates nine independent observations. There were 27 participants in each session, with participants not being allowed to participate in more than one session.

Session began with instruction which can be found in Appendix B. Participants had printed copies of the payoff tables for all five games. They received feedback about the actual state of the world after each round. In the centralization treatments this made it possible to know whether a division had lied about the game being played.

The sessions were run at the LINEEX lab at the University of Valencia, with participants being undergraduate students from the university. The payoffs were denominated in Experimental Currency Units, with 1 ECU = 0.2 €. Participants were paid for all rounds. Including a 5€ show-up fee average pay was 19.94€. Sessions lasted around an hour.

4. Results: Section 4.1 looks at the treatment effects of centralization vs. decentralization and strangers vs. partners matching and analyzes the factors behind observed differences. In particular, we study how the difficulties of coordination affect behavior under decentralization. Section 4.2 focuses on the two centralization treatments in detail. We study the relation between games, messages and the CM's decisions and show how the tendency to truth-telling and poor information processing affect the results.

4.1. Treatment Effects: Figure 1 shows total surplus for all four treatments, where maximum total surplus is always 80 and the expected surplus from the babbling equilibrium is 70.4.[12] The data is shown in three period blocks to reduce the noise. Total surplus is higher for centralization than for decentralization under either strangers or partners matching. The difference is significant at the 1% level for strangers matching ($z = 2.61$; $p < .01$) using a Wilcoxon rank-sum test on session averages. For partners matching the test is done using group averages, and the difference between centralization and decentralization is again significant at the 1% level ($z = 5.56$; $p < .01$). The difference between centralization and decentralization narrows over time for both types of matching, but remains significant for Rounds 10 – 18 under both strangers ($z = 2.61$; $p < .01$) and partners ($z = 3.89$; $p < .01$) matching.

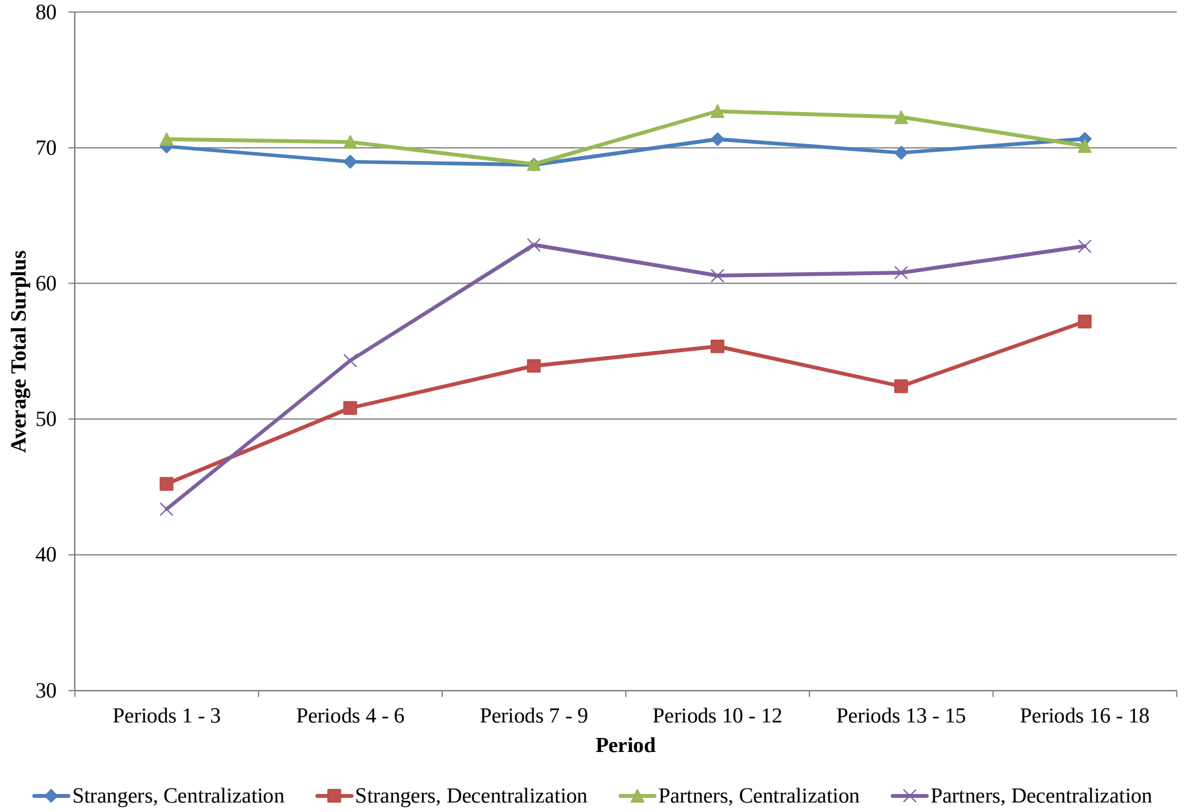
The type of matching has little effect on total surplus with centralization, but total surplus appears higher with partners matching under decentralization. The latter difference does not achieve significance using an admittedly conservative Wilcoxon rank-sum test ($z = 1.43$; $p = 0.15$).[13] Overall, the partners-strangers distinction is not crucial in our data.

[12] To be precise, we define total surplus as the sum of the payoffs for D1 and D2. This is equivalent, by construction, to CM's payoffs.

[13] The unit of observation is a session for the strangers matching and a group for the partners matching, giving a total of 32 independent observations.

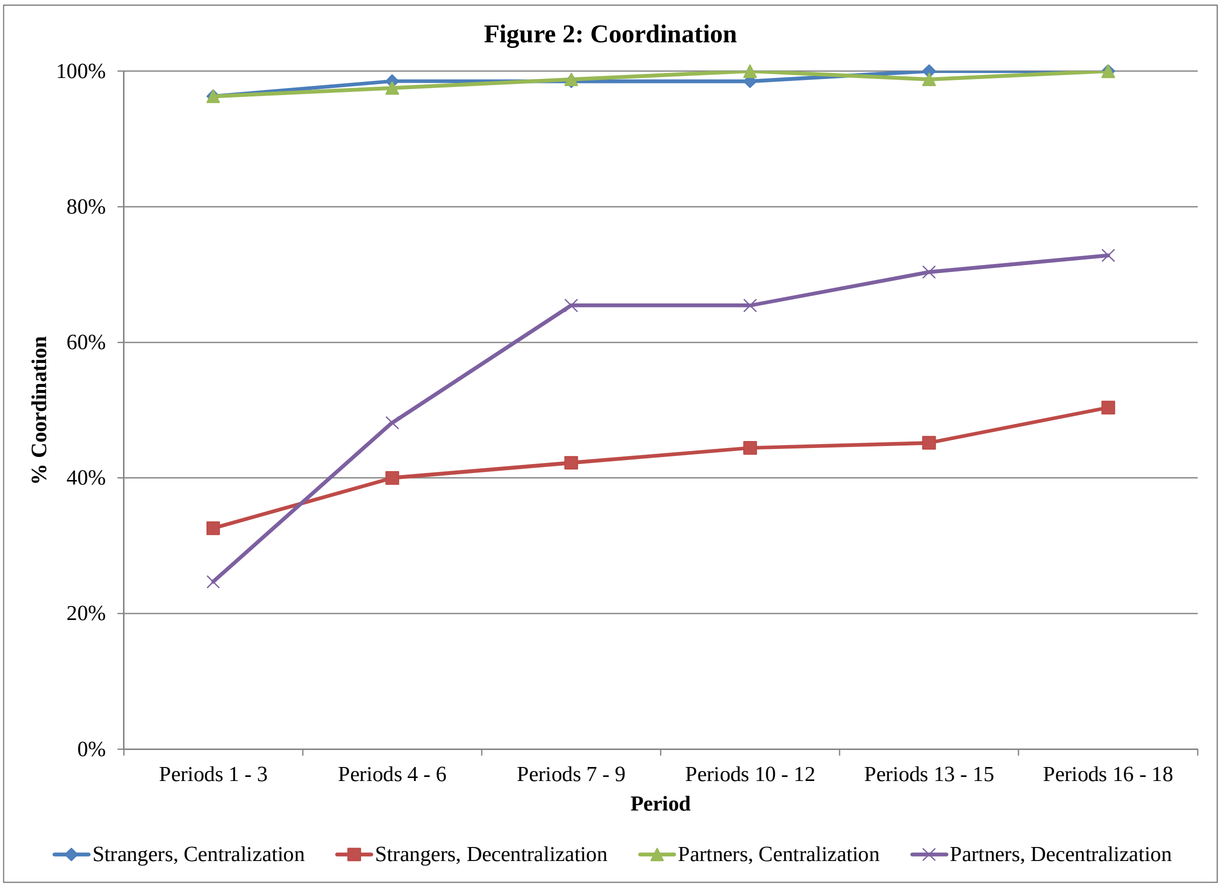
Result 1: *Total surplus is higher under centralization for both types of matching. The data is not consistent with H1.*

Figure 1: Total Surplus



Under centralization average total surplus hovers around 70, close to the level achieved by the babbling equilibrium but well below the feasible maximum of 80, while under decentralization average total surplus levels are quite low. This raises two questions: What causes the low surplus under decentralization and does play under centralization correspond to the babbling equilibrium? The answers to these questions are linked to the behavioral phenomena discussed in the introduction.

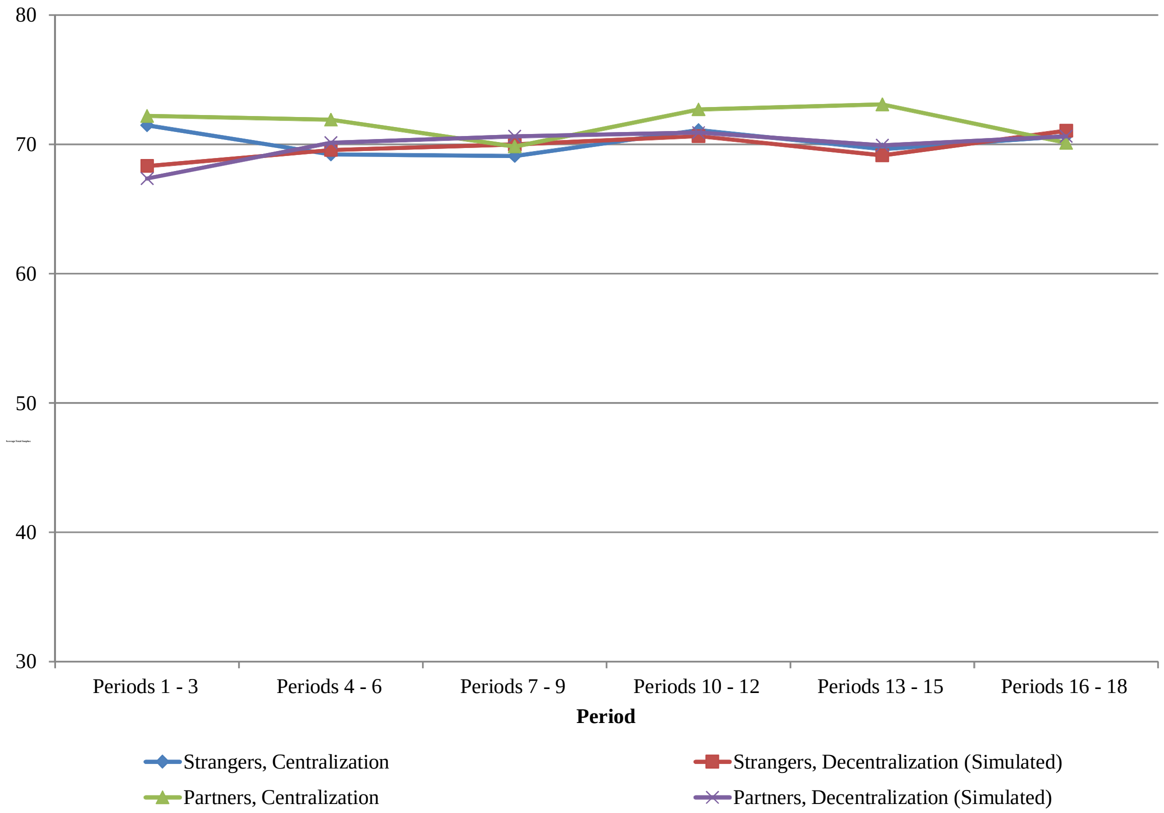
Low surplus can be due to two different factors: failures to coordinate on an action or coordinating on an action that is not the most efficient one (implying a failure to use the divisions' private information). Figure 2 shows for all four treatments the frequency of coordination (choices are the same for D1 and D2). For both centralization treatments, coordination is very close to 100% throughout; in these treatments participants in the role of the central manager have no difficulty in seeing that a coordinated choice of row and column is always preferable. In stark contrast, coordination in the decentralization treatments is below 40% in initial rounds. This increases with experience but never gets close to the near perfect coordination observed under centralization.



The differences shown in Figure 2 are significant at the 1% level for the strangers matching (z = 2.63; p < .01), using a Wilcoxon rank-sum test on session averages. They are also significant at the 1% level for partners matching, using a Wilcoxon rank-sum test on group averages (z = 6.00; p < .01). The difference narrows over time for both types of matching, but remains significant for Rounds 10 – 18 under both strangers (z = 2.66; p < .01) and partners (z = 4.82; p < .01) matching. As was the case for efficiency, under decentralization coordination is higher for the partners matching but the difference just misses significance (z = 1.62; p = .11). Once again we note that the statistical test is conservative; we think it likely that coordination is actually higher with the partners matching.

There is a direct link between the low coordination rates and the surprisingly low surplus under decentralization. This can be seen through a counterfactual exercise. Figure 3 shows total surplus as in Figure 1. The true data is shown for the two centralization treatments. For the two decentralization treatments the data are simulated in the following way. When the choices of D1 and D2 differ, we adjust the choice of one division so as to obtain coordination on an equilibrium outcome. Since there are always two ways to adjust the outcome we choose the one that corresponds to lower total surplus.

Figure 3: Total Surplus w/ Forced Coordination



One can see that the data, real and simulated, corresponding to the four different treatments are basically indistinguishable from each other. Even taking the conservative approach of assuming coordination always takes place at the worse possible outcome (between the two chosen by one of the divisions), artificially resolving the frequent coordination failures under decentralization largely eliminates the gap between centralization and decentralization.

Result 2: *Coordination failure is more common under decentralization for both types of matching. This coordination failure explains the lower total surplus with decentralization.*

Given the high degree of coordination under centralization and payoffs close to the expected value from the babbling equilibrium, it is tempting to guess that play under centralization is converging on the babbling equilibrium as predicted by the theory (implying that central management makes no use of the divisions' information). This is not the case. Table 2 shows the distribution of pairs of choices by

D1 and D2. The data has been broken down by structure (centralization vs. decentralization) and by block (Periods 1 – 9 vs. Periods 10 – 18). We have pooled data across the two types of matching as they differ little, but similar conclusions follow if we consider strangers and partners matching separately.

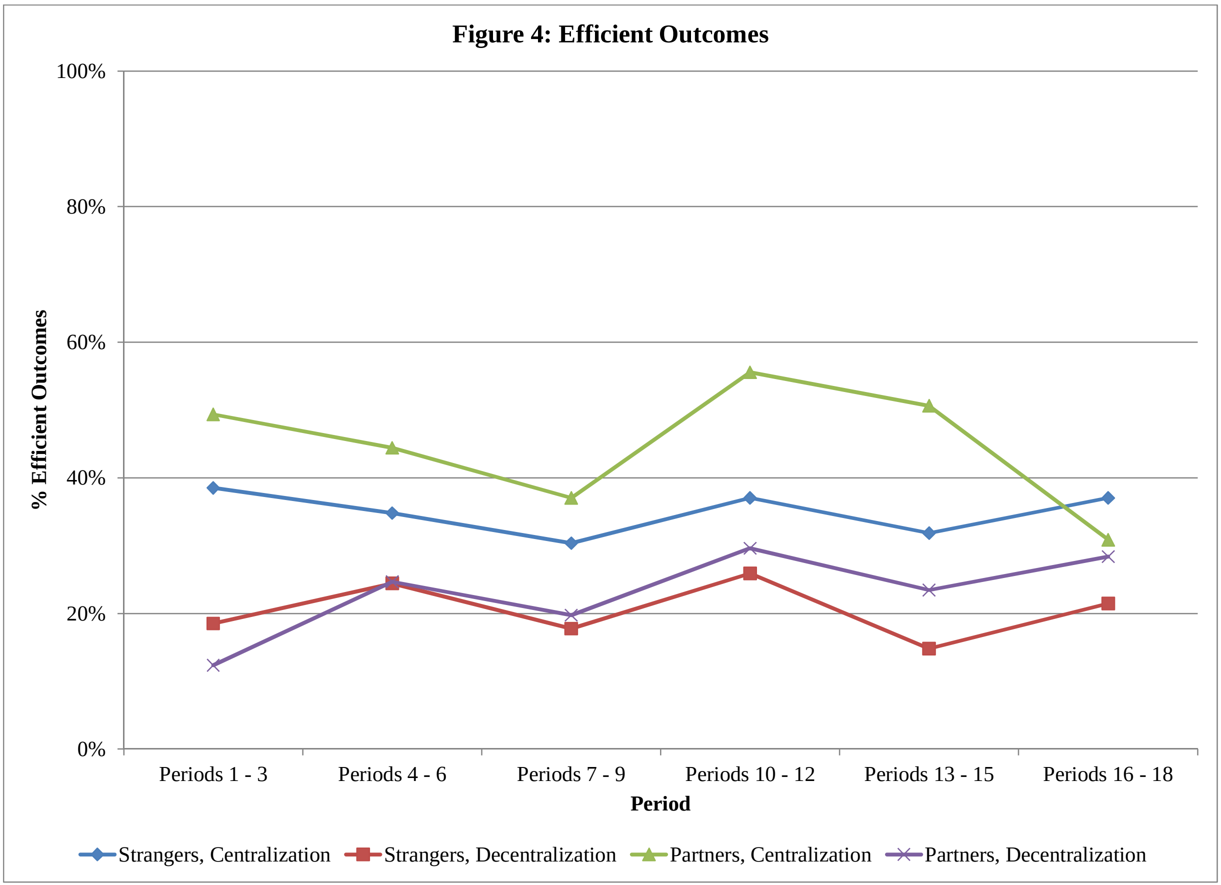
[Table 2 about here]

With centralization, almost all of the data is on the diagonal since the choices of D1 and D2 are almost always coordinated by CM. Only about a third of the choices are consistent with the babbling equilibrium (R3 / C3) in Block 1. This increases slightly in Block 2, but only to 42%. Comparing choices under decentralization and centralization, there is less coordination with decentralization but play of the babbling equilibrium is more likely (R3 / C3) subject to coordination (68% in Block 1 and 81% in Block 2). In general, choice of R3 and C3 is more common under decentralization than centralization (51% vs 34% in Block 1 and 63% vs. 42% in Block 2). Under decentralization divisions learn to coordinate, albeit imperfectly, but in way that does not use the information they have. While D1 and D2 choices are almost always coordinated under centralization and average total surplus closely resembles the babbling equilibrium, it is clear that the babbling equilibrium is *not* emerging under centralization. If anything, it would be more accurate to say the babbling equilibrium is emerging under decentralization even though both divisions are fully informed about the state of the world. This is an important point. The predicted efficiency advantage of decentralization comes from the possibility of coordinating on the surplus maximizing equilibrium *subject to the state of the world*. The failure of divisions to respond to their information when coordinating largely eliminates the primary benefit of decentralization.

While it is true that the babbling equilibrium does not emerge under centralization, it is also true that the efficient (surplus maximizing) equilibrium does not emerge either. Figure 4 shows the proportion of efficient outcomes (surplus maximizing equilibrium) obtained in all four treatments. For both types of matching, efficiency rates are higher under centralization than decentralization. And in both cases, efficiency rates are consistently above the 20% rate implied by the babbling equilibrium. Yet, there is a lot of level to improve since efficiency rates only rarely climb above 50%.

Result 3: *Play under centralization is generally consistent with neither the babbling equilibrium nor the efficient equilibrium. Under decentralization, when divisions coordinate their play is generally consistent with the babbling equilibrium, implying a failure to use their private information.*

To see why this is true, in Section 3.2 we explore the relationship between divisions' information, the messages they send, and CMs' choices.



4.2. Information Transmission with Centralization: In the two centralization treatments, the divisions have private information that could help the central manager make a decision. For this information to help the CM, two things have to happen. D1 and D2 have to send messages that are, collectively, informative about the state of the world, and CM has to correctly interpret the information contained in the messages. The theory presented in Section 2 focuses on the first issue and concludes that information transmission will fail since D1 and D2 have no incentive to send informative messages. Built into the theory is an assumption that the messages would be interpreted correctly if informative. In this section we show that neither conclusion is warranted. The messages sent by D1 and D2 often contain useful information. While CMs respond to this information, they often make errors in how they respond to messages. This explains why CMs are performing about the same as in the babbling equilibrium even though a babbling equilibrium is not being played – any advantages from better than expected information transmission are wiped out by errors in using this information.

Table 3: Message Sent as a Function of the Game (Remapped)

Strangers Matching

	Message				
	1	2	3	4	5
Game 1	15.25%	5.08%	7.12%	20.00%	52.54%
Game 2	2.46%	21.23%	12.31%	16.62%	47.38%
Game 3	1.58%	1.58%	50.79%	8.95%	37.11%
Game 4	1.23%	1.23%	2.46%	55.38%	39.69%
Game 5	0.34%	0.34%	1.69%	4.41%	93.22%

Partner Matching

	Message				
	1	2	3	4	5
Game 1	24.86%	1.13%	10.73%	18.08%	45.20%
Game 2	0.51%	36.41%	13.85%	13.85%	35.38%
Game 3	1.32%	1.32%	67.98%	9.21%	20.18%
Game 4	2.05%	1.03%	2.56%	73.33%	21.03%
Game 5	2.26%	1.13%	4.52%	4.52%	87.57%

Note: Cell entries are percentage of messages sent by game. Let G ∈{1,2,3,4,5} be the game being played and let M2 ∈{1,2,3,4,5} be the message sent by D2. The remapped game is given by RG = 6 – G. The remapped message for D2 is given by RM2 = 6 - M2.

Table 3 shows the frequency of the different messages sent by a division as a function of the realized game. The data from D2s is remapped to be are shown as if all division managers were D1s. With this remapping, Game 1 is always the least preferred and game 5 the most preferred game. Throughout the discussion of Table 3, when we refer to games and messages we are using remapped data.[14] A message is defined as truth-telling if it equals the game being played as a lie if it does not.

Divisions' messages should be uninformative in a babbling equilibrium. Instead, there is strong correlation between the message sent and the game being played (ρ = .31). Underlying this, division managers tell the truth more than expected. With five possible states of the world, play of a babbling equilibrium implies that division managers will only tell the truth in 20% of the observations (i.e. no more than by chance). In reality, the likelihood of truth-telling is 51%. Even in the case where it is least beneficial to do so (Game 1), 19% of messages tell the truth. Truth-telling decreases only slightly with experience, falling from 53% in Block 1 to 50% in Block 2. This implies that truth telling is probably not due to a failure to grasp the strategic value of lying. When division managers do lie, it is often an incomplete lie which is shaded towards the truth.[15] Purely self-interesting division managers can reasonably be expected to always send a message of 5.[16] This is indeed the most common type of lie for all states of the world under both types of matching. But 35% of lies involve sending a message other than 5.

It is rare for a division manager to be either consistently truthful or consistently dishonest. Instead, almost all subjects display a mixture of truth-telling and lying. For each division manager we calculate the ratio of how often they told the truth for games other than Game 5 – in other words how often do they tell the truth when it is not to their benefit (for Game 5 virtually all DMs tell the truth).

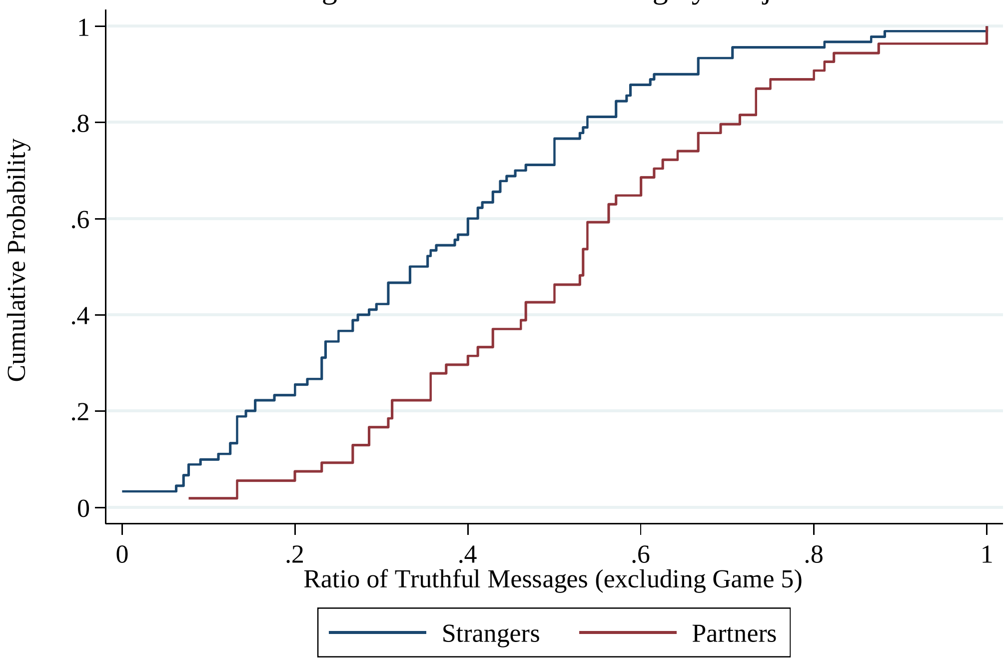
[14] Let G ∈ {1,2,3,4,5} be the game being played and let M_2 ∈ {1,2,3,4,5} be the message sent by D_2. The remapped game is given by RG = 6 – G. The remapped message for D2 is given by $RM_2 = 6 - M_2$. This effectively remaps the games and messages to make them identical for D1 and D2.

[15] This is similar to the partial lying observed by Fischbacher and Föllmi-Heusi (2013).

[16] All division managers have an incentive to make the CM believe they are playing Game 5 (recall that the efficient equilibrium for Game 5 corresponds to the division manager's preferred equilibrium for all games). If they expect the CM's choices to respond to their messages, they should always send a message of 5.

Figure 5 displays the CDF of these truth-telling ratios, broken down by type of matching. There is little weight on either extreme. Figure 4 also shows that telling the truth is somewhat more common with partners matching than strangers matching (58% vs. 47%).

Figure 5: CDF of Truthtelling by Subjects



The regressions reported in Table 4 put the preceding discussion on firmer statistical footing. The dataset includes all observation from the centralized treatment. An observation is the message sent by a single division manager in a single round. The dependent variable for Model 1 is the message, remapped as described above for D2. Since messages have a natural order and are categorical, we use an ordered probit. In Model 2 the dependent variable is whether the division manager told the truth. This is a binary variable so we use a probit, reporting marginal effects. In both regressions, the independent variables are the game (remapped), a dummy for the partners matching, and an interaction term between these two variables. Period dummies are included to control for time effects, but are not reported to save space in the table. Observations are not independent, for obvious reasons, so the standard errors are corrected for clustering at the session level (strangers matching) or the group level (partners matching). This yields a total of 32 clusters.

Table 4: Regression Analysis of Messages

	Model 1	Model 2
Dependent Variable	Message (Remapped)	Truth-telling
Model Type	Ordered Probit	Probit (Marginal Effects)
Game (Remapped)	0.279	0.228
	(0.027)***	(0.014)***
Partners	-0.338	0.250
	(0.191)*	(0.072)***
Partners * Game	0.011	-0.039
	(0.050)	(0.020)*
# Observations	2,592	2,592

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Note: Standard errors, reported in parentheses, are corrected for clustering at the session level (strangers matching) or the group level (partners matching).

Both regressions find a strong relationship between the game and the message being sent. The divisions' messages are not pure babble but instead contain potentially useful information. Both regressions show significant differences between the two matching protocols. The differences are strongest for truth-telling, as division managers are more significantly more likely to tell the truth with partners matching. The difference between matching protocols narrows as it becomes less costly for to be truthful.

Result 4: *The messages sent by division managers are informative. The data is not consistent with H2.*

On aggregate, the CMs seem to realize that the division managers' messages contain valuable information. Table 5 shows the CM's average choices as a function of the messages sent by the two division managers, where the first entry in each cell pertains to strangers matching and the second to fixed matchings. Note that the messages from D2 are ***not*** being remapped. Cells where D2's message is greater than D1's message have been left blank due to the small number of observations. One can easily see that when the two messages coincide the CM follows those messages rather closely. When the two messages differ then the CM's choices are, for a given message by one of the divisions, increasing in the other division's message. Hence, the CM consistently respond to the DMs' messages. There are only minor differences in this pattern between the strangers and partners matchings.

Table 5: Central Manager Choices

		Message Branch 2				
		1	2	3	4	5
Messsage Branch 1	**1**	1.23/1.38	.	.	.	.
	2	2.29/1.57	2.09/2.25	.	.	.
	3	2.48/2.42	2.72/2.58	2.98/2.95	.	.
	4	2.93/2.72	3.21/3.00	3.46/3.64	3.82/3.71	.
	5	3.20/2.90	3.29/3.08	3.72/3.50	3.83/4.50	4.92/4.79

Table 6 looks more formally at the relationship between DMs' messages and the CM's choices through regression analysis. The data set only includes observations where the CM choose the same row and column, imposing coordination. This eliminates 18 out of 1296 observations, but allows us to summarize a CM's choice as a single number. The dependent variable is the row/column (1, 2, 3, 4, or 5) chosen by the CM. The CM's choices are categorical and ordered in nature, so we use an ordered probit model. Standard errors are corrected for clustering at the session level (strangers matching) or the group level (partners matching). All of the regressions include period dummies to control for time effects. These are not reported to save space.

If information is being transmitted from the DMs to the CM, the CMs' choices should be correlated with the game being played. In Model 1, the sole dependent variable (other than period dummies) is the game being played. The estimate is positive and significant, indicating that successful information transmission occurs. Model 2 looks directly at the effect of the DMs' messages, with the messages of D1 and D2 added as separate variables. Both estimates are positive and significant, consistent with our observation from Table 5 that CMs are responding to DM's messages. The two estimates are virtually identical (and not significantly different). There is no particular reason for CMs to be more systematically more responsive to one DM than the other, and indeed they aren't. Model 3 adds a dummy for the Partners matching as well as interactions between this dummy and the messages from the two DMs. None of these added variables are significant. There is little difference, on average, in responses to messages between the two types of matching.

Table 6: Regression Analysis of Information Usage

	Model 1	Model 2	Model 3	Model 4
Dependent Variable	Row/Column	Row/Column	Row/Column	Row/Column
Game	0.161			
	(0.026)***			
D1 Message		0.368	0.365	0.302
		(0.032)***	(0.041)***	(0.036)***
D2 Message		0.359	0.345	0.344
		(0.048)***	(0.067)***	(0.052)***
Partners			-0.229	-0.101
			(0.354)	(0.120)
Partners * D1 Message			-0.009	
			(0.066)	
Partners * D2 Message			0.057	
			(0.083)	
Strangers *				-0.388
Lagged Truth (D1)				(0.345)
Strangers *				0.113
Lagged Truth (D2)				(0.141)
Partners *				-0.501
Lagged Truth (D1)				(0.275)*
Partners *				-0.567
Lagged Truth (D2)				(0.193)***
Strangers * D1 Message				0.102
* Lagged Truth (D1)				(0.066)
Strangers * D2 Message				-0.036
* Lagged Truth (D2)				(0.053)
Partners * D1 Message				0.208
* Lagged Truth (D1)				(0.068)***
Partners * D2 Message				0.115
* Lagged Truth (D2)				(0.067)*
# Observations	1,278	1,278	1,278	1,211

* p<0.1; ** p<0.05; *** p<0.01

Note: Standard errors, reported in parentheses, are corrected for clustering at the session level (strangers matching) or the group level (partners matching). Only observations where divisions' choices are coordinated are included in the regression.

Model 4 looks at a different aspect of how CMs respond to DMs' messages. Recall that the feedback allows CMs to know, *ex post*, whether D1 or D2 lied. Model 4 modifies Model 2 by adding information about whether D1 or D2 told the truth in the previous period. With Strangers matching the CM knows that a lagged observation of truth-telling came (almost certainly) from a *different* subject than the current DM, but with Partners matching the DM knows that it came from the *same* DM who sent the current message. We therefore expect the response to previous truth-telling to differ across the two types of matching. For each matching and each division manager (D1 and D2), we add a dummy for whether the CM observed truth telling by that division manager in the previous round plus an interaction between that dummy and the division manager's current message. This adds eight variables to the regression, two for each cell of matching and division manager. For the Strangers matching none of the added four variables are significant, but for the Partners matching all four variables are statistically significant. For both division managers the term for lagged truth-telling is negative and the interaction with the division managers' current message is positive. In other words, with Partner matching CMs are more sensitive to a message from a division manager who they know told the truth in the previous period.

Result 5: *CMs respond to the DMs' messages. With Partners matching, a history of truth-telling makes CMs more sensitive to DMs' messages.*

Table 7: Best Responses by CM with Centralization

		D2 Message				
		1	2	3	4	5
D1 Message	1	1 81% 36	N/A	N/A	N/A	N/A
	2	2 42% 24	2 78% 59	N/A	N/A	N/A
	3	3 47% 97	2 38% 37	3 84% 105	N/A	N/A
	4	4 38% 123	3 45% 58	3 42% 38	4 78% 50	N/A
	5	3 39% 340	2 30% 130	3 51% 81	4 38% 24	5 92% 50

Note: Each cell contains the CM's best response, the percentage of CMs using the best response, and the number of observations.

Just because CMs respond to the information contained in DMs' messages doesn't mean that their use of this information is optimal. In fact, CMs quite often miss the mark. Table 7 breaks the data down by the messages sent by D1 and D2. Once again, cells where D2's message is greater than D1's message have been left blank due to the small number of observations. Each cell contains three pieces of information: the CM's best response as a function of the messages,[17] the percentage of CMs using the best response, and the number of observations. We have pooled data over the two types of matching as there is little difference in use of best responses.[18]

We observe frequent failures to play a best response. While it is not surprising to see some mistakes, many of these mistakes are hard to explain since the best response seems obvious. For example, if the two division managers' messages match (i.e. both say it is Game 1), they are almost certainly telling the truth (97%) and, by extension, it is strongly a best response to choose the row/column that corresponds to their messages. Aggregating over the five possible cases, the CM does not play the best response in 17% of the observations. These CMs earn an average payoff of 63.3 ECUs, compared with 79.5 ECUs for those who play the best response. The good news is that CMs learn to stop making this particular mistake, which drops from 22% in Block 1 to 12% in Block 2. Other mistakes are harder to eradicate. Suppose D1 sends a message of 5 and D2 sends a message of 1. Obviously at least one of the DMs is lying. Given that each is sending the message that is most to their advantage, there is no obvious reason to believe one over the other. Indeed, the best response is to choose row/column equal to 3. In reality, 61% of CMs fail to play the best response. This figure only decreases slightly with experience, going from 63% in Block 1 to 60% in Block 2. This makes some sense as the loss from not playing the best response is smaller in this case (68.1 vs. 63.7), except the worst possible mistakes (choosing row/column 1 or 5) actually get no less common with experience (46% in both blocks). This seems like an obvious mistake to avoid, costs a significant amount of money (68.1 vs. 62.6), but the CMs keep on making the same error.

Failures to play the best response explain why CMs in the Centralized treatment earn no more than in a babbling equilibrium. To give a better sense of the magnitude of lost surplus due to errors, recall that the CM has an expected payoff of 70.4 ECUs in a babbling equilibrium. The maximum possible CM payoff (from the efficient equilibrium where the row/column choice always matches the game) is 80

[17] These are empirical best responses, not theoretical constructions. For each cell we have calculated the average payoff the CM would have achieved by always choosing 1 for both divisions, 2 for both divisions, etc. The best response is the action that maximizes this average payoffs.

[18] Suppose we break the data down by matching type and whether the two DMs' messages agreed (in which case they are almost certainly telling the truth). When the DMs don't agree, the probability of playing a best response is 39% with Strangers matching versus 41% with Partners matching. When the DMs agree, these figures become 83% versus 82%. More formally, a probit regression indicate no significant difference in use of a best response between the two types of matching (the estimated difference is 1% with a standard error of 4%).

ECUs, so the possible gain over the babbling equilibrium is 9.6 ECUs. The realized average payoff for CMs is 70.2, virtually identical to the babbling equilibrium. If CMs had used the best response, taking advantage of the information contained in the DMs' messages, they would have achieved an average payoff of 72.9. The increase from playing the best response is equivalent to 28% of the maximum potential gain over the babbling equilibrium.[19] Abstracting from the specific setup of our experiment, inefficient use of information makes centralization look less good relative to decentralization.[20]

The preceding analysis uses the empirical best response, but it would be difficult for a CM to exactly replicate this as they only have access to a limited amount of data about the relationship between messages and the underlying game. It turns out that using a simple common sense strategy for CMs does almost as well as the best response. This strategy amounts to avoiding obvious mistakes. If the two DMs send identical messages, treat their messages as true. If they disagree strongly (D1 sends 4 – 5 and D2 sends 1 – 3 OR D1 sends 3 – 5 and D2 sends 1 – 2), the messages are non-informative and you should act as if you are uninformed (choose R3/C3). If D2 sends a higher message that D1, which is rare, somebody has obviously made a mistake. Once again treat this as uninformative and choose R3/C3. Finally, if the two DMs almost agree in a way that suggests one is going for the truth over his own interest (D1 sends 5 and D2 sends 4 OR D1 sends 2 and D2 sends 1), treat the more conservative of the two messages as being true. Following this "sensible" strategy would have earned an average payoff of 72.8, almost the same as the 72.9 earned by the best response. Since the "sensible" strategy only relies on drawing rather obvious conservative conclusions from the messages, is realistic to think that CMs could and should have done better with the information they received.

Result 6: *CMs systematically make errors using the information contained in DMs messages. These mistakes are largely responsible for their failure to beat the babbling equilibrium.*

5. Concluding Remarks: Our experiments study a simple new model comparing centralization and decentralization. The primary tension within the model is between failure to coordinate and failure to use divisions' private information. If coordination problems are relatively severe, centralization should do relatively well, while decentralization should do better when informational problems are prominent. Standard theory suggests that the maximum total surplus achievable in an equilibrium is greater for decentralization, but we observe consistently higher total surplus under centralization.

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[19] Regression results show that both divisions lying, discussed above, and central management best responding increase significantly over time, but at a rather slow rate.

[20] Average payoffs for CMs increase somewhat over time, from 69.5 in Block 1 to 70.8 in Block 2. This is explained largely by a decrease in mistakes, particularly the mistake of not believing the DMs when they agree.

Our experiments are not intending to test any specific theory from the literature, but instead are meant to explore how several behavioral phenomena affect the relative performance of centralization and decentralization. We find that pervasive coordination failure under decentralization tips the scales in favor of centralization. There is better information than expected with centralization, reflecting a bias towards truth-telling, but the benefits of successful information transmission are almost completely offset by failures to respond correctly to this information. While we have no doubt that there exist settings where decentralization does better than centralization, we suspect the behavioral phenomena we observe will predictably affect performance under centralization and decentralization in most environments.

The behavioral phenomena of coordination failure, partial truth-telling and suboptimal processing of information have all been studied independently in previous experimental studies. That said, these phenomena manifest themselves in our experiments in ways that go beyond what had been observed in previous work. Under decentralization, performance is limited not just by coordination failure, but also by a strong tendency to coordinate on always playing the same equilibrium regardless of the state of the world. If the primary advantage of decentralization is the ability to use divisions' information, use of an equilibrium that does not respond to the state of the world eliminates this advantage. Along a different dimension, the failure of central managers to correctly process information under centralization parallels the results of Vespa and Wilson (forthcoming), but is even worse. Vespa and Wilson find consistent failures for cases where it is relatively difficult to infer the correct course of action. In our data, CMs are getting it wrong even in cases where the best response is rather obvious.

A natural question for a study like ours is how well the results will generalize to other settings. Like all empirical studies, be they lab experiments, field experiments, or conventional field studies, we study outcomes for a specific population in a specific setting. We view lab experiments as a complement rather than substitute for theory papers and other types of empirical studies. The game we study is intentionally simple and confronts subjects with stark trade-offs in a way that is unlikely to occur in a field setting. The cost of having a high level of control over our environment and intentionally choosing a simple game is that we lose some of the richness present in field settings. Starting simple is a sensible research strategy, but in the future we plan to extend our study by adding complexities that mirror real world organizations. Some possible extensions are probably not worth the effort. For instance, it could be argued that we should be using "real" people rather than students – firm managers in this particular case. Existing evidence (see Frechette, 2009, for a summary) gives little reason to think that use of a different subject population would affect our results.[21] Three other issues are of particular interest. First,

[21] In the field information transmission is done by professionals, who typically are strongly influenced by notions of professional integrity and may, therefore, be reluctant to lie (Gintis, 2014). This suggests that the truth-telling we observe in our experiments may carry over to actual organizations.

all of the decisions in our experiment are made by individuals. In most organizations these decisions would be made by groups, and there is an extensive literature suggesting that groups and individuals do not make identical decisions either for games generally or coordination games specifically (see Feri et al., 2010). It would be interesting to see how performance under centralization and decentralization was affected by the use of groups as decision makers. For example, are groups less prone to making mistakes in processing messages from DMs, leading to total surplus exceeding the babbling equilibrium? Second, our experiment makes coordination relatively easy by only having two divisions. A natural question is how performance would change with more divisions. Finally, we have simplified the experimental environment by not allowing communication between divisions or from central management to divisions. While poor communication among divisions is likely typical of the settings we have in mind, an inability of central management to communicate with divisions is probably not. Adding in more channels of communication is a natural avenue for future work.[22]

[22] No communication between divisions is realistic for firms with numerous divisions which are physically separated and lack obvious channels of communication. The existing literature for BOS games (Cooper, DeJong, Forsythe, and Ross, 1989 and 1992) suggests that communication will not automatically lead to successful coordination when agents' preferences over equilibria differ.

REFERENCES

Alonso, Ricardo, Wouter Dessein and Niko Matouschek (2008a), "When Does Coordination Require Centralization?" *American Economic Review*, 98(1), 145-179.

Alonso, Ricardo, Wouter Dessein and Niko Matouschek (2008b), "Centralization versus Decentralization: An Application to Price Setting by a Multi-Market Firm," *Journal of the European Economic Association*, 6 (2-3), 457-467.

Alonso, Ricardo, Wouter Dessein and Niko Matouschek (2015), "Organizing to Adapt and Compete," *American Economic Journal: Microeconomics*, 7(2), 158-187.

Battaglini, Marco (2002), "Multiple Referrals and Multidimensional Cheap Talk," *Econometrica*, 70(4), 1379–1401.

Blume, Andreas and Andreas Ortmann (2007), "The Effects of Costless Pre-play Communication: Experimental Evidence from Games with Pareto-ranked Equilibria," *Journal of Economic Theory*, 132, 274–290.

Brandts, Jordi and David J. Cooper (2007), "It's What You Say Not What You Pay: An Experimental Study of Manager-employee Relationships in Overcoming Coordination Failure," *Journal of the European Economic Association*, 6, 1223-1268.

Camerer, Colin F. (2003), *Behavioral Game Theory*. Princeton University Press, Princeton, New Jersey.

Colin F. Camerer and Roberto A. Weber. (2012). "Experimental Organizational Economics." In Robert Gibbons and John Roberts (Eds.), *Handbook of Organizational Economics*. Princeton University Press, Princeton, New Jersey.

Charness, Gary and Martin Dufwenberg (2006), "Promises and Partnership," *Econometrica*, 74, 1579-1601.

Charness, Gary and Dan Levin (2005), "When Optimal Choices Feel Wrong: A Laboratory Study of Bayesian Updating, Complexity, and Affect," *American Economic Review*, 95(4), 1300-1309.

Cooper, Russell, Douglas DeJong, Robert Forsythe, and Thomas Ross (1989), "Communication in the Battle of the Sexes Game: Some Experimental Results," *RAND Journal of Economics*, 20, 568-587.

Cooper, Russell, Douglas DeJong, Robert Forsythe and Thomas Ross (1992), "Communication in Coordination Games," *Quarterly Journal of Economics*, 107, 739-771.

Crawford, Vincent P. and Joel Sobel (1982), "Strategic Information Transmission," *Econometrica*, 1431-1451.

Crawford, Vincent P., Uri Gneezy and Yuval Rottenstreich (2008), "The Power of Focal Points is Limited: Even Minute Payoff Asymmetry May Yield Coordination Failures," *American Economic Review*, 98(4), 1443-1458.

Dessein, Wouter, Luis Garicano and Robert Gertner (2010), "Organizing for Synergies," *American Economic Journal: Microeconomics*, 2, 77-114.

Evdokimov, Piotr and Umberto Garfagnini (2015), "Mend Your Speech a Little: Authority, Communication, and Incentives to Coordinate," Working Paper.

Feri, Francesco, Benrd Irlenbusch and Matthias Sutter (2010), "Efficiency Gains from Team-based Coordination – Large-scale Experimental Evidence," *American Economic Review*, 100(4), 1892-1912.

Erat, Sanjiv and Uri Gneezy (2012), “White Lies,” *Management Science*, 58(4) 723-733.

Fehr, Dietmar, Dorothea Kübler and David Danz (2012), “Information and Beliefs in a Repeated Normal-form Game,” *Experimental Economics*, 15(4), 622-640.

Fischbacher and Föllmi-Heusi (2013), “Lies in Disguise – An Experimental Study on Cheating,” Journal of the European Economic Association June 2013 11(3):525–547.

Fréchette, Guillaume R. (2009), Laboratory Experiments: Professionals versus Students, in *The Methods of Modern Experimental Economics*, Guillaume Fréchette and Andrew Schotter (editors), Oxford University Press, forthcoming.

Gintis, Herbert (2014), The Moral Basis of the Business World. Working paper.

Gneezy, Uri (2005), “Deception: The Role of Consequences,” *American Economic Review*, 95(1), 384-394.

Grether, David M. (1980), “Bayes Rule as a Descriptive Model: The Representativeness Heuristic,” *Quarterly Journal of Economics*, 95(3), 537-557.

Source: The Quarterly Journal of Economics, Vol. 95, No. 3 (Nov., 1980), pp. 537-557

Hamman, John and Miguel A. Martínez-Carrasco (2015), “Optimal Organizational Structure: An Experimental Study,” Working Paper.

Hart, Oliver and John Moore (2008), “Contracts as Reference Points,” *Quarterly Journal of Economics*, 123, 1-48.

Hart, Oliver and Bengt Holmstrom (2010), “A Theory of Firm Scope,” *The Quarterly Journal of Economics*, *125*(2), 483-513.

Hayek, Friedrich von (1944), “The Use of Information in Society,” *American Economic Review,* 35(4), 519 – 530.

Heath, Chip and Nancy Staudenmayer (2000), “Coordination Negelct: How Lay Theories of Organizingf Complicate Coordination in Organizations,” *Research in Organizational Behavior*, 22, 153-191.

Hyndman, Kyle, Antoine Terracol and Jonathan Vaksmann (2009), “Learning and Sophistication in Coordination Games,” *Experimental Economics*, 12, 450-472.

Ichniowski, C., K. Shaw, and G. Prennushi (1997), "The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines," *American Economic Review*, 87(3), 291-313.

Knez, Marc and Duncan Simester (2002), “Form-Wide Incentives and Mutual Monitoring At Continental Airlines”, *Journal of Labor Economics*, 19(4), 743-772.

Kriss, Peter H. and Roberto A. Weber. (forthcoming), “Economic Laboratory Experiments on Organizational Formation and Change.” In Anna Grandori (Ed.) *Handbook of Economic Organization*. Edward Elgar.

Lange, Oskar and Fred M. Taylor (1938), *The Economic Theory of Socialism*. Lippincott, editor. University of Minnesota Press.

McElheran, Kristina (2014), “Delegation in Multi-Establishment Firms: Adaptation vs. Coordination in I.T. Purchasing Authority,” *Journal of Economics and Management Strategy*, 23(2), 225-258.

Mookherjee, Dilip (2006), “Decentralization, Hierarchies and Incentives: A Mechanism Design Perspective,” *Journal of Economic Literature*, XLIV, 367-390.

Plott, Charles R. and Shyam Sunder (1988), “Rational Expectations and the Aggregation of Diverse Information in Laboratory Security Markets,” *Econometrica*, 56(5), 1085-1118.

Rantakari (2008), “Governing Adaptation,” *The Review of Economic Studies*, 75, 1257-1285.

Terracol, Antoine and Jonathan Vaksmann (2009), “Dumbing Down Rational Players : Learning and Teaching in an experimental game,” *Journal of Economic Behavior and Organization*, 70(1-2), 54-71.

Thomas, Catherine (2011), “Too Many Products: Decentralized Decision Making in Multinational Firms,” *American Economic Journal: Microeconomics*, 3, 280-306.

Van Huyck, John, Raymond Battalio, and Robert Beil (1990), "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure," *American Economic Review*, 80, 234-248.

Vespa, Emanuel and Alistair J. Wilson (forthcoming), “Communication With Multiple Senders: An Experiment,” *Quantitative Economics*.

Table 1: Stage Game Payoffs

Note: Each cell contains the payoffs for D1 (π_{D1}), D2 (π_{D2}), and CM (π_{CM}).

Game 1

	C1	C2	C3	C4	C5
R1	26, 54, 80	12, 29, 41	-2, 4, 2	-16, -21,-37	-30,-46,-76
R2	15, 40, 55	29, 43, 72	15, 18, 33	1, -7, -6	-13, -32,-45
R3	4, 26, 30	18, 29, 47	32,32, 64	18, 7, 25	4, -18, -14
R4	-7, 12, 5	7, 15, 22	21, 18, 39	35, 21, 56	21, -4, 17
R5	-18, -2, -20	-4, 1,-3	10, 4, 14	24, 7, 31	38, 10, 48

Game 2

	C1	C2	C3	C4	C5
R1	22, 50, 72	8, 33, 41	-6, 8, 2	-20, -17, -37	-34,-42,-76
R2	19, 36, 55	33, 47, 80	19, 22, 41	5, -3, 2	-9, -28,-37
R3	8, 22, 30	22,33, 55	36, 36, 72	22, 11, 33	8, -14, -6
R4	-3,8, 5	11,19,30	25, 22, 47	39, 25, 64	25, 0, 25
R5	-14,-6,-20	0,5,5	14, 8, 22	28, 11, 39	42, 14, 56

Game 3

	C1	C2	C3	C4	C5
R1	18, 46, 64	4, 29, 33	-10,12, 2	-24, -13, -37	-38, -38, -76
R2	15, 32, 47	29, 43, 72	15, 26, 41	1, 1, 2	-13, -24,-37
R3	12, 18, 30	26, 29, 55	40, 40, 80	26, 15, 41	12, -10,2
R4	1,4, 5	15, 15, 30	29,26, 55	43,29, 72	29, 4, 33
R5	-10,-10,-20	4,1, 5	18,12, 30	32, 15, 47	46, 18, 64

Game 4

	C1	C2	C3	C4	C5
R1	14, 42, 56	0, 25, 25	-14, 8,-6	-28, -9, -37	-42, -34, -76
R2	11, 28, 39	25, 39, 64	11, 22, 33	-3, 5, 2	-17,-20,-37
R3	8, 14, 22	22, 25, 47	36, 36, 72	22, 19, 41	8, -6, 2
R4	5, 0, 5	19, 11, 30	33, 22, 55	47, 33, 80	33, 8, 41
R5	-6,-14,-20	8, -7, 5	22, 8, 30	36, 19, 55	50, 22, 72

Game 5

	C1	C2	C3	C4	C5
R1	10, 38, 48	-4, 21, 17	-18, 4,-14	-32,-13,-45	-46,-30, -76
R2	7, 24, 31	21, 35, 56	7, 18, 25	-7, 1,-6	-21,-16,-37
R3	4, 10, 14	18, 21, 39	32, 32, 64	18, 15, 33	4, -2, 2
R4	1,-4,-3	15, 7, 22	29, 18, 47	43, 29, 72	29, 12, 41
R5	-2,-18,-20	12,-7, 5	26,4, 30	40, 15, 55	54, 26, 80

Table 2: Frequency of pairs of actions

Block 1 (Rounds 1 - 9)

D1 Choice \ D2 Choice	1	2	3	4	5
1	15.6%	0.2%	0.2%	0.0%	0.0%
2	0.2%	13.4%	0.2%	0.2%	0.0%
3	0.2%	0.5%	33.8%	0.0%	0.0%
4	0.0%	0.0%	0.0%	17.0%	0.2%
5	0.3%	0.3%	0.0%	0.2%	17.9%

Block 1 (Rounds 1 - 9)

D1 Choice \ D2 Choice	1	2	3	4	5
1	1.7%	0.5%	1.9%	0.0%	0.2%
2	2.2%	4.5%	2.6%	0.6%	0.0%
3	6.3%	9.3%	28.1%	2.8%	1.5%
4	2.5%	2.8%	13.6%	6.5%	0.3%
5	0.6%	2.2%	7.4%	1.7%	0.5%

Block 2 (Rounds 10 - 18)

D1 Choice \ D2 Choice	1	2	3	4	5
1	11.9%	0.0%	0.0%	0.0%	0.0%
2	0.0%	15.7%	0.2%	0.0%	0.0%
3	0.0%	0.0%	42.0%	0.0%	0.0%
4	0.0%	0.0%	0.0%	14.8%	0.0%
5	0.2%	0.0%	0.2%	0.0%	15.1%

Block 2 (Rounds 10 - 18)

D1 Choice \ D2 Choice	1	2	3	4	5
1	2.0%	0.8%	1.7%	0.2%	0.0%
2	2.0%	4.6%	4.9%	0.3%	0.0%
3	4.0%	10.7%	44.6%	2.2%	0.5%
4	1.4%	1.2%	6.3%	3.9%	0.3%
5	0.2%	0.9%	5.7%	1.5%	0.2%

Appendix A: Proof of Theorem

Lemma: For any beliefs, the manager will choose the same actions for the two branches.

Proof: Suppose not. This implies the manager is choosing an outcome that is not a Nash equilibrium if the two branches are allowed to choose their own actions. Either of the branches could improve its payoff by switching to the action chosen by the other branch. Moreover, the other branch's payoff is also increased by this change. Since the manager's payoff equals the sum of the two branches' payoffs, the manager's payoff also increases. This implies that the manager's ignition choice could not have been optimal.

Given the preceding lemma, we can refer to the manager as choosing a single action in response to the branches' messages.

Theorem: There does not exist a pure strategy PBE where the manager chooses different actions for two different states of the world.

Proof: Suppose that such an equilibrium existed. Let S1 and S2 be two states where different actions are chosen. Let A1 and A2 be the actions chosen by the manager in equilibrium in S1 and S2 respectively. Without loss of generality, assume that Branch 1 prefers the outcome in S1 and Branch 2 prefers the outcome in S2. Let M_i^j be the message sent by Branch i in Sj.

It cannot be the case that $M_1^1 = M_1^2$. This implies that the manager's choice is determined solely by Branch 2's message. Since Branch 2 prefers A2, it should always send M_2^2 when the true state of the world is either S1 or S2. By the same logic, $M_2^1 \neq M_2^2$.

Suppose that Branch 1 deviates by sending M_1^1 in S2. The resulting pair of messages (M_1^1, M_2^2) cannot make Branch 1 better off than A1. The possible outcome that is least bad for Branch 1 and least good for Branch 2 is A2, so assume without loss of generality that (M_1^1, M_2^2) leads to A2. However, this implies that Branch 2 can gain by sending M_2^2 in S1, giving Branch 2 a profitable deviation from equilibrium. A contradiction follows. **Q.E.D.**

Appendix B: INSTRUCTIONS

DECENTRALIZATION TREATMENT

Thanks for coming to the experiment. You will receive 5 euros for participation in the experiment. Also, you will earn additional money during the experiment.

Participants have been randomly assigned to one of three roles: F, C and A. This role will be the same throughout the experiment.

There will be 18 separate periods. We will now present the instructions for the first block of nine periods. Later you will receive further instructions. In each period, you will be in a group of three participants, one in each role. The persons that you are matched with will change from period to period. During the nineperiods you will never meet another person twice. Also, at no time will you know the identity of who you are matched with.

Each period is independent from the others and develops in the following way. At the beginning of the period, the computer will randomly determine which of the following five games will be played.

In each of the cells the first number shown in yellow is the payoff that the person in the F role will receive, the second number shown in green is the payoff that the person in the C role will receive and the third number shown in red is the payoff for the person in the A role. As you can see all five games have five rows: f1, f2, f3, f4 and f5 [Note: The Spanish word for row is "fila". We have kept the original abbreviations in the payoff tables.], and five columns; c1, c2, c3, c4 and c5. [Note: The Spanish word for row is "fila". We have kept the original abbreviations in the payoff tables shown below.] Observe also that the numbers in the different cells differ between the games.

Game 1

	c1	c2	c3	c4	c5
f1	26, 54, 80	12, 29, 41	-2, 4, 2	-16, -21,-37	-30,-46,-76
f2	15, 40, 55	29, 43, 72	15, 18, 33	1, -7, -6	-13, -32,-45
f3	4, 26, 30	18, 29, 47	32,32, 64	18, 7, 25	4, -18, -14
f4	-7, 12, 5	7, 15, 22	21, 18, 39	35, 21, 56	21, -4, 17
f5	-18, -2, -20	-4, 1,-3	10, 4, 14	24, 7, 31	38, 10, 48

Game 2

	c1	c2	c3	c4	c5
f1	22, 50, 72	8, 33, 41	-6, 8, 2	-20, -17, -37	-34,-42,-76
f2	19, 36, 55	33, 47, 80	19, 22, 41	5, -3, 2	-9, -28,-37
f3	8, 22, 30	22,33, 55	36, 36, 72	22, 11, 33	8, -14, -6
f4	-3,8, 5	11,19,30	25, 22, 47	39, 25, 64	25, 0, 25
f5	-14,-6,-20	0,5,5	14, 8, 22	28, 11, 39	42, 14, 56

Game 3

	c1	c2	c3	c4	c5
f1	18, 46, 64	4, 29, 33	-10,12, 2	-24, -13, -37	-38, -38, -76
f2	15, 32, 47	29, 43, 72	15, 26, 41	1, 1, 2	-13, -24,-37
f3	12, 18, 30	26, 29, 55	40, 40, 80	26, 15, 41	12, -10,2
f4	1,4, 5	15, 15, 30	29,26, 55	43,29, 72	29, 4, 33
f5	-10,-10,-20	4,1, 5	18,12, 30	32, 15, 47	46, 18, 64

Game 4

	c1	c2	c3	c4	c5
f1	14, 42, 56	0, 25, 25	-14, 8,-6	-28, -9, -37	-42, -34, -76
f2	11, 28, 39	25, 39, 64	11, 22, 33	-3, 5, 2	-17,-20,-37
f3	8, 14, 22	22, 25, 47	36, 36, 72	22, 19, 41	8, -6, 2
f4	5, 0, 5	19, 11, 30	33, 22, 55	47, 33, 80	33, 8, 41
f5	-6,-14,-20	8, -7, 5	22, 8, 30	36, 19, 55	50, 22, 72

Game 5

	c1	c2	c3	c4	c5
f1	10, 38, 48	-4, 21, 17	-18, 4,-14	-32,-13,-45	-46,-30, -76
f2	7, 24, 31	21, 35, 56	7, 18, 25	-7, 1,-6	-21,-16,-37
f3	4, 10, 14	18, 21, 39	32, 32, 64	18, 15, 33	4, -2, 2
f4	1,-4,-3	15, 7, 22	29, 18, 47	43, 29, 72	29, 12, 41
f5	-2,-18,-20	12,-7, 5	26,4, 30	40, 15, 55	54, 26, 80

Each of the five games has the same chance of being chosen in each period separately. That is in each period, each of the games will be chosen with 20%probability. Player F and player C will be informed of which game has been chosen, but player A will not be informed of which game has been chosen.

After having seen which game has been selected by the random draw, players F and player C will separately make decisions. Player F will choose between f1, f2, f3, f4 and f5 and player C will choose between columns c1, c2, c3, c4 and c5. Player A will not make any decisions.

The payoffs of players F, C and A will be the ones in the cell determined by the row chosen by F and the column chosen by C for the game selected by the random draw. Remember that players F and C will make their decisions independently from each other.

After each period everybody will be informed about what row was chosen by F and what column was chosen by C sent and about which game was randomly selected.

After this, a new period will start which will develop in the same way until reaching period 9. Remember that the persons you play with will change from period to period.

Each ECU is worth 0,02 euros. At the end of the session you will receive 5 euros plus what you will have earned in all 18 rounds of the experiment.

You can ask questions at any time. If you have a question, please raise your hand and one of us will come to your place to answer it.

INSTRUCTIONS

CENTRALIZATION TREATMENT

Thanks for coming to the experiment. You will receive 5 euros for participation in the experiment. Also, you will earn additional money during the experiment.

Participants have been randomly assigned to one of three roles: F, C and A. This role will be the same throughout the experiment.

There will be 18 separate periods. We will now present the instructions for the first block of nine periods. Later you will receive further instructions. In each period, you will be in a group of three participants, one in each role. The persons that you are matched with will change from period to period. During the nineperiods you will never meet another person twice. Also, at no time will you know the identity of who you are matched with.

Each period is independent from the others and develops in the following way. At the beginning of the period, the computer will randomly determine which of the following five games will be played.

In each of the cells the first number shown in yellow is the payoff that the person in the F role will receive, the second number shown in green is the payoff that the person in the C role will receive and the third number shown in red is the payoff for the person in the A role. As you can see all five games have five rows: f1, f2, f3, f4 and f5, and five columns; c1, c2, c3, c4 and c5. Observe also that the numbers in the different cells differ between the games.

Game 1

	c1	c2	c3	c4	c5
f1	26, 54, 80	12, 29, 41	-2, 4, 2	-16, -21,-37	-30,-46,-76
f2	15, 40, 55	29, 43, 72	15, 18, 33	1, -7, -6	-13, -32,-45
f3	4, 26, 30	18, 29, 47	32,32, 64	18, 7, 25	4, -18, -14
f4	-7, 12, 5	7, 15, 22	21, 18, 39	35, 21, 56	21, -4, 17
f5	-18, -2, -20	-4, 1,-3	10, 4, 14	24, 7, 31	38, 10, 48

Game 2

	c1	c2	c3	c4	c5
f1	22, 50, 72	8, 33, 41	-6, 8, 2	-20, -17, -37	-34,-42,-76
f2	19, 36, 55	33, 47, 80	19, 22, 41	5, -3, 2	-9, -28,-37
f3	8, 22, 30	22,33, 55	36, 36, 72	22, 11, 33	8, -14, -6
f4	-3,8, 5	11,19,30	25, 22, 47	39, 25, 64	25, 0, 25
f5	-14,-6,-20	0,5,5	14, 8, 22	28, 11, 39	42, 14, 56

Game 3

	c1	c2	c3	c4	c5
f1	18, 46, 64	4, 29, 33	-10,12, 2	-24, -13, -37	-38, -38, -76
f2	15, 32, 47	29, 43, 72	15, 26, 41	1, 1, 2	-13, -24,-37
f3	12, 18, 30	26, 29, 55	40, 40, 80	26, 15, 41	12, -10,2
f4	1,4, 5	15, 15, 30	29,26, 55	43,29, 72	29, 4, 33
f5	-10,-10,-20	4,1, 5	18,12, 30	32, 15, 47	46, 18, 64

Game 4

	c1	c2	c3	c4	c5
f1	14, 42, 56	0, 25, 25	-14, 8,-6	-28, -9, -37	-42, -34, -76
f2	11, 28, 39	25, 39, 64	11, 22, 33	-3, 5, 2	-17,-20,-37
f3	8, 14, 22	22, 25, 47	36, 36, 72	22, 19, 41	8, -6, 2
f4	5, 0, 5	19, 11, 30	33, 22, 55	47, 33, 80	33, 8, 41
f5	-6,-14,-20	8, -7, 5	22, 8, 30	36, 19, 55	50, 22, 72

Game 5

	c1	c2	c3	c4	c5
f1	10, 38, 48	-4, 21, 17	-18, 4,-14	-32,-13,-45	-46,-30, -76
f2	7, 24, 31	21, 35, 56	7, 18, 25	-7, 1,-6	-21,-16,-37
f3	4, 10, 14	18, 21, 39	32, 32, 64	18, 15, 33	4, -2, 2
f4	1,-4,-3	15, 7, 22	29, 18, 47	43, 29, 72	29, 12, 41
f5	-2,-18,-20	12,-7, 5	26,4, 30	40, 15, 55	54, 26, 80

Each of the five games has the same chance of being chosen in each period separately. That is in each period, each of the games will be chosen with 20%probability. Player F and player C will be informed of which game has been chosen, but player A will not be informed of which game has been chosen.

After having seen which game has been selected by the random draw, players F and player C will separately send messages to player A saying which game has been selected . This message can be truthful or not. Once player A has received the messages he will choose a row and column without knowing which game was selected.

The payoffs of players F, C and A will be the ones in the cell determined by the row and the column chosen by A for the game selected by the random draw. Remember that players F and C willsend their messages independently from each other.

After each period everybody will be informed about what row and what column was chosen by A and about which game was randomly selected.

After this, a new period will start which will develop in the same way until reaching period 9.

Each ECU is worth 0,02 euros. At the end of the session you will receive 5 euros plus what you will have earned in all 18 rounds of the experiment.

You can ask questions at any time. If you have a question, please raise your hand and one of us will come to your place to answer it.