

ORGANIZATIONAL LANGUAGES

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Abstract

The paper is concerned with communication within a team of players trying to coordinate in response to information dispersed among them. The problem is nontrivial because they cannot communicate all information instantaneously, but have to send longer or shorter sequences of messages, using coarse codes. We focus on the design of these codes and show that members may gain compatibility advantages by using identical codes, and that this can support the existence of several, more or less efficient, symmetric equilibria. Asymmetric equilibria may exist only if coordination across different sets of members is of sufficiently different importance. The results are consistent with the stylized fact that firms differ even within industries and that coordination between divisions is harder than coordination inside divisions.

I. INTRODUCTION

The paper explores the implications of coarse communication with individually constructed codes. This problem is most notably found in firms, but its properties are present in a great number of other situations of economic interest. Each member of a team has private knowledge about the state of his or her local environment, and the team needs at least some information from all members in order to coordinate. It is impossible to transmit all information (Polanyi, 1962; Simon, 1976, p. 238), so each member needs to design an ordered set of coarse categories – a code - for use in sending messages. The paper characterizes the set of codes that can be supported in equilibrium. Under reasonable assumptions, it is found that members may gain compatibility advantages by using identical codes, and this supports the existence of several more or less efficient symmetric equilibria. Asymmetric equilibria may exist only if the importances of coordination across different sets of members differ sufficiently.

More specifically, we are looking at a resource allocation problem in which each member of a team has a privately known valuation of the resource. Coordination takes the form of a decision made by the “Center”, which could be one of the team members, and communication takes place in a series of discrete rounds. The information cumulates such that more has been revealed in later rounds, and the process stops as soon as the Center knows enough to allocate the resource. A code defines a nested sequence of one-bit messages aimed at describing a member’s valuation with increasing precision. Because delays are costly, the team is looking for codes that minimize the expected number of rounds of communication. We abstract from incentive conflicts and assume that each member is looking for a code that helps the team, given the codes used by other members. We get two results.

(1) The compatibility advantages of identical codes support the existence of several more or less efficient symmetric equilibria, while ruling out asymmetric equilibria.

To see the forces driving the result, assume that there are four possible values and “low” means “one or two” from one member, but “one, two, or three” from another. In this case the Center cannot order the values based on the message pair “high”, “low”. It is better if the two members use the same codes. This preference for compatibility supports even very inefficient symmetric equilibria. In fact, any element of a very large set of codes can be supported in a symmetric equilibrium.

(2) Asymmetric equilibria exist if the importance of coordination across different sets of members differ sufficiently.

To see the forces driving this result, suppose that the team has two resources and two pairs of members. In the extreme situation where the objective is to allocate one resource to each pair, the games are separable, and the first result tells us that any pair of sub-game equilibria forms an equilibrium for the entire team. In less extreme situations, it is possible that only some asymmetric equilibria exist.

Literature

The theory of linguistic categories, which is a sub-field of the general theory of language, has drawn contributions from a number of fields, including linguistics, philosophy, psychology, and sociology. In contrast to the point made here, much of the literature appears to suggest that codes are not arbitrary. One line is often associated with Rosch (1973) and argues that “basic level categories have an integrity of their own. They are our earliest and most natural form of categorization.” (Lakoff, 1987, p. 49). In fact, it

is claimed that the basic level structure of categories “depends on human perception, imaging capabilities, motor capabilities, etc.”(Lakoff, 1987, p. 56). The present paper is based on the premise that the natural forces leave some room for other influences.¹ The categories here portrayed as arbitrary are not basic ones, but those referred to by Dougherty (1992, p. 180) when she quotes a technical director as saying, “there are little shadings of meaning that gets lost in the requirements statement from marketing”. On this level, our second result could be consistent with the perspective that more fine-grained categorization is a result of subjects’ learning about the frequency with which different features co-vary in their environments (Holland, Holyoak, Nisbett, and Thagard, 1986). If members of an R&D group live in an environment with a different pattern of co-variation than that lived in by members of the marketing group, then it stands to reason that this could play a role in the (not modeled) choice of equilibrium categories.

The economic theory of languages, within which the present paper falls, is a comparatively small literature. Economic arguments about efficiency and equilibrium seem well suited to investigate aspects of communication and language (Marschak, 1965; Rubinstein, 1998), and have in fact been applied to several classes of questions in the area. The most closely related works are concerned with finding the most efficient language for transmitting information. Dow (1991), Kofman and Ratliff (1996), Meyer (1991), and Shannon and Weaver (1949) search a class of codes for those that transmit most information given a limit on bits. More recently, Nisan and Segal (2003) have applied some ideas from computer science (Kushilevitz and Nisan, 1997) to characterize codes that minimize the number of bits required to identify an approximately Pareto efficient allocation in an economy with privately known valuations. The papers in this stream are extremely heterogeneous, but all differ from the present paper by looking at languages as results of optimization problems (as opposed to equilibria of games). Our

¹ Since we observe that several different languages exist, this seems to be an innocuous premise.

first result contributes to this literature by making the point that there are compatibility advantages (beyond learning advantages) associated with different players' use of the same code. It also shows that (even in the absence of incentive conflicts) it may matter a great deal whether a language is found by central optimization or as an equilibrium of a team theory problem or a game.²

The second result is of more applied interest and is consistent with the sociological literature on problems with inter-functional communication in organizations. Starting at least with Cyert and March, (1963, Ch. 3) and continuing today (Weber and Camerer, 2003), there is a lot of experimental evidence that communication is more efficient within than between groups. A common explanation is that the employees in different departments have trouble communicating because specialization has led them to use different "thought worlds" (Douglas, 1987). "A certain thought world is likely to best understand certain issues, but also to ignore information that may be essential to the total task"(Dougherty, 1992). The present paper contributes to this sociological literature by offering, as a possible formal explanation, the possibility that that the groups use different codes. A similar result is found in Cremer, Garicano, and Prat (2003), although they find the language as an optimum rather than an equilibrium.

In the next section, we describe the basic model and demonstrate the existence of several symmetric equilibria. In Section III, we briefly explore the limits of the result by introducing two classes of members and looking at the tension between more efficient "intra-class" and "inter-class" coordination. Not surprisingly, it turns out that the tradeoff

² A number of papers ask how incentive constraints influence what actors will, and can, communicate. This includes mainly the cheap-talk literature (e. g. Crawford and Sobel, 1982). Most work on this question has focussed on the multiplicity of equilibrium codes. This multiplicity is, essentially, due to the fact that the codes have no necessary pay off consequences. The model analyzed in the present paper also exhibits multiple equilibria, but the players' choice of codes have real implications.

depends on the relative importance of the two types of coordination. The paper closes with a discussion of several broader implications in Section IV.

II. BASIC RESULT

We look at a resource allocation problem in which a team with M members wants to allocate a set of resources equally among those members for whom they have the highest value. Each member knows how valuable the resource is for him or her, but it is not possible to communicate the exact value instantly.³ Instead, the members communicate in rounds. In each round, some or all members send one-bit messages to a Center, and the process ends when the Center can identify the complete set of members for whom the resource is worth the most. We assume that only the center observes these messages.⁴ Because delays are costly, the team is looking for codes that minimize the expected number of rounds of communication.⁵ We abstract from incentive conflicts and assume that each member is trying to use that code and send those messages that most help the Center draw the correct conclusions as fast as possible.

We assume that the resource may have one of a finite number V possible values, $v_m \in \Omega = \{1, 2, \dots, V\}$, to each member. An important assumption about the probability distribution over Ω^M is that all realizations have strictly positive probability, such that the resource may be worth any of the V values to any member.⁶ A member's code can be represented by a sequence of nested bisections of Ω . A code is said to be *linear* if when $x_1 < x_2 < x_3$, and it sends the same message for x_1 and x_3 , then it also sends that message for x_2 . Messages in any linear code can be interpreted as " $v_m > v^o$ " or " $v_m < v^o$ " for some

³ We are assuming that the members know their valuations precisely. They use sequentially finer categories hoping to economize on communication, not as a reflection of coarse perceptions.

⁴ Other literature, notably in the computer science tradition (Nisan and Segal, 2003; Kushilevitz and Nisan, 1997), has assumed that messages are sent sequentially and that each member observes prior messages sent by other members. Such an assumption would presumably change the results, but I do not feel that it reflects organizational reality – in most organizations, the majority of messages travel upwards only.

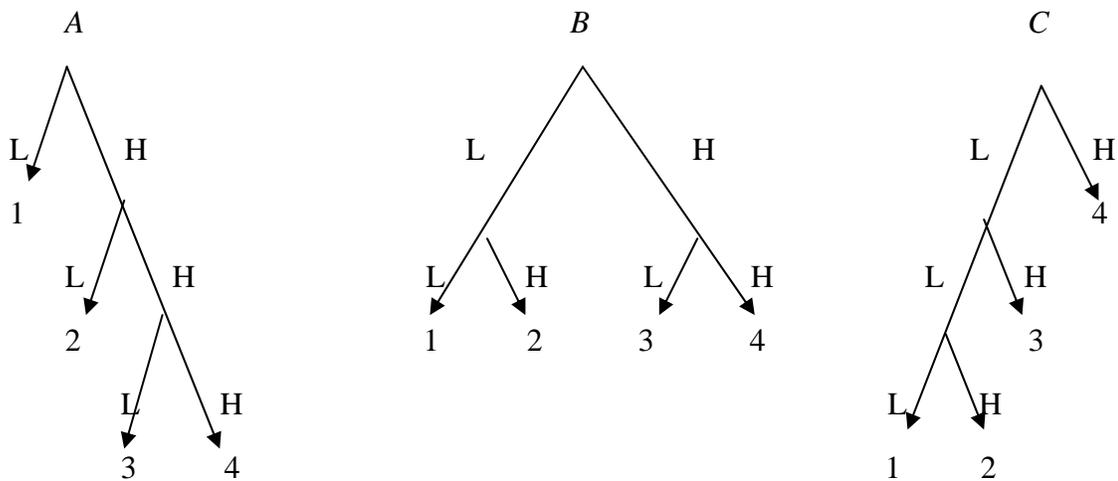
⁵ An alternative objective is to minimize the expected number of bits sent. This would be more complicated. For example, if the team cares about the amount of communication per round it could gain by having the Center stop messages from members once they are known to have low valuations. We would need to complicate the strategy space accordingly. On the other hand, the essential tradeoffs in the model should still be at work if we focus on bits rather than rounds.

⁶ Without this assumption, different branches of a code may be redundant for different members.

v^o , and the code can be represented by a binary tree in which the leaves are labeled, from left to right, by 1, 2, ... V . For example, if $V = 4$, there are three possible linear codes, illustrated as A , B , and C in Figure 1 below.

Figure 1

Possible Linear Codes When $V = 4$.



The Center knows the codes used by each player, and a set of M codes is then said to be in *equilibrium* if no unilateral deviation gives the team higher expected performance. In a *symmetric equilibrium* all members use the same code.

To better explain the nature of codes and the communication process, we look at an example in which $M = 2$ and $V = 4$. That is, the team has two members and the resource is worth 1, 2, 3, or 4 to each of them. The three possible linear codes are those labeled A , B , and C in Figure 1 above. To see how the communication process works, we will look at three candidate equilibria in detail.

Example 1

Candidate AB. In this case one member (a) uses code A , while the other member (b) uses code B . We will walk through several realizations.

- (i) In the first round, a says “high” while b says “low”, so the Center knows that a ’s value is 2, 3, or 4, while b ’s is 1 or 2. Suppose now that a ’s second round message is “low”, meaning 2 when *she* says it after a “high” in round one, and b ’s second round message is “high”, meaning 2 when *he* says it after a “low” in round one. The Center now knows that the resource is worth the same to both members and the process can stop.
- (ii) Suppose that a and b say “low” and “high” respectively, in the first round. Under the assumed codes this means that the resource is worth 1 to a and 3 or 4 to b . So in this case the process can stop after one round.
- (iii) If both players say “low” in the first round, the Center can conclude that the resource is worth 1 to a and 1 or 2 to b . In the second round, a has nothing more to add. However, if b says “high”, meaning 2 when *he* says it after a “low” in the first round, the Center knows that the resource is worth more to b and the process can stop after two rounds.
- (iv) Proceeding in this way, we can create a matrix showing how many rounds of communication are needed for each pair of valuations.⁷ This is depicted in Table 1 below.

Table 1

Number of Rounds when One Member Uses Code A and the Other Uses Code B.

| | | Code B | | | |
|-----------|---|--------|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Code A | 1 | 2 | 2 | 1 | 1 |
| | 2 | 2 | 2 | 2 | 2 |
| | 3 | 2 | 2 | 3 | 3 |
| | 4 | 2 | 2 | 3 | 3 |

⁷ I am indebted to a referee for this mode of presentation.

Candidate AA. We continue to look at the same two members and the same sixteen equally likely realizations. However, we now assume that both members use code A. In this case the performance is summarized in Table 2 below.

Table 2

Number of Rounds When Both Members Use Code A.

| | | Code A | | | |
|-----------|---|--------|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Code A | 1 | 1 | 1 | 1 | 1 |
| | 2 | 1 | 2 | 2 | 2 |
| | 3 | 1 | 2 | 3 | 3 |
| | 4 | 1 | 2 | 3 | 3 |

Candidate BB. Suppose finally that both members use code B. In this case the performance is summarized in Table 3 below.

Table 3

Number of Rounds When Both Members Use Code B.

| | | Code B | | | |
|-----------|---|--------|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Code B | 1 | 2 | 2 | 1 | 1 |
| | 2 | 2 | 2 | 1 | 1 |
| | 3 | 1 | 1 | 2 | 2 |
| | 4 | 1 | 1 | 2 | 2 |

Summary. Comparison of the three candidates reveals that the team's performance in the first case is dominated by that in the second and third. For all pairs of valuations, the

team does weakly better when the members use identical strategies and for some realizations its does strictly better. This implies that it is an equilibrium for both members to use code A , even though it is quite uninformative compared to code B .

As the main result of the paper, we will now show that the properties of example 1 generalize to arbitrary values of M and V .

Proposition: *When all sets of realizations are possible, (i) any linear code can be sustained in a symmetric, strict equilibrium, and (ii) no asymmetric equilibria exist.*

Proof: Consider a vector of realizations in which the highest valuation is held by only one member and label the members such that $v_I > \text{Max} \{ v_2, v_3, \dots, v_M \}$. Given this realization, communication will stop once it has revealed the existence of a v^o such that $v_I > v^o$, $v_2 < v^o$, $v_3 < v^o$,and $v_M < v^o$. If r_i , $i= 1, 2, \dots, M$, denotes that round of communication in which the inequality containing v_i is established, the number of rounds of communication for this specific realization is $\text{Max}\{r_1, r_2, \dots, r_M\}$. For any linear code used by member 1, if it reveals that $v_I > v^o$ by round r_I , then for all $i > 1$, it would also reveal that $v_i < v^o$ by round r_I or earlier. So if all members use member 1's code, the number of rounds of communication will be at most $r_I \leq \text{Max}\{r_1, r_2, \dots, r_M\}$.

Consider next a realization in which the highest valuation is held by $N > 1$ members and label such that $v_I = v_2 \dots = v_N > \text{Max} \{ v_{N+1}, v_{N+2}, \dots, v_M \}$. In this case, communication only stops when (1) the N members have fully revealed their valuations, and (2) it has revealed the existence of a v^o such that $v_I > v^o$, $v_{N+1} < v^o$, $v_{N+2} < v^o$,and $v_M < v^o$. If r_i , $i= 1, 2, \dots, M$, denotes that round of communication in which this has happened, the number of rounds of communication for this specific realization is $\text{Max}\{r_1, r_2, \dots, r_M\}$. For any linear code used by member 1, if all members use it, the requirement (1) will be met in r_I rounds and the requirement (2) will be met in r_I rounds or less (by the argument in the

preceding paragraph). So also for this realization, if all members use member 1's code, the number of rounds of communication will be at most $r_1 \leq \text{Max}\{r_1, r_2, \dots, r_M\}$.

To obtain strict inequality for at least one realization, note that if two codes are different, each must reveal at least one valuation in fewer rounds than the other.

Q.E.D. ⁸

The implication of the Proposition is that the team prefers that all pairs of members use identical codes, even if decoding is not a problem. This then suggests a very strong preference for compatibility over informativeness. For any linear code, no matter how uninformative it is, there is an equilibrium in which all members use it.

III. Equilibria When Both Local and Global Maxima Matter.

To explore the limits of the Proposition, we briefly generalize the model and look at situations in which both local and global maxima matter. Unlike the team analyzed in Section II, many organizations are structured into subsets, divisions, and it is generally believed that there is more coordination inside a division than across divisional boundaries. In our context of resource allocation, one could imagine that two sets of resources mostly are earmarked for two different subgroups, corresponding perhaps to different classes of projects (such as new products versus cost reduction), and that the team only sometimes puts all resources in one subset. It seems reasonable to conjecture that the tendency to use identical codes will be weaker in such circumstances.

To think more formally about this, we start with two teams, $M1$ and $M2$, and use $R(X)$ to denote the expected number of rounds of communication required to

⁸ I am indebted to a referee for this method of proof.

find the highest valuing members in X . If α is a real number between 0 and 1, we assume that the combined team's objective is to minimize

$$\alpha[R(M1) + R(M2)] + (1-\alpha)R(M1 \cup M2).$$

It is now trivial to prove our second result.

Result: *There exists an $\alpha^0 < 1$, such that asymmetric equilibria exist if $\alpha > \alpha^0$.*

Proof: If only local maxima matters ($\alpha=1$), the problem decomposes and the Proposition tells us that any pair of linear codes can be sustained in an asymmetric, strict equilibrium in which members in $M1$ use one code while members in $M2$ use the other. Since the strategy space is discrete, there exists an $\alpha^0 < 1$, such that this continues to be true.

Q.E.D.

We now modify Example 1 to illustrate the existence of asymmetric equilibria.

Example 2

Suppose that $M1$ and $M2$ have two members each, that $V=4$, and that all 4^4 realizations are equally likely. We look at two candidate equilibria.

Candidate AA,CC. In this case both members of $M1$ use code A from Figure 1, while both members of $M2$ use code C . Tedious, but trivial calculations reveal that $R(M1) = R(M2) = 29/16$, while $R(M1 \cup M2) = 682/256$. If one member of $M1$ deviates to code C , $R(M1) = 39/16$, $R(M2) = 29/16$, while $R(M1 \cup M2) = 597/256$.

So global coordination is improved, but local coordination is less good, and the attractiveness of the deviation is unattractive if $\alpha > 17/49 \approx .35$.

Candidate AA, BB. In this case both members of $M1$ use code A from Figure 1, while both members of $M2$ now use code B . In this case $R(M1) = 29/16$, $R(M2) = 24/16$, while $R(M1 \cup M2) = 664/256$. If one member of $M1$ deviates to code B , $R(M1) = 34/16$, $R(M2) = 24/16$, while $R(M1 \cup M2) = 600/256$. So also here, global coordination is improved while local coordination is hurt, but this equilibrium is sustained if $\alpha > 4/9 \approx .44$.

IV. CONCLUSION

We saw that an individual's choice of code depends on a tradeoff between compatibility with the individual's personal environment and the codes and environments of those with whom the individual wishes to communicate. This tradeoff can typically support the use of several more or less efficient sets of codes.

The extension presents organizational languages as functions of the importance of inter-group coordination. Groups in different local environments may find it efficient to use different codes, even though this will hurt coordination between the groups. If inter-group coordination is not too important, and the local environments are sufficiently different, the language barriers can be so large that meaningful communication is very costly. On the other hand, if inter-group coordination is important, the groups may facilitate communication by using the same code, although this may come at some expense to their local adaptation.

The importance of the results depends to a large extent on whether we can interpret firms as examples of the teams. Fortunately, a lot of literature supports the claim that there is more communication within, than between, firms. Most models in the information processing literature (Bolton and Dewatripont, 1994; Radner, 1992; Van

Zandt and Radner, 2001) implicitly or explicitly define the firm by the flow of messages, and Wernerfelt (1997, 2001) provides a theoretical rationale for it. In particular, Wernerfelt (2001) compares game forms in which two players negotiate before and after possible communication. In the latter case, “the market”, players may refrain from communication because it can hurt their bargaining position. Finally, Simester and Knez (2002) and Tushman (1978) offer empirical evidence showing that there is more communication in firms than in markets.

If we therefore interpret the model as describing firms, the results are consistent with Arrow (1974, p. 56), Nelson and Winter (1982, p. 102) and Williamson (1975, p. 25), who argue that the use of different internal languages may be a source of long-lived differences between firms in the same industry. The fact that we found some very inefficient equilibria suggests the possibility of taking this argument further, linking the differences to enduring competitive advantages. (Of course, many other intra-firm coordination games will yield similar predictions and it is not clear that the code game is that most important factor.)

Another set of interesting implications follow from an interpretation of divisions of firms as examples of teams whose members face heterogeneous environments. The results seem to be consistent with a lot of common beliefs about the difficulties associated with inter-functional coordination. One could imagine that these issues are particularly acute when two firms merge. Indeed, when the popular business press is discussing mergers, it often raises concerns about the ability of the merged entity to preserve the “cultures” of its constituent parts (Lewis, 1998). It may be possible to take this further and argue that difficulty of communicating about different environments can be a source of organizational diseconomies and thus play a role in determining the optimal scope of the firm.

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