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Failure of common knowledge of language in common-interest communication games ☆

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ABSTRACT

This paper explores higher-order uncertainty about message availability in communication games with perfectly aligned preferences. It can be impossible to achieve *ex post* efficiency in equilibrium even when it is mutual knowledge that the size of the set of available messages would be sufficient to convey all payoff-relevant information. There are equilibria that achieve *ex post* efficiency whenever a *rich language* condition is satisfied: the set of available messages is large relative to the sender's assessment of the number of information sets of the sender the receiver considers possible. Weaker conditions suffice if one adopts an *ex ante* perspective.

1. Introduction

The tools available to interlocutors matter for their ability to share information. Lack of a shared natural language, to take an extreme example, is an obvious impediment to successful communication. More broadly, communication may be negatively impacted by insufficient familiarity with an organization's code, the specialized terminology of a different occupation or scientific discipline, or the conventions employed in writing contracts and statutes. In these settings, communication may fail when (potential) participants have limited access to messages that would be appropriate for the situation at hand.

On top of limited message availability itself, uncertainty about that availability can reduce the effectiveness of communication. Even if the speaker has access to a set of messages that would be adequate for conveying all payoff-relevant private information, the listener's uncertainty about whether this is the case may lead him to discount the significance of any given message. In this paper I ask whether these observations extend to higher-order uncertainty. Specifically, can there be a substantial payoff loss from lack of common knowledge of which messages are available to the sender when both sender and receiver either know which set of messages is available to the sender or attach high probability to it?

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To shed light on this question I study a class of communication games in which a sender with private payoff-relevant information sends a message to an uninformed receiver before actions are taken that determine payoffs as a function of the payoff state. Communication is cheap talk in that messages do not affect payoffs directly. I focus on common-interest games, so that restrictions on message availability and (higher-order) uncertainty about that availability are the only impediments to efficient communication. The set of messages available to the sender is the sender's private information. In addition, the receiver has information about which messages may be available to the sender, the sender has information about the receiver's information about message availability and so on. This is captured by an information structure that summarizes players' higher-order knowledge and beliefs about which messages are available to the sender.

Representative for the type of situation I have in mind is that of a physician trying to diagnose a patient's illness, relying in part on communication by the patient. The physician's time with the patient is limited, which rules out a completely open-ended conversation; the more accurate and concise the patient can describe his symptoms, the better. Only a small portion of natural language is germane to this interaction; this is the set of relevant messages, the 'message space' in the formal analysis. Communication success will depend on the patient's familiarity with that message space and the physician's thinking about that familiarity. Patients have varying degrees of knowledge of the relevant medical terminology (because of different educational backgrounds, prior treatment histories, internet searches etc.) while physicians have reason to be skeptical about the scope of that knowledge. Therefore, communication may be impeded by the patient's inability to express himself, by the physician believing that the patient is using medical terms inappropriately, or by the patient believing that the physician believes that the patient is misusing medical terminology.[1]

A highly stylized version of this might have the patient privately learn whether she has two messages or only one of the two messages (with each of the two messages being equally likely to be the only available message). Having two messages would allow the patient to make her description of symptoms contingent on the state of the world (her perception of symptoms); with only one available message the patient's communication would necessarily be uninformative. The physician then receives an imperfectly informative signal about whether or not the patient has two messages; the patient, in turns, receives an imperfectly informative signal about the physician's signal, and so on.

A familiar instance of such an information structure is obtained by adapting Rubinstein's (1989) electronic mail procedure: the patient privately learns whether she has both messages; if she has both messages an email is (automatically) sent to the physician; emails arrive with some probability less than one, and when received automatically prompt a reply email. Since the arrival probability is less than one, the email exchange will eventually terminate. If it terminates with the patient having received $K = 1$ emails, the patient knows that the physician knows that the patient has two messages, but is uncertain about whether or not this fact is known by the physician: the patient has second-order knowledge of having both messages but is uncertain about the order of knowledge of the physician. Similarly, if the process stops after the patient receiving $K > 1$ emails, the patient has $K + 1$th order knowledge of having both messages, but is uncertain about the knowledge order of the physician. I will make extensive use of information structures like these when constructing examples.

The literature cites numerous instances of language constraints adversely affecting communication (see Blume and Board, 2013 for references). Clark and Marshall (1978, 1981) raise the specter of possible misunderstandings due to higher-order uncertainty about shared meaning. At the same time, when constraints take the form of (higher-order) uncertainty about language there are also reasons for optimism about agents being able to overcome them. Specifically, communication itself can be used to reduce uncertainty about the degree to which language is shared. Senders can use messages to convey information about their language at the same time as they convey directly payoff-relevant information.

For a simple example of communication removing uncertainty about language, consider the case of a sender who has access to a set of messages that is large enough to communicate payoff information accurately and that has the additional property that any message in that set is only available to the sender if all other messages in that same set are also available; this resembles the case of a native speaker being able to reveal fluency in her mother tongue through a few statements during conversation. Whenever the sender has access to such a "jointly available set of messages", those messages can be used to achieve *ex post* efficiency, irrespective of the receiver's beliefs about message availability at the interim stage: if the sender uses messages in a jointly available set to fully identify payoff states, upon receiving such a message the receiver learns that all of these messages are available (if he did not know this before) and since they are only jointly available he learns also that none of these messages are compromised by alternative (constrained) uses.[2]

In this paper I both validate the concerns one may have about higher-order uncertainty possibly undermining *ex post* efficient communication and provide sufficient conditions for players using communication to be able to achieve efficiency. The validation of concerns about higher-order uncertainty is by way of a series of examples in which *ex post* efficiency fails even though the set of available messages would be large enough to convey all payoff relevant information and this is mutual knowledge. The sufficient conditions for achieving *ex post* efficiency are in terms of the sender having access to a *rich language*; these conditions do not require joint availability of messages. Even weaker conditions suffice if one takes an *ex ante* perspective.

[1] Ong et al. (1995) document communication difficulties between physicians and patients arising from uncertainty about whether patients communicate in "everyday language" or attempt to use "medical language". They also note that physicians and patients frequently disagree about the meaning of common psychological terms like "depression", "migraine", "eating disorder" etc.

[2] This is formalized in the appendix.