How is group communication possible?: Explorations and Possibilities

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The small group communication context provides a unique window to the nature of human interaction and collective sense making. It is a place where work is done, negotiations are hashed out, relationships are established, and common memories are shared.

The dialectics of individuality and society

Human beings are both individuals and social beings. People are individualized in that each one of us is an isolated entity, aware of the fact that we are different from other people, and the fact that we don't know and feel how others perceive the world in the same way we know and perceive the world. As social psychologists (e.g. Fromm) believe, there is a need for individuals to exist in groups to escape this freedom/loneliness; to embed ourselves in the world external to us so that we can be part of something bigger. At the same time, the way that our own existence can have meaning depends on others' sense making of us. There is a discrepancy between the individualized isolated nature and the need to bond with each other. To resolve this discrepancy, communication happens. In its vaguest form, communication can be defined as the interactions through which individuals share objects.

Language is a sign system we use to communicate most commonly. One purpose of verbal communication is to build common language referent bonds among individuals. Through this process, individuals come to have shared meanings. A subset of such meanings exists only on the group level (when the individuals form relationships within groups). This co-reference building process is interactive and adaptive; co-built multilaterally. Meaning is not presumed and can change based on the process.

The dialectical relation between individual and group

How is group communication process to be modeled? Groups and individuals exercise co-influence upon each other. Groups, whether transient or long term, large or small, or even societal, are made up of and built by the individuals in that group. Thus, the group's behavior, performance, norm, culture etc. are the result of its members' communicative behavior. On the other hand, the group also exerts great influence on its members, delimiting their roles and shaping their communicative behavior and psychology. Individuals are both the subjects and objects of the group, the two identities unified in the group communication process. The group spits out communication outputs of its members and takes those outputs as inputs for future communication. A group, a miniature society, iterates and evolves.

Communication as a group-level learning process

Computational social science is hot nowadays and primarily consists of efforts to apply computer science methods to social science contexts (e.g., data scraping, text mining, Big Data, simulation). Computational communication scholars in my field almost exclusively see computation as a method. However, my mentor and I understand computation as a fundamental mechanism that can be discovered using both computer science and other tools. And we believe communication IS a computation process, akin to how many scholars see evolution as a computational process. In this sense, computation is not only a good methodology, but also a way to think about communication dynamically and multi-scaled. Executing a common verbal algorithm in group contexts gives rise to the emergence of higher-level group concepts such as cooperation or groupthink or contention. Such a perspective is rich with good questions whose answers are needed in order to model communication processes.

Traditional and current communication research is developed around the study of persuasion, or simply put, message effects. In such paradigm, communication is thought of as a one-shot, one-way, isolated, input-output, black-boxed process. The methodologies of studying communication phenomena have been mainly random-variable-based statistics and comparison group/control group experiments. A quintessential part of communication, small group communication, was also studied in such a way. However, small group discussion processes are in nature interactive, adaptive, emergent, nonlinear, dynamic, complex processes. The amount of insights gained in this sub-field is limited despite the huge amount of papers published on the topic. This sub-field needs new perspectives and new theories to make further breakthroughs in its research.

Some interesting questions

I think of a group discussion as a learning process in the machine learning sense. One of the core ideas of machine learning is to "feel out" the **best fitting models and parameters** through multiple iterations of estimation, each of which fixes the previous estimation and improves the estimate according to some algorithm and eventually arrives at some sort of optimum. We can think of the small group's discussion as a process through which the group members "estimate" the best fitting parameters through iterations of interaction. Each iteration could be conceptualized as a round of discussion or even as a single talk turn. The models being trained could be the overall strategies and attitudes each group member can hold. The parameters could include: (1) the weight of the influence that each person has on each other (e.g. how much they agree and tolerate disagreement of each other); (2) to whom to respond; (3) how much to respond; (4)when to say what; etc. The group is not only learning the opinion of each other, but also how they should react to each other. On some level, there might exist a certain **goal function** that the group members are collectively minimizing or maximizing. What might that function be? How is it decided collectively? When the group converges at **equilibrium**, does that necessarily mean a consensus or stalemate? How do we tell? Under what conditions (e.g. discussion styles) might the group be able to converge? What parameters of the group are being learned and updated in the process and how? Might there be **overfitting**, say, a family's members have learned parameters that fit and predict each other's opinion and behavior very well within the family's communication but these parameters (communication choices/weights/styles) do not fit to workplace groups very well? It is interesting to see what **progression algorithm** the group collectively uses to find that optimum. For example, do they use gradient descent? If so, how does the group **"know"** to do that? Through some meta algorithm? Or is there some fundamental universal algorithms? Perhaps certain groups can find an algorithm that increases the parameter fit over time (i.e., through trial and error and a lot of quarreling) resulting in that group being able to draw conclusions from their discussion; but, other groups that are unable to collectively create an algorithm that increases the fit of the group parameters and are also unable to draw conclusions from their discussion? Different group level algorithms may decide how quickly the group discussion can converge and how well a set of parameters a group can estimate/learn. **Can there be local optimum,** such as a comfort zone/attractor in which interactions between members fail to move the group toward greater consensus or acrimony?

This "group learning" mechanism has promise to integrate and explain many observed constructs from communication and social psychology such as polarization, risky shift, hidden profile, group think, social loafing, bystander effect, majority and minority influence and emergence of social norms. Most of these constructs are better understood as one-off behavioral phenomena that have been observed, but not explained by communication and psychology scholars. It will be fruitful to further carve out what each construct (analogy) really means for the group communication and how the whole system plays out; especially how the individuals' behavior choices and their interactions give rise to these constructs and the group behaviors. My job is to find mechanisms that explain and subsume the plethora of communication and psychological constructs. What are the law-like rules of group processes that give rise to many of these psychological constructs?

Some Explorations

Linear Discrepancy Model. Back in the 1960s, group research scholars modeled how people with conflicting opinions converge to a consensus (e.g. Abelson, 1964; Taylor, 1968) through group communication. However, this line of research was soon abandoned with few successors in the social science fields (e.g. Boster, Fryrear, Mongeau, Hunter, 1982; Frank, 2009) and replaced with social psychology methods (e.g. ANOVA). This line of research was interesting in that they mathematically showed how individual behaviors and their relations led to group level convergence or biases. The model also integrated the interaction between group and the external environment by considering boundary conditions of an open system, explaining the group's opinion position over time if external information keeps flowing into the group.

However, some of their assumptions were limiting. For example, the core assumption that the listener's attitude change is a linear function of the discrepancy between the speaker's attitude and the listener's position (*the linear discrepancy assumption*) is not well-grounded empirically. For another example, they assumed that the group discussion was merely the ensemble of dyadic inter-influences, so that the group discussion is reducible to how frequently each pair of dyads talk to each other and how much influence members in each dyad have on each other. In one of my class projects, I found that dyads were not always the unit of communication, specifically when one-to-many communication was available in the group discussion. After analyzing empirical online small group discussion networks, I found that dyadic reciprocity was either significantly negative or insignificant, indicating that the fundamental level of group discussions didn't usually happen on dyad levels. Instead, people tended to talk downwards: individuals on the top of the hierarchy are more frequently senders of messages than receivers. The biggest shortcoming of this early line of research in the 60s was that it was modeling the change of attitudes. Attitudes are very high-level constructs which are themselves phenomena to be explained and require a certain amount of data to reliably infer. Due to this nature of attitudes, it is hard to sensitively measure the values of attitudes in small time intervals over and over again to accurately capture its change over a discussion process. This is also one of the reasons why social psychology has avoided dynamic models. Newton used to face a problem: (by definition) instant speed exists but people didn't know how to characterize it. The problem with social psychology constructs (such as attitude) is the opposite: (by definition) the constructs are impossible to make sense of and measure for an instant (or short period of time).

Cooperative Game Theory. Although cooperative game theory has not been very relevant to economists (Maskin, 2016), it has its unique bearing on group communications. Cooperative game theory thinks of subgroups of group members (coalitions) rather than dyads as the primary units of decision making and analyses. The preservation and breaking of coalitions lend insights to how group members with different positions on a topic choose to contribute opinions to the group through their talks. Fuzzy coalitions (Branzei, Dimitrov & Tijs, 2008) could be used to take into account the vagueness of personal opinions in a discussion process. Cooperative game theory can model the general discussion strategies of group members in group decision making processes. Moreover, cooperative game theory can help break down the contributions of each group member to the discussion result. For example, if a real valued function $v:2^N \rightarrow R$ with $v(\emptyset)=0$ is defined to be a game of N players, and L defined to be a communication network with the same N players, the set of subsets of the N players whose elements are networked forms a Poset under set inclusion (cf. Fujimoto & Honda, 2009). Then we can use Mobius functions to define the contribution of each element and each edge/interaction to the value of the game. Mobius function is designed to calculate the parts as a function of the wholes that these parts sum up to. The game's values on the group level can be easily defined/measured/calculated. Individual values can be calculated using Moebius functions based on group level values for a measure of each member's value/contribution (e.g. Shapley value, Myerson value) and each interaction's value/contribution (e.g. the position value).

Some limitations come with cooperative game theory when it's used to model group communication and decision making. First, a player's behavior in a group discussion is the content of the player's talk in each talk turn (reduceable to a position in a high dimensional space), but game theory only allows binary behaviors (to cooperate or not). Second, the group plays the game (of discussion) for many rounds, but the theory does not include an iterative aspect. Third, it is hard to make explicit the game (function) when the group's behavior is discussions. It is hard to assign values to the discussion results and update that value after each talk turn. One approach to address these problems is to think of utterances (sentences spoken by members) as the players of the game. We could either treat each sentence as a player (who knows only to speak that sentence, and speaks up if choose to cooperate and not speaks up if chooses not to cooperate) or treat each player as a finite set of sentences (each talk turn of a player is to choose to play one of its sentence-cards). The sentences will be enumerated, their relations to each other will be judged and values will be assigned to different combinations of communication situations. This approach quickly becomes intractable if these work with sentences can only be done manually.

Physics Methods. In Frank's (2009) paper, a non-linear Fokker-Planck equation was used to model risky shift of group opinion after group communication. The model assumes when one talks to another with a different opinion, (x-x') away from self, one's opinion tends to move towards that other position, with the amount of change proportional to the probability, frequency and distance of the other opinion. Integrating the product of these mathematical entities over the set of all possible opinion states (Ω) gives the dynamic of opinion change due to interaction between group members. The model also added an extra term to the equation to account for the random force that keeps the whole group from converging to a single point in infinite time and maintains some opinion variance. This paper modeled the centripetal and centrifugal forces of group opinions without including any external force field. This line of research is rarely followed by scholars.

A popular line of research represents group members' opinions as binary spinners on a ferromagnetic grid. Ising model and mean field theory may have oversimplified individual's verbal behaviors in the process of conversational interactions. To build a theory that may potentially explain, say, the transcript of a group's discussion during a meeting, more additional parts need to be added to such physical models to integrate the language part of the phenomena.

Group members do not directly exist in binary (agree or disagree) relations with each other. They see, define, and change this relation through their verbal communication. The relation they exist in is the relation that their utterances put them in. How the sentences uttered by group members exist in relation to each other and in turn shape the relation of the group members is missing in the Ising model class.

Another possible approach is the synchronization literature (e.g. Acebrón, 2005). If we can find a way of representing group members' verbal communication behaviors as phase oscillators with describable frequencies and find out the fundamental representation of members' influence on each other (e.g. have the linear discrepancy assumption confirmed) then the Kuramoto model of coupled oscillators could be immediately relevant. Among the plethora of publications on the topic of synchronization by psychologists, cognitive scientists and communication scholars, almost no research takes this approach.

Discussion Network. Graph theory is amazing. However, graph theory is essentially static. The idea of representing a system as linked nodes was not meant to be a dynamic theory. Usually the conclusions affordable by graph theory are about whether something exists or could exist in a network. Questions about how changes in some network measures lead to other changes in the network and the rate of change are rarely discussed. Besides network-based simulations, the best use of network theory to capture dynamic processes is to represent the whole process as a static graph in some higher dimension space. For example, time-expanded network (e.g. Ford & Fulkerson, 1958; Holme, 2015; Scholtes et al., 2014) represents the same node at different time points as separate nodes and represent interactions with links between nodes at different times. Dynamic theorems on the original network are then proved on this new static network.

Network theories can capture the interdependence and interactions of members in a group communication process using the group's metadata (who talked to whom at what time), but the simplification of interactions into links between nodes does not capture the content/meaning of the group members' verbal interaction (if nodes are members in the group). To solve this problem, we can assume the utterances are drawn from a finite set of sentences utter-able by the group members and represent each sentence as a node. This way the sentence contents are naturally integrated, but then the link between them would be hard to define. The sentences could exist in many relations (e.g. agree, disagree, question, clarification, incommensurate etc.) to the sentences uttered just now and several talk turns earlier. Whenever a new sentence is uttered, it would be important to figure out which other sentence it is trying to establish a link with and what kind of link that would be. Some scholars try to represent sentences expressing beliefs and attitudes as nodes and their causal relation as links (Dalege et al., 2016). But it is not clear how this line of research could help explain how a group of people with different attitudes interact through verbal communication. Perhaps, it is possible to assume each group member has such a network of attitudes and each utterance of this member is describing/referring to the node(s) or link(s) in its subjective attitude network; members update their subjective network based on each other's utterances. In this case, verbal communication between group members is just an externalization of the interactions of members' internal attitude networks in human language. It would be important to formalize how different attitude networks can influence each other and merge into the group's collective attitude network expressed in its discussion conclusion.

Computation Theory and Process Algebra. Computation theory can help set the boundaries and prove feasibilities for the communication of groups. Goedel's famous incompleteness theorem showed that a consistent arithmetic language system cannot prove all the true sentences that are expressible in the system. Similar attempts have been made and failed on natural language systems. Mathematicians started to make real progress once they shifted their focus onto formal axiomatic language systems. However, I feel another attempt needs to be made to characterize how people use natural language to do verbal reasoning; to develop formal theories of what's provable and expressible by a (natural) language system following explorations Wittgenstein did with his work on the inexpressible. (A quick joke: it seems to me that the language system used by many social scientists is just not capable of expressing certain views no matter how hard they try;).

Kolmogorov (algorithmic) Complexity sheds light on the solvability of problems (by groups). A team's discussion may loosely be interpreted as a proof (process) of a sentence describing the team's decision or discussion conclusion. The proof (process) is a series of sentences being uttered (by group members) with certain rules of generating the next sentence based on previous ones. If there is a way of representing sentences with binary strings, then the set of initial sentences that a group knows to say could only strictly prove a sentence that has less algorithmic complexity (Chaitin, 1987; Downey & Hirschfeldt, 2010). Sentence sets with less (algorithmic) information cannot prove sentences with more information.

Process algebra provides a promising paradigm for merging the parallel thoughts and sentences of group members. Although the computer science version of process algebra may be too formalized to be directly applied to verbal communication processes, we may explore looser versions of axioms (e.g. relevant, progressive, interpretable rules for talking) for the algebra of verbal communication. We could start by exploring the definition of equivalence relations on sentences and sets of sentences. For example, there are infinitely many possible things a person can say, but the number of things that are relevant are more limited; there are infinitely many ways of saying the same (relevant) thing, but the number of ways that significantly differ from each other is far less. If more analyses of a certain type of conversation could loosely define a way of enumerating the things that are relevant, then cardinal sets can be defined on utterable things. Or if rules are imposed on the discussions, perhaps bijections can be established between equivalent utterable sentences and some cardinal numbers. Once the structure of the set of utterable, expressible sentences in reasonable, relevant, progressive discussions under explicit, imposed, external rules is successfully described mathematically, then an algebraic theory of this kind of verbal communication could follow.

Group Theory and Abstract Algebra. Human communication has symmetry. Conversations are iterative. The course of the conversation revisits the same points made earlier. If we have served in any sort of committee, we should at some point have felt that there are multiple ways to arrive at the same conclusion; there could be many variations of the same conversation by the same group of people depending on the sequence of the talk turns. So, assuming the group's knowledge is limited, assuming the number of possible discussion results is finite, and assuming that the set of things the group could talk about is closed under reasonable, relevant, knowledge-based talking, then group theory may provide better structures to our understanding of the symmetry of conversations: what sets of sentences could generate equivalent discussion results; how to structure the network/hierarchy of attitudes (under inclusion/deduction); how to count the number of possible discussion outcomes; what is needed to counter-say something etc. Admittedly, all this would require that we know how to represent the effect of sentences (in texts) on the discussion as functions or transformations in explicit formalized mathematics, which is not easily achieved. When we turn the Rubik's cube we can see the solid rigid result, but when we hear one sentence uttered, we usually find it hard to extract and describe what just happened, we can do very little more than just quoting that sentence.

Machine Learning with Deep Neuro Network. Data driven approaches have been able to solve (or avoid solving) theoretical problems. The theoretical difficulty of modeling group communication from the text level is due to an insurmountable difficulty to formally represent natural language (text) or meaning. We can do it intuitively, but we cannot quite access how we do it. We already know a lot about sets, groups, graphs, matrixes, algebra etc., and I could see the similarity between verbal behaviors and the behaviors of these mathematical entities. But to make concrete connections between human (verbal) communication and formal representations more than on the level of analogies has been unsuccessful. No such theory, model, or algebra of communication has been discovered yet. Although it is the dream of linguistists and communication scholars, almost no attempts are being made any more these days. Perhaps people realized a simple formal theory of human communication is not meant to be found. On the other hand, whatever function is generating the next round of discussion based on previous rounds of discussions (if there is one) can be approximated (Hornik, Stinchcombe & White, 1990) by training neuro networks with data without the need to first make explicit the rules of verbal communication. Scholars are usually model thinkers in the strict sense that they want to uncover the philosophy and the mathematics embedded in a phenomenon. However, none of the attempts to hard-code empirical knowledge in formal languages has led to breakthroughs (Goodfellow, Benjio & Courville, 2016). Perhaps, ultimately this is a machine learning problem. We may have to give up the ability to comprehend how we have conversations but only settle with the ability to build machines that can learn how we have conversations and help us have conversations more efficiently. After all, we know more about natural language now and we have more computation power and machine learning methods in our hands. It would be a great advance if we could build a theory, a models or at least an algorithm that can make groups of machines holding sets of sentences talk to each other, hold a discussion and even prove/solve problems in a fashion that humans do.

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