The Complex System of Individuals Sharing Information

Eric Schultz

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This paper is an effort to explore and unravel how and why individuals share information, deconstruct the models used to uncover these dynamics, and to take a glimpse as to where we could look next to gain a deeper understanding.

To understand the dynamics of individuals sharing information, we need build a foundation on the role of communication. The rest of this paper will generalize communication as just an act of sharing information.

A research paper by John H. Miller and Scott Moser illustrates how communication could plausibly be a key component to efficient coordination. Miller and Moser employed an adaptive model of agents playing the Stag Hunt game. The Stag Hunt game is a popular two player game in which both players will have a greater incentive to play similar strategies. The only caveat is that they without knowing what the other player is going to do, they should end up playing similar strategies that will yield a lower pay-off than what could have been achieved. A good analogy of this scenario is a team of baseball players deciding whether they should attend and play a game. Clearly, only some members showing up is less desirable than everyone not showing up at all, but ideally all members showing up is best solution. Without knowledge of the others actions all members should choose to not show up at all (Miller and Moser 2003).

In Miller's and Moser's model each agent plays another player in the Stag Hunt, but before agent's choose a final strategy they are allowed to send meaningless messages, or tokens, to each other. The experiment was ran several times changing the number of tokens and amount of strategies an agent could use in addition to the difference in pay-offs between Stag/Stag play and

Hare/Hare play. Strategy here refers to what the agent does with tokens received by another agent. As the simulation runs the agents are tracked by what percentage of time they spend in a particular state: (Stag, Stag) (Hare, Hare) or (Other). The simulation showed that as tokens and strategies increased from 0 to 4 the system went from playing (Hare, Hare) 96.1% of the time to playing (Stag, Stag) 99.4% of the time. Another interesting phenomenon that arose from this simulation was how the system transitioned from (Hare,Hare) to (Stag, Stag). The transition was initiated when some agent's starting playing a strategy that involved deciding whether to play (Hare, Hare) or (Stag, Stag) based on what was communicated. This strategy was short-lived since when a majority of the population started playing (Stag, Stag) communication become less important (Miller and Moser 2003).

Another model developed by Miller, Butts, and Rode uses a similar adaptive agent-based model to illustrate how communication can lead to cooperation. In this simulation agents play the Prisoner's Dilemma against each other. The Prisoner's Dilemma is similar to the Stag game except that each player should always defect no matter what the other player does. Again, agents receive communication tokens from other players and can form strategies based on those tokens, but they are limited in interaction such that they can not readily identify another player. Such constraints should theoretically force agents to defect all of the time (Miller, Butts, and Rode 1999).

The simulation demonstrated quite a bit of mutual defection, but it would also repeatedly fall into short periods of mutual cooperation. More interestingly, though, is that the repeated occurrences of mutual cooperation increased as tokens and strategies increased. In addition, the uniqueness of communication exchanged by agents increased when mutual cooperation would break out (Miller, Butts, and Rode 1998). It's reasonable to believe that this simple simulation demonstrates the affect communication could have on larger group dynamics.

Lachmann, Sella, and Jablonka developed a model demonstrating how sharing information is more efficient and could lead to higher levels of organization. In this model individuals exist in an environment that switches between two states, and each individual has a probability of assessing the correct state of the environment. An individual's fitness is determined by how many times, at a given instance, the individual has correctly assessed the environment. Lastly, information collected by an individual is available to all other individuals (Lachmann, Sella, and Jablonka, 1999).

Running the experiment showed that an increase in individuals led to overall increase in fitness. Even more, the fitness with more individuals outweighed what could be have been achieved by one individual with infinite memory. The simulation was also tested with an extra constraint that of adding a cost to sharing information. Again, even with cost, the average fitness of more individuals outweighed a single individual with the optimal amount of individuals hovering in between 3 to 10 individuals (Lachmann, Sella, and Jablonka, 1999).

This research illuminates several important aspects of information and communication that I will constantly consider further on. First, information sharing is not like food sharing in that the individual that collects the information does not lose any of it, or at least costs minimally when it is shared with the others. Second, the collective can accumulate more information about the environment than a single individual. Third, an individual whom information is shared with gains most of the benefits, but it costs considerably less than if it were acquired in solidarity. Fourth, the information a group can collect increases with the increase of individuals, thus, allowing the entire group to address bigger problems that a small number of individuals couldn't (Lachmann, Sella, and Jablonka, 1999).

Hopefully, the preceding paragraphs help set up, in a simplistic way, the notion that information sharing and communication are not only efficient ways for individuals to process information from the environment, but could serve as a cornerstone to creating a rich and complex system for individuals interacting with each other and information.

The benefits of information sharing are probably too idealistic and could be fraught with individuals forming differing views on what is a correct assessment of the environment. I'd like to call these differing views simply opinions; what an individual believes to be true of the environment.

How do individuals utilize information from others when differing opinions may be encountered? Weisbuch, Deffuant, Amblard, and Nadal constructed several agent-based models that may indirectly answer this question. In the first model, when an agent encounters another agent they adjust their opinion if the difference in their opinions are less than a given threshold, otherwise they refuse to talk. When the threshold is constant among all agents and is significantly large, the entire population converges to one opinion. For lesser threshold values, several dominant opinions emerged (Weisbuch, Deffuant, Amblard, and Nadal, 2002).

The first model assumed that agents had an equal chance of interacting with another agent while the second model constrained agents to a specific network of agents. The results were the same with the exception that when opinion thresholds were high a few "extremist" agents would not converge on opinions and when thresholds were low clusters of similar opinions emerged as opposed to converging to just two solid opinions. When agent thresholds are mixed, some being high and most being low, the population converged onto one opinion again. Having just a few "open-minded" agents enabled the system to converge on an opinion (Weisbuch, Deffuant, Amblard, and Nadal, 2002). This is particularly interesting when we look back to Miller's and Moser's model of communication and cooperation. In that model, it was demonstrated that when agents weren't solely dedicated to one strategy or another, they could end up tipping the entire system. What makes open-mindedness so influential in which only a few agents can determine the outcome of the system?

Weisbuch, Deffuant, Amblard, and Nadal also extended their model to include how agents weigh their opinion based on the variance of past opinions at a given time, opinions on differing subjects, and value of older opinions decaying over time. While most of these simulations didn't always converge to a single consensus, the salient point we could extract from this is that agents' opinions can disperse through a population. This is important to understand how issues in which many agents can have slight to extremely differing opinions are resolved. Without this model we might have be expected that the efficiency captured by information sharing would eventually crumble as agents multiply, diversify, and become opinionated. In fact, I suspect that if a system always converged to a single opinion would create an inefficiency in the sharing of information and limit the groups ability to search the information space. Specifically, Lachmann, Sella, and

Jablonka's model described an environment that could be distilled down to a binary choice of true or false. If we expand this model to include many environmental variables, varying degrees of understanding that variable, and how that information is dispersed throughout the population we might find that for information sharing to be effective it may need to be out-of-equilibrium. A model that coupled these two models detailing agents collecting information, sharing information, and changing to other agent's opinions would be quite enlightening.

Conversely, another phenomenon that can crop up in information sharing is when a strong consensus opinion becomes prevalent. In such a case, individuals may stop spending cognitive resources on reassessing a particular issue and accept it without "thinking" about it. I would like to characterize this occurrence as a social norm. While it may seem disturbing to think of individuals thoughtlessly conforming to what everyone else thinks, it should be obvious that there are benefits for individuals to spend his/her cognitive resources on processing other information. In turn, this benefits the group as a whole. Of course, I wouldn't assert that is always efficient. There is more than likely instances were a less efficient social norm becomes entrenched. My goal here isn't quite to illustrate when a social norm is beneficial or detrimental but to illustrate that the transition of a weak social norm into a strong social norm affects the individuals of that population.

Epstein has created an interesting model that illustrates this point beautifully. Epstein created an agent-based model illustrating that the strength of a social norm is inversely proportional to an individual's information processing of that norm. In the model, agents are assigned an attribute indicating its stance on a norm. Agents update what they think based on a set of other agents stance on the norm. The set of agents that an individual agent samples adapts based on whether there is value in increasing or decreasing number of surrounding agents to sample. In short, if a larger sample yields different results an agent will adapt to a larger sample. If the larger sample is the same an agent will adapt to a smaller sample. If neither yield differing results an agent will stick with the sample set it has. After which an agent will update its norm to the majority norm found in its selected sample set. In addition, an agent's computation of the norm is indicated by how large it made it's sample set in order to decide which norm to follow (Epstein, 2000).

This model was ran several times with changing parameters such as probability an agent randomly selects a norm, the initial norm make-up of the population, and inducing shocks into the system at a given time step. Overall, given the variety of initial parameters, an agent computation of a norm decreased as the norm became entrenched. There were some other interesting characteristics that arose as well. For instance, when the system was given a shock the agents would still entrench themselves into norms, but it would lead to a differing set of agents accepting a norm. The amount of computation an agent spent on a norm decreased as prevalent norms decreased. Agents on the fringe of two differing norms would exhibit higher levels of computation due to an agent's inability to decide on which norm to follow. Increasing the probability of an agent selecting a random norm often led to more localized groups of agents sharing a norm. Lastly, even though a the strength of a norm resulted in a minimum of computation, setting all the agents to picking random norms didn't result in agents maximizing their sample set (Epstein, 2000).

These simulations offer some interesting characteristics, but most importantly it adds a new dynamic to understanding how groups share information. Specifically, individuals can benefit not only by looking at neighbors for information but also looking at an aggregate of individuals for information. Lachmann, Sella, and Jablonka describe that information sharing will lead to higher levels of organization. Epstein's model appears to extend group information sharing and illustrate this higher level or organization. The higher level of organization is that individuals are not just sharing opinions but that those opinions converge and create social norms that feedback into the individuals. In addition, I think we can draw a parallel between when individuals in Epstein's model stop "thinking" and when Miller's and Moser's agents stopped utilizing communication once they reached a (Stag, Stag) configuration.

It would be worthwhile to extend Epstein's model to include the aggregate of all agent's norms and allow each individual agent to utilize that aggregate norm for deciding what to think. For instance, I envision including the dynamic exhibited when all individuals in the stock market are informed about what a current stock price is.

We can also look at Weisbuch and Stauffer's research to get another aspect that arises in group information sharing. Put simply, individuals will rely on others for information about the quality of something. For instance, whether a DVD is worth purchasing. Instead of an individual just collecting several opinions and finding the average, the individual knows that each other individual consulted will add a personal bias to his or her opinion (Weisbuch and Stauffer, 2001).

In Weisbuch and Stauffer's model an individual will look to a neighbor that gives the most weight to the opinion or the several characteristics that comprise that opinion. The individual will then compare that neighbors weighting with his or her own preferences in order to make a decision. The rationale is that the neighbor that cares the most about the thing being consulted will give the highest quality of information. Lastly, after the individual has made the decision, the individual will update his or her own weighting and begin transmitting that information to other neighbors (Weisbuch and Stauffer, 2001). What's salient here, though, is that an individual doesn't just look to his or her neighbor for information, but also reflects on his or herself in order to arrive to an answer.

Simulations of this model have shown to cause abrupt transitions between things becoming successes or failures (Weisbuch and Stauffer, 2001). We can look back previously mentioned models and imagine that opinions or norms could also start gaining traction and then disappear abruptly. Those models could be extended to include this dynamic of an opinion or social norm that was initially present at the start of the simulation but allowing the possibility for it to become extinct.

In conclusion, information sharing allows a group to process information from an environment more efficiently than each individual by itself could accomplish. The interactions of individuals and information can also produce rich and complex behaviors that we might not have expected; everything from converging dissimilar opinions to individuals reflecting on one's self to gather information.

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