Zollman Models

Now that I've specified a sense of model, we can dive deeper into Zollman's network epistemology project, keeping an eye out for how his models can be broken into pieces and what targets those pieces have. For my thesis, I will focus on Zollman's model from *The Epistemic Benefit of Transient Diversity*,[1] however, similar analysis could in principle be performed with any model with similar properties. Thus, this section is focused on enumerating the pieces of Zollman's transient diversity model M_d and discussing how each of those pieces correspond to possible target worlds W_d.

While I will argue my division of the model makes conceptual sense for rigorously specifying model-target relationships, this does not rest on the model code actually being structured in this manner. Zollman himself happened to take a very different approach to laying out his own simulation code,[2] however, this does not mean it isn't possible to structure the code in accordance with the divisions I specify here. In fact, as I will discuss in later sections, I wrote an implementation of M_d along these lines.

Zollman's Project

Before describing the model, it is important to understand Zollman's project and research purpose so as to have a good characterization of his intent with this model. As discussed in the previous section, the intent of the model matters as it determines which target the model is supposed to represent. Choice of target can make or break a model, as I showed with the example of how a kinematic equation can simultaneously be a great model when the target is an object on the Earths and a very inaccurate model for a target without constant gravitational acceleration. Thus, here I discuss a charitable interpretation of Zollman's intentions and use those intentions to more rigorously specify his target world.

At a high level, Zollman aims to understand how a diverse cognitive division of labor in science develops. Zollman notes that science has a striking property that different scientists work on very different problems and those working on the same problem even pursue different strategies to tackling that problem. Zollman paints this diversity as counter-intuitive, citing Kuhn as saying that any "shared algorithm" for deciding what to work on would lead to a lack of disagreement and to all scientists working on the same thing.[3] He also cites Philip Kitcher[4] and Michael Strevens[5] as taking a related stance which explains diversity as resulting from reward structures, for example: one which disproportionately rewards the first discoverer. Zollman seeks to reframe the problem as a social

[1] Zollman, "The Epistemic Benefit of Transient Diversity."
[2] Zollman, "Epistemic Benefit of Transient Diversity Simulation."
[3] P. 332 Kuhn, "Collective Belief and Scientific Change."
[4] Kitcher, "The Division of Cognitive Labor."
[5] Strevens, "The Role of the Priority Rule in Science."

epistemic problem of a group of individuals trying to collectively discover which theory will be most fruitful to work on. He defines the most fruitful theory to work on as the one which is right, though it feels natural to understand "right" as "consensus" or "accepted" as Zollman frames theory choice in the context of Kuhn, who suggests that theory choice is not a cut and dry process of right or wrong.

Zollman first makes a case for the value of diversity by highlighting the story of peptic ulcer disease, where a prominent scientist published an influential study ruling out bacteria as the cause of the disease in 1954, leading to work on understanding the disease as bacteria dying off. However, 50 years later, a scientist revived the bacterial theory by ingesting the bacteria, causing the disease in himself, then using antibiotics to cure himself, thus proving that the *H. pylori* bacteria was responsible. Zollman uses this anecdote as motivation and positioning for why we might think diversity of ideas might be useful as latching onto a theory too early was arguably responsible for the lag in this discovery.

Within this framing, Zollman seeks to see if a set of rules from social epistemology which give agents prior beliefs, limit them to work on one theory at a time and allow them access to limited information from others in the community give rise to diversity. Zollman ultimately finds this possible when information is sufficiently limited or when agents have extreme priors, though when both cases are true, the diversity becomes detrimental and scientists never drop inferior theories. From these results, Zollman concludes that diversity is not an inherent goal, as it can prevent convergence to a "better" theory, though it is helpful temporarily to reach an optimal result. Furthermore, Zollman emphasizes that this social model demonstrates that behavior that seems sub-optimal for an individual can become optimal within a community structure. From these modeling results, Zollman concludes that limiting information exposed to scientists or scientists holding more extreme priors creates transient diversity, which ensures theories aren't discarded too quickly so the overall community reaches more optimal results.

Given these intentions, I attribute Zollman's transient diversity model (referred to as M_d), as corresponding to the target world which contains real scientists acting within a real community structure (W_s). I argue a correspondence to the real world is a charitable interpretation as Zollman includes a real-world anecdote about real scientists and concludes by calling transient diversity a virtue for science. Furthermore, Zollman makes the claim that the peptic ulcer disease snafu "might have been better had Palmer's result not been communicated so widely or had people been sufficiently extreme in their beliefs that many remained unconvinced by his study,"[6] indicating that he does take these findings as applying to actual scientists.

However, there is one important distinction to be made with the model between the actual and hypothetical worlds. A model concerning an actual world would

[6] P. 33 Zollman, "The Epistemic Benefit of Transient Diversity."

model the world and phenomena we could, in principle observe, whereas one targeting a hypothetical world models phenomena we couldn't directly observe without making some sort of modification or intervention. A good analogy here is the difference between a longitudinal study and a controlled experiment in epidemiology. A longitudinal study measures data about the actual world, so is limited to studying and characterizing already existing effects. A controlled experiment, on the other hand, allows researches the ability to modify the actual world within an experiment group to make claims about a hypothetical world in which that modification was applied to the rest of the world. Zollman's models seem to be, for the most part, hypothetical ones as they ascribe certain behaviors to modeled scientists without making any empirical claims that scientists actually act accordingly. There is much more to be said about this distinction, but it is best to discuss Zollman's model-target relationships as corresponding to hypothetical targets before a more in-depth evaluation of the effectiveness of these relations.

The Model Algorithmically

Before discussing model-target relationships, I'll first partition the model into pieces which each have their own distinct targets as described in the previous chapter. Zollman pulls the generic model structure from an earlier work by Bala and Goyal[7] which presents a model that combines graph structure and bandit problems as a means of modeling social learning. Thus, to understand Zollman's models, we first must understand Bala and Goyal's model M_{bg}. While such models are inherently about social structure, I'll start by describing individual behavior to emphasize how social structure effects this behavior.

In M_{bg}, we refer to the piece of model machinery meant to represent an individual person as an *agent*. Each agent is tasked with picking a way to act without knowing *a priori* the probabilities of success for each possible action.

Target Relationships

Social Network

Facts and Actions

Beliefs

Action Rules

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[7] Bala and Goyal, "Learning from Neighbours."

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