

A Return to the Toolbox: Thoughts on Diversity and Performance

April 11, 2002

In the beginning is my end. In the end is my beginning.

-T.S. Eliot *Burnt Corker*

1 Thoughts on Diversity

So appealing was his intellectual vision that late in his life, Ralph Waldo Emerson had the luxury of sitting oracle like on his front porch and greeting a steady stream of admirers and acolytes. How historically accurate then (and how fortunate) for us to finish this class on Emerson's front porch. Emerson, who many describe as uniquely American, held deeply his love of diversity. Emerson belongs entirely in the toolbox camp. In his writing, he emphasized the beauty and strength of human individuality. It has been said that when he looked at a collection of people, he saw the crowd not as one, but as the many, as diverse, as multitudinous. This philosophy is perhaps no where as evident as in his prescient comment that the many colored wheel has to "spin very fast to appear white."

In this final lecture, we return to the toolbox model of abilities and apply it in economic, political, and social contexts. We focus on problem solving contexts as those are the most appropriate for the framework and we come to some conclusions that some of us will find both counter-intuitive and comforting –The former because they contradict the logic of markets and the latter because they decouple success and ability.

In this class, we have already discussed how people solve problems differently, how they have different belief systems, how they carry around different ideas in their heads about how the world works, and how they might settle into different equilibria for common problems. We have not taken an ideological stance on diversity. That it's all good or all bad. While we have shown the possibility of a positive relationship between diversity and robustness, we have also seen how diversity can frustrate decision making processes. Reaching consensus can be much more difficult in diverse groups, and in some cases, no consensus exists to be reached. In this final lecture, we emphasize how individual differences can be a force for good, how they can enable a society

comprised of limitedly intelligent agents (people and computers) to be collectively more intelligent than any of its individual parts.

In this final lecture, the toolbox model serves as a workhorse. For that reason, we return briefly to its core assumptions: People have perspectives which are mental representations of reality. People also have heuristics which are tools that they use to solve problems given their perspectives. How well a person solves a particular problem depends on the appropriateness of her perspective and the strength of her heuristics.

For the remainder of this lecture, we have three goals. First, we will use the toolbox model to demonstrate two counterintuitive results related to diversity and performance and to speculate on a third. Second, we will link these results to some of our earlier models. We will end with some thoughts about where to go from here.

2 Diversity and Performance

We often characterize intelligence as one dimensional. We say that someone is smart or really smart or even really really smart. We also tend to infer intelligence from performance. So we think of someone with a Nobel Prize or a Fields Medal as smarter than someone without such honors. We think of computer magnates like Bill Gates as smarter than those people who invested in the fusion craze in the late 1970's and early 1980's.

We will show using our toolbox model that such thinking may be misguided. Success be it economic, political, or scientific may be correlated with some forms of intelligence, but context and diversity may matter more.

2.1 Does Success Imply Intelligence?

Aisha and Bill work in the same field. Both are trying to solve a difficult problem, perhaps protein folding or engine design or wine making. There is a large set of possible solutions to this problem X . Each has a perspective on the problem, call these P_A and P_B . These are just mappings of X into something that makes sense to Aisha and Bill respectively. Each also has a set of heuristics they use to find improvements. Denote these sets by $H_A = \{h_{A1}, h_{A2}, h_{A3}, \dots, h_{An}\}$ and $H_B = \{h_{B1}, h_{B2}, h_{B3}, \dots, h_{Bm}\}$. To keep the model simple, we assume that there is a value function V that maps X into a monetary value between \$0 and \$200 million.

Each day, Aisha and Bill awake, go to work, and work on this problem. One day, Bill happens upon a \$100,000 solution. He's happy. He goes home that night rather pleased with himself. Two weeks later, Aisha solves the problem completely. She gets the \$200 million (less of course the meager \$100,000 that Bill has captured.) As a society, we bestow honors on people like Aisha. After all, only a brilliant scientist like her could have solved this problem. But, we have to be careful. Let's consider two scenarios:

Scenario 1: There are twenty solutions with non zero value, call these $\{x_1, x_2, \dots, x_{20}\}$. The value of x_1 equals \$200 million, and the value of each of the others is less than or equal to \$100,000. Suppose that Aisha's toolbox is such that if any of the nineteen suboptimal x_i 's are found, she can construct a way to get to x_1 . Suppose that Bill would only ever have been able to find x_{13} which eventually he did. Moreover, suppose that if Bill were placed at any of the other x_i then Bill would remain stuck there.

Scenario 2: As before there are twenty solutions with non zero value, call these $\{x_1, x_2, \dots, x_{20}\}$, the value of x_1 equals \$200 million, and the value of each of the others is less than or equal to \$100,000. Now however, Aisha's toolbox is such that she cannot find any of the x_i 's on her own. However, if by chance someone finds x_{13} , then she can easily find a way from there to x_1 , the optimal solution. In contrast, suppose that Bill can find any of the x_i 's, including x_1 but that if he gets to x_{13} , he'll be stuck there for a long time because the route to x_1 from there is difficult for him. If Bill happens to locate x_{13} first. Suppose that Bill happens upon x_{13} first.

In each of these scenarios, Aisha gets the money and the associated social acclimation. Bill is considered a minor player. In the first scenario, we can say with some degree of fairness that Aisha's fame is deserved. In the latter scenario, Aisha's success was to a large extent a random event.

Now, we might say that these are just examples. They are. However, Hong and Page (2001) have proved that problem solvers of equal individual ability (i.e. equally good toolboxes at a specific problem) can generate arbitrary individual performances. In other words, how we do on a problem can be pretty arbitrary once we are among people of the same skill level. Since people should tend to sort into careers based on abilities at that career, we should expect similar relative abilities for people working on the same problem.

Now, we could argue that people solve lots of problems each day and that in the end, this all washes out. The cream rises. To see the problem with this logic, consider the case of Warren Buffett, whose company Berkshire Hathaway has made billions with value investing. If Buffett had not entered the market, then his strategy, would have looked brilliant in retrospect from 1997. However, if in 1997, you began using his approach, you would not have made much money. How could the same person go from smart to dumb? He didn't. The point is that his perspective and heuristics worked for one problem but didn't work for another.

One could argue that all that this says is that intelligence demands flexibility in one's perspective and heuristics. That's fine to say, but in practice, it takes time to build up a new perspective and heuristics. We're sort of forced to dance with the ones that brought us that far. Success, to some extent, depends on context. On how your collection of tools fits the problem and how your collections works with the collections of others. The great irony in all of this is that those who do best should have tools

that complement the tools of others. Yet, this is precisely like our scenarios. If you positioning yourself to bootstrap your successes off the tools of others, the others can do the same to you.

3 Group Performance

Our next model, analyzes how diversity effects collective performance. We're going to ignore all of the details of how groups interact. Our neglect of several aspects of groups notwithstanding, our analysis can be informed and supported by a burgeoning literature on the performance of diverse groups. At first glance, this literature appears to say that diverse groups have higher variance outcomes - that some do better than homogeneous groups and some do worse (Ruderman, Hughes-James and Jackson [1996]). But a careful look reveals a more nuanced relationship. To grasp the benefits and costs of diversity we must first distinguish between diverse values and diverse skills. Diverse values muck up the group problem solving process (Raghuram and Gerhard [1996]). Diverse skills do not. They tend to be beneficial. Second, we must draw a distinction between cognitive diversity and identity diversity (Northcraft, Polzer, Neale, and Kramer [1996]). A group consisting of people of different races, cultures, genders, and ages need not be cognitively diverse, just as two white males of similar training and background need not think about a problem the same way. That said, the literature on group problem solving tends to assume correlation between cognitive diversity and identity diversity. This assumption rests on the idea that gender, ethnicity, race, etc... must influence how people interpret and interact with the world (Ceci and Roazzi 1994).

In fact, studies that take these forms of identity diversity as proxies for cognitive diversity find support for diverse group composition. Consider the following excerpt from a widely used organizational behavior textbook Robbins [1994]:

When a group is heterogeneous in terms of gender, personalities, opinions, abilities, skills, and perspectives, there is an increased probability that the group will possess the needed characteristics to complete its tasks effectively. The group may be more conflict laden and less expedient as diverse positions are introduced and assimilated, but the evidence generally supports the conclusion that heterogeneous groups perform more effectively than do those that are homogeneous. (p 261)

More careful studies strip away or control for value and identity differences and focus only on the cognitive differences. The evidence here in favor of diverse group composition is even stronger. Studies of creativity and innovation conclude that cognitive variation is the key explanatory variable (Hoffman [1959], Maier [1930], and Amabile [1983]). Social psychologists show that heterogeneous teams which bring multiple perspectives outperform homogeneous teams in idea generation (Filley, House, and Kerr [1976], Hoffman [1979], and McGrath [1984]). In a recent experimental paper, Blinder and Morgan [2000] find that two people perform better than one, though

there analysis rests more on Nisbett and Ross's [1980] idea that two people are less likely to make the same mistake. Turning to more applied research, if you rank top management teams by functional diversity (training, background, etc...), you find that the more diverse teams introduce more innovations (Finkelstein and Hambrick 1990, Bantel and Jackson 1989). Similarly, if you evaluate the long history of affirmative action in the marketplace and analyze its successes and failures, you find that cognitive diversity is a key explanatory variable for success. Thomas and Ely [1996] in just such an analysis write "Diversity should be understood as *the varied perspectives and approaches to work* that members of different identity groups bring."¹ And finally, if the proof is in fact in the pudding, management gurus such as R. M. Kanter [1983] find evidence that firms purposefully create diverse teams in order to exploit multiple interpretations and skills.

We will demonstrate the importance of group diversity with a simple model that includes the following assumptions:

- 2000 points on a circle
- Each point has a value in $[0, 100]$ assigned according to a nonlinear function
- Agents all use the same perspective: they all see the same circle
- Heuristic = $\{i, j, k\}$, $i, j, k \in \{1, 2, 20\}$, which is how many points ahead you look. This arrangement leads to 6840 possible problem solvers.

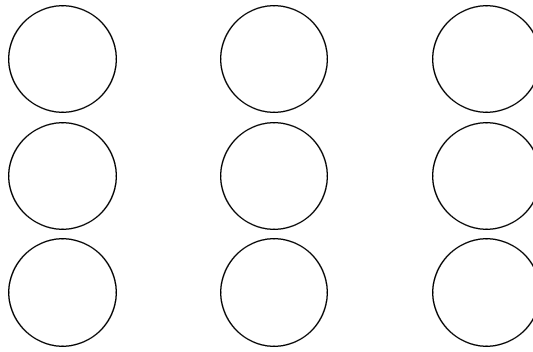
If the current best point is number 432, and the agent's heuristics are $\{7, 11, 13\}$, then the agent compares the value at 432 with the values at 439, 443, and 445. If none are higher, the agent stops searching.

Amazing Result: Take best 10 (20,40,50..) agents and have them work collectively until they are at a jointly local optimum. Compare this to a same sized group of randomly selected agents. The latter group does better almost always.

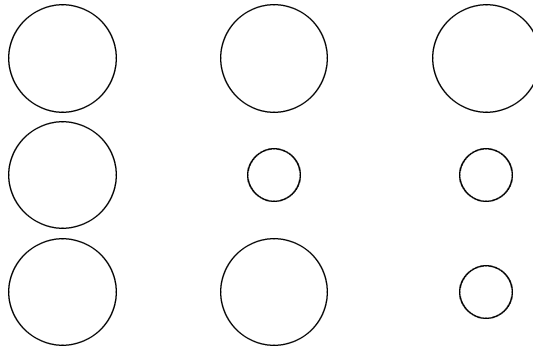
How can this be? Here's the idea. If we let head size denote how well someone does alone than the two groups might look as follows:

¹The *italics* are theirs.

Group of the Best



Random Group



If, we represent these groups by their heuristics and not by their average performance, we see what drives the result.

Group of the Best:

1. 7,9,11
2. 7,9,12
3. 7,11,12
4. 8,9,11
5. 8,9,12
6. 7,8,9
7. 7,8,11
8. 2,9,11
9. 7,14,19

Random Group:

1. 6,7,9
2. 3,8,14
3. 2,9,19
4. 1,7,11
5. 2,4,12
6. 12,18,20
7. 5,8,17
8. 3,5,8
9. 2,16,19

The set of heuristic is much larger for the second group. The first group has less diversity. Again, you may just say that this is an example, but Hong and Page have a theorem that shows that this is generally true provided that some rather modest conditions are met. One of these conditions is that the problems solvers “know calculus” relative to the problem - that they only get stuck at a countable number of points (a set of points that you can list). Otherwise, the theorem would be saying that enough monkeys can solve any problem, something that we know is false.

3.1 Diverse Toolboxes and Fun

So far, all of our talk has been about problem solving in economic and scientific contexts. We’ve restricted our attention because these areas seem more important and practical. But this leave out fun. Even if we make great scientific discoveries and have an enormous GDP, if we don’t have any fun, why bother?

Perhaps no where is the boundary between fun and functionality more obvious than in architecture. Christopher Alexander has written two books, *A Timeless Way of Being* and *A Pattern Language* which lay out a perspective and set of heuristics for architecture. His approach is to combine patterns to form a cohesive whole. His patterns form the building blocks (pun intended) of spaces. For example, two of his patterns: “different chairs” (we like rooms with different types of chairs) and “light from two sides” (rooms with light on one side do not have enough light, more than two sides and we do not feel safe). Alexander argues that successful spaces, buildings, and (yes even) lives satisfy many of these patterns.

The point is, that these patterns are not necessarily intended for function in an economic or scientific sense. (In fact, he advocates only giving glimpses of great views.

He abhors glass walls with panoramic vistas.) These patterns give meaning and make life fun. Look at buildings and houses, you'll realize that the buildings we like best have something fun about them and that this fun was probably not economical apart from the benefit that fun brings.

The difference between fun and economic value can be hard to define. Economists would like to quantify fun. One way to think about the difference, is to say that capturing the rents from fun are harder. Whoever developed hide and seek did not become wealthy from it. Nor did the inventor of baseball. The chef who recently came up with butter infused lobster (which is now all the rage at trendy restaurants) captured only a small portion of the total rents from his idea.

To the extent to which we all think about things the same way, we are less likely to come up with fun new ideas. So, when we think about the importance of diversity with regards to heady stuff like scientific advancement, economic development, environmental sustainability, we should not leave out stuff like pig Latin, hopscotch, beach volleyball, crossword puzzles, and henna.

4 Keep It Together, Keep It Together, Keep It Together..

The idea that individual diversity makes us collective more efficient and more fun has a nice happy feel about it. But we should not read into this that more diversity is necessarily better. That is too much of a leap. At this point, all we can do is identify some of the implications of increasing and decreasing diversity. We'll leave the conclusions and the jumping to others.

The route we'll follow will involve rethinking what we've covered in this class now that we've got a more complete picture:

- *Week 1:* When we say more or less diversity is better, we have to first have a measure of diversity, of which there are several. We do have the ability to identify what characteristics define environments of low and high diversity and this explains why most paper is eight and a half inches by eleven but key chains come in a variety of sizes.
- *Week 2:* People have different perspectives and these perspectives play a role in how well we understand things. Diversity might be best understood not as racial, gender, or ethnic differences, but in how we see the world. However, cultural tags can be shortcuts for anticipating how others think.
- *Week 3:* People also differ in what we like. This may be because we have different fundamental preferences or because we have diverse perspectives and similar outcome preferences. These differences in what we want are fine in

market and social settings, but when we must make a collective decision, we run afoul of Arrow's theorem: we can get rock paper and scissors. This is more likely when people have multidimensional preferences, which can occur because..

- *Week 4:* People tend to become like those around them and therefore necessarily unlike those not around them. This within group homogeneity occurs for strategic regions. The across group heterogeneity occurs for one small reason: how likely is it that we all make the same random choices? and one big reason: we play multiple games not just one and we try to construct games that fit with our behavioral repertoires.
- *Week 5:* Given that people across countries, regions, ethnicities, genders, etc.. differ, this begs the question of whether they should also specialize economically. From a portfolio investment strategy, diversity is important, from an efficiency standpoint or if they want maximal growth they should specialize.
- *Week 6:* Our economic and social success depends not only on the tools we choose but also upon who we know. Diverse social networks can explain why we have such small degrees of separation between people even though we have tight knit groups. They can also explain why weak ties are so important.
- *Week 7:* Diversity, be it in networks, toolboxes, or shoes either evolves or is created. Diversity occurs in evolutionary settings from geographic segregation or from the underlying problem having multiple hills. It might also arise from neutral mutations. Creation generates diversity through the distinct mental processes that people bring to bear on problems. Again, we see the importance of a broad diversity in human and human assisted thinking, yet we have also seen why there may be some incentives or pressures to not diversify at the individual level.
- *Week 8:* In thinking about whether diversity evolves, one obvious reason it might is the perception that diverse systems can be more stable, more robust. Stability in fact depends on particular types of diversity - in the case of trees diversity of structures. In the case of immune systems, too much diversity might not be good, you'd rather be able to kill the viruses in the present environment. We could think of immune systems as toolboxes - it's not a bad idea. In this way of thinking, the Native Americans didn't have worse immune systems than the Spanish, they just didn't have the germs to kill the Spanish. If different germs had been present, the Spaniards may have been wiped out. The Spaniards immune systems were only better because they chose the germs. Their interaction was the equivalent of a spelling bee in their own language. In thinking of this lecture in light of our earlier ideas about diversity and collective decisions and our later work on diversity and conflict, we notice that this robustness is relative to external shocks. The problems all deal with internal robustness. What

we see is a conflict. To be externally robust, we must be internally less robust. Thus, more diversity may not always be better depending on which threat is larger.

- *Week 9:* In our previous discussions of how evolution and creation generate diversity, we did not talk about how they might suppress it. In this lecture, we say how chains could lead to the homogenization of the economic, cultural, and social landscape. The potential implications are huge in light of all of our thinking about the importance of diverse mental models. The big question is whether the endogenous diversity that results from all of us living in a common culture will be larger or different than the exogenous diversity imposed upon us in the past.
- *Week 10:* One way in which this endogenous diversity can emerge is through segregation as we saw in Schelling's elegant model. The intended message of this model - that the micro and the macro need not link - is secondary for our purposes. For us, the fact that once these tips occur returning to desegregation is hard was more important.
- *Week 11:* When we get this sorting, differences are more likely to become apparent. We are also less likely to know those that sort away from us. This lack of information can make cooperation more difficult to sustain and we can have conflict. Therefore, we want diversity, but we do not want too much sorting. That may be impossible, unless of course we have cross cutting cleavages.
- *Week 12:* The potential for all of this diversity to make life more efficient and more fun exceeds what we might think if we did not make some fun little models. However, in these models, we made an assumption that people could talk to one another, listened to and respected one another. This does not always happen. Therefore, the idea that the benefits of diversity require tolerance becomes clear.

5 More Thoughts

I'd like to think that we have come to some coherent views about diversity. Systems and life would not be much fun or productive or robust without diversity. But, without diversity we would not have as much conflict, misunderstanding, or wacky collective decision making. Evolutionary and creative forces both work in favor and against diversity and levels of diversity can be predicted (fairly well) by looking at some characteristics of the environment.

We have purposefully tried to avoid the moral and philosophical dimensions of the dialog about diversity. Nevertheless, some of our models have bumped into the ideas in those literatures. You should take away ideas from this class, not facts. The facts are fine, but they constantly change on us. Ideas remain ideas. The ideas I would like you to have carrying around in your heads range from the obvious: *we see the*

world differently and that helps us make the world more fun but it makes it harder for us to understand one another to the specific differences in opinion may not be over what we really care about but over something as silly as policy mappings and macro level sorting by types need not indicate micro level racism to the chew-able evolution and creation differ- both contain forces that dampen and generate diversity, the diverse typically beat the best, your successes depend on a context created by the successes and failures of others and harnessing our differences and quelling the internal instability leads to greater collective robustness and performance.