Superminds

THE SURPRISING POWER OF PEOPLE AND COMPUTERS THINKING TOGETHER

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are taking, (3) some interconnections between these actions, and (4) some goals with respect to which we can evaluate these actions.

Whenever I see a combination of these four things, I see a supermind. But it's important to realize that seeing a supermind is sometimes useful and sometimes not. For instance, I might say that the four legs on the table in my office constitute a group of individuals acting collectively to keep the top of the table from falling to the floor. This is true as far as it goes, and in this sense my table is an extremely simple kind of supermind. But applying the concept of superminds to my table in this way is probably not very useful because—as far as I can tell—it doesn't give us any new insights about how to use tables or do anything else.

Just as physicists need to learn how to artfully apply concepts like force, mass, and energy to get useful insights about real physical situations, so, too, do we need to learn how to artfully apply the concepts of superminds and collective intelligence to get useful insights about the real world.

CHAPTER 2

Can a Group Take an Intelligence Test?

For perhaps as long as humans have existed, people have known informally that some humans seem to be smarter than others. Some people just figure things out faster, know more, and learn more quickly. But in the early 1900s, psychologists made a breakthrough in our understanding of this phenomenon: they developed a way to objectively measure something similar to what we have always called intelligence.

Can we do the same thing for groups? Can we objectively measure how smart a group (or supermind) is? If so, can we objectively say that some groups are smarter than others? Is there even a scientific sense in which we can say that a group is "intelligent" in the first place? Thanks to recent research my colleagues and I did, we now know that the answer to all these questions is yes. But to understand why, we first need to know a little more about individual intelligence and how it is tested.

MEASURING INDIVIDUAL INTELLIGENCE

The most important advance that made intelligence tests possible was the discovery of a surprising fact about human abilities. Imagine that you know John is good at math and Sue is good at reading. How would you guess each would perform at the other subject? If you're like many people, you might guess that John is probably average or worse at reading and Sue is similarly average or below in math. Based on our everyday experience, it seems like this might well be true in general.

But here's the surprising fact that we now know from hundreds of scientific studies: on average, people who are good at one kind of mental task are good at most others, too.[1] Those who are good at reading are usually better than average at math and vice versa. Those people who are good at math and reading also tend to have good memories, possess greater general knowledge about the world, and be better at logical reasoning, among many other qualities.[2] Of course, different people *develop* their skills more fully in some areas than others, but some people are just better than others at what we defined in the previous chapter as general intelligence—the ability to do a wide range of mental tasks well.

Here's a more scientific way of saying this: if you ask lots of people to do lots of different mental tasks, and if you analyze the results statistically, you'll find that their scores on each task are positively correlated with their scores on most of the other tasks.

Then, with that data set, you can use a statistical technique called factor analysis to see the underlying structure of how the different scores are related. If you want to use factor analysis to analyze the structure of people's political attitudes, for instance, you could ask their opinions on lots of issues (like abortion, taxes, gay marriage, and universal health care). And the analysis would tell you whether a single underlying dimension (like liberal versus conservative) explains most of their answers or whether multiple dimensions (like for social issues and economic issues) are necessary.

When psychologists use this technique to analyze people's scores on different mental tasks, they usually find that a single statistical factor predicts about 30–60 percent of the variation in people's performance on all the tasks. No other single factor predicts more than about half this much variation.[3] The statistical technique calculates a score on this factor for each individual, and the people with high scores do better on most of the tasks than those whose scores are low. This statistical factor corresponds well with what we intuitively call intelligence, and all modern intelligence tests are designed to include the kinds of tasks that measure this factor.

It is important to realize that this result wasn't preordained. There are other characteristics of people, like personality, for which there is no single factor that predicts others. For instance, if you know that someone is an introvert, that doesn't predict either way whether he or she will be conscientious or agreeable.[4] But it turns out to be a very well-established scientific fact that different people have different amounts of general intelligence for doing mental tasks.

Of course, this result is scientifically interesting, but it also has significant practical importance. With any standard intelligence test, you can predict how well someone will do on lots of other tasks without taking months or years to observe them all individually. If you want to predict how well someone will do in school, for instance, or how successful he or she will be in many jobs, you can do so pretty well with just the results of a short paper-and-pencil intelligence test.[5] It even turns out that, statistically speaking, people who are more intelligent live longer. Being able to predict these important life outcomes based on an objective measure has lots of very important practical consequences, including, among many others, the growth of the multibillion-dollar educational testing industry, which uses tests very similar to intelligence tests.

But it's important to remember that these intelligence tests are far from a magic bullet for predicting everything about a person's future. There are many other important kinds of abilities that are not measured by standard intelligence tests. For example, Howard Gardner includes musical ability, physical ability, and interpersonal ability as different kinds of intelligence.[6] And there are many other factors besides intelligence that affect success in school and life, including—to name just a few—how hard you work, how much help you receive from your family and friends, and—of course—how lucky you are.

Some people have—rightly—criticized our excessive reliance on standardized intelligence and other tests. (SATs and other similar educational tests aren't intentionally designed as intelligence tests, but their results are highly correlated with those of intelligence tests.) But the problem is not that the tests have no value; it's that we sometimes expect too much from them. We often assume that the tests are even better predictors than they actually are, and we place too much emphasis on the qualities the tests measure and not enough on other things that also matter.

But this shouldn't cause us to lose sight of the fact that intelligence tests are often the best single predictors we have of how well people will perform on things that matter to us. For instance, in one very comprehensive study, intelligence tests were the most accurate single predictor of job success, proving more accurate than job tryouts, reference checking, interviews, and academic achievement.[7] So even though they're certainly not perfect predictors of all life outcomes, it's fair to say that the development of individual intelligence testing is one of the most important achievements in the field of psychology in the 20th century.

AN INTELLIGENCE TEST FOR GROUPS

But what do all these results about *individual* intelligence mean for *collective* intelligence? Can groups be intelligent in the same way individuals are? Is there any objective way to say that some groups are smarter than others? In other words, is there a single statistical factor for a group—like there is for an individual—that predicts how well the group will perform on a wide range of very different tasks?

As far as my colleagues and I could tell, no one had ever asked this obvious question before. So we set out to answer it. My colleague Anita Woolley played a key role in all this work and was the first author on the paper in which we reported our original results.[8] Christopher Chabris and a number of others (named in the notes for this chapter) were also involved in parts of the work.

To create an intelligence test for groups, the first thing we needed to do was to select a set of tasks for the groups to do. We could have just asked groups to work together to answer the questions on a standard individual intelligence test. That would have included a variety of *mental* tasks, but it wouldn't necessarily have included a variety of tasks on which groups work together. So we used a well-known framework created by social psychologist Joseph McGrath for classifying group tasks,[9] and we selected tasks from each of the main categories in his framework: generating, choosing, negotiating, and executing.

For tasks involving *generating* something new, for instance, we asked groups to brainstorm various uses for a brick. For tasks involving *choosing* from among specified alternatives, we asked groups to solve visual puzzles from a standard individual intelligence test called Raven's Matrices. For *negotiating* tasks, we asked members of groups to pretend that they all lived in the same house and then to plan a shopping trip subject to various constraints on travel time, costs, and perishability of the items they needed to buy. Finally, for *executing* tasks, we asked them to type a long text passage into a shared online text-editing system. We also asked them to perform other tasks like word-completion problems, spatial puzzles, and estimation problems. Overall, we used these tasks to represent the wide range of tasks that groups might perform in the real world.

The next thing we needed to do was recruit groups to take our test. It would have been easy to recruit college undergraduates like those who surround us on the campuses of MIT and Carnegie Mellon University, the two universities where we carried out these studies. But we thought that—especially for a study of group intelligence—our results might be skewed if all our subjects were the kind of highly intelligent and academically accomplished students who study at our universities. So instead we recruited our test subjects from the general public in our cities using a variety of channels, including public websites like Craigslist, because we wanted the groups to be representative of a broad cross-section of our communities. And according to the short individual intelligence tests we gave our subjects, their intelligence distribution was very similar to that of the general US population.

In our two original studies, we had a total of 699 people in 192 groups of two to five people each. Unlike most groups in businesses and other organizations, our groups had no assigned leaders, and people weren't selected for the groups based on any special skills. But in all cases, the groups worked together on their assigned tasks as a group, not as individuals.

DOES THE TEST WORK?

After we had given all the groups a chance to perform all the tasks, we analyzed the correlations among them. This was a key moment of suspense in our research. Would there be a single factor that explained how well groups performed a wide range of tasks, as there is for individuals? Or would there be some more complicated factor structure where, for example, some groups were good at mathematical tasks and others were good at verbal tasks?

The answer was: groups are like individuals. It turned out that there is a single statistical factor for a group—just as there is for an individual—that predicts how well the group will do on a wide range of tasks. As we saw above, for individuals this factor predicts about 30–60 percent of the variation on different tasks. For the groups in our studies, it was in the middle of that range—about 45 percent. Because

this factor is called intelligence for individuals, we called our new factor for groups collective intelligence.

In other words, we found that groups have a form of general intelligence, just as individuals do. This means that, just as with individual intelligence, we may be able to use collective intelligence to understand much more about what makes groups effective on a wide range of tasks.

To begin this process, our original studies included a check to see whether the collective intelligence factor we measured predicted performance on tasks not used to calculate it. To do this, we also asked the groups to perform more complex tasks that required a combination of different kinds of abilities. In one study, for instance, the groups played checkers against a computer. In another study, they built structures using building blocks, subject to a set of rules about what to build.

We found that the collective intelligence scores did indeed significantly predict performance on these more complex tasks. In fact, a group's collective intelligence score was a much better predictor of how well the group did on these more complex tasks than either the average or the maximum individual intelligence of the group members.

WHAT MAKES A GROUP SMART?

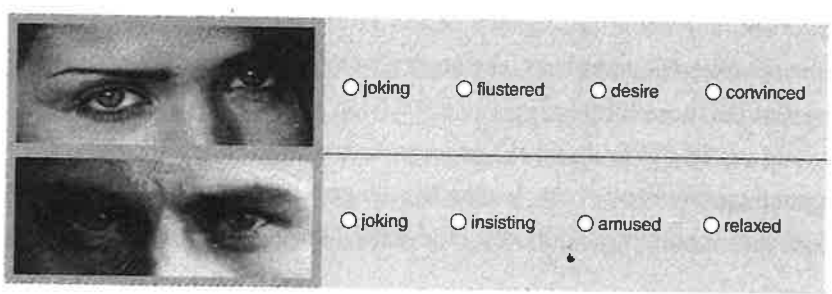
Before we conducted our studies, we thought we might find a single *collective* intelligence factor for groups that was mostly predicted by the average *individual* intelligence of the group members—that is to say, the smarter the members, the smarter the group. But what we found was much more interesting.

First, we did find that the average and maximum intelligence of the group members was correlated with the group's collective intelligence, but this correlation was only moderately strong. In other words, just putting a bunch of smart people together doesn't guarantee that you'll have a smart group. You might guess this from your own experience: most of us have seen plenty of groups of smart people who couldn't get anything useful done. But if just having a bunch of smart people in a group isn't enough to make the group smart, what is?

We looked at a number of factors that previous research suggested might have predicted how effective a group would be, such as how satisfied the group members were with their group, how motivated they were to help the group perform well, and how comfortable they felt in the group. None of these factors was significantly correlated with the group's collective intelligence.

But we did find three factors that were significant. The first was the average *social perceptiveness* of the group members. We measured this using a test called Reading the Mind in the Eyes, in which people looked at pictures of other people's eyes and tried to guess the mental state of the person in the picture (see below).[10] This test was originally developed as a measure of autism—people with autism and related conditions do very poorly on the test—but it turns out that even among "normal" adults, there is a significant range of people's abilities to do this task well.

You might call this a measure of a person's social intelligence, and we found that the groups in which many of the members were high on this measure were, on average, more collectively intelligent than other groups.



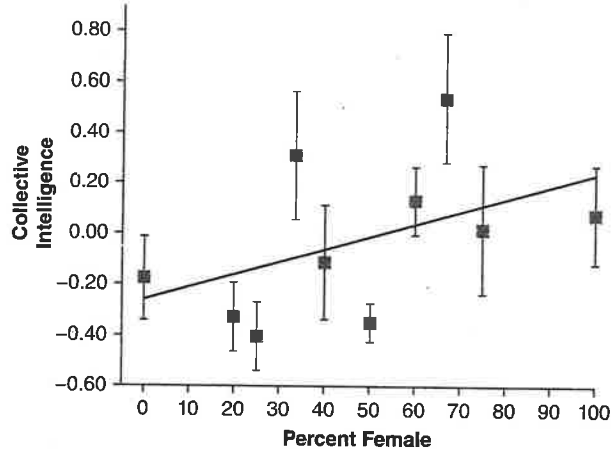
The second important factor we found was the degree to which group members *participated about equally* in conversation. When one or two people dominated the conversation, the group was, on average, less intelligent than when participation was more evenly distributed.

Finally, we found that a group's collective intelligence was significantly correlated with the *proportion of women* in the group. Groups with a higher proportion of women were more intelligent. But this result was mostly explained statistically by the measure of social perceptiveness.

It was already known before we started our research that women, on average, score higher on this test of social perceptiveness than men. So one possible interpretation of our result is that what matters in making a group collectively intelligent is the social perceptiveness of the group members, not their gender. In other words, if you have enough people in a group who are high on social perceptiveness, that may be enough to make the group smart, regardless of whether those people are men or women. But if you're choosing people to be in a group, and you know nothing about a person except his or her gender, you are a little more likely to find social perceptiveness in women than in men.

Interestingly, our result didn't match up with typical assumptions about diversity. Most people would think that the most intelligent groups should be the ones that have about half men and half women. But in our data, the groups with an equal number of men and women were among the least intelligent. As the following graph shows, our data suggests that the collective intelligence of the group may continue to increase along with the percentage of women.[11]

It's also important to realize that, since the points on the graph don't follow any smooth line, there is probably a fair amount of "noise" in the data (for instance, the vertical lines extending from the data points show what statisticians call the standard error of the points). We expect that future research will shed more light on the complexities



of what is happening here. But at a minimum, our results already provide intriguing suggestions about the role that the proportion of men and women in a group might play in determining the group's collective intelligence.

SOCIAL INTELLIGENCE IS A KEY TO COLLECTIVE INTELLIGENCE

An important clue to what's going on comes from the fact that when we tried to predict collective intelligence using all three factors at the same time (social perceptiveness, distribution of speaking turns, and percentage of females), we found that the only factor that was statistically significant was social perceptiveness. This doesn't mean that the other two factors were unimportant. It just suggests that the underlying mechanism at work in both of the other cases may be social perceptiveness. We saw above, for instance, that social perceptiveness might be what causes the effect of gender and that perhaps socially perceptive people are more likely to take turns speaking, too.

A striking demonstration of how powerful this social perceptiveness factor can be comes from a later study we did with online groups.

In this study, we randomly assigned people to one of two kinds of groups.[12] The *face-to-face groups* sat around a table talking to one another while they took a version of the collective intelligence test on laptop computers. The *online groups* took the same test, but they couldn't see each other at all, and they could only communicate by typing text messages to one another. We found that the social perceptiveness of the group members was equally good at predicting collective intelligence in both kinds of groups. In other words, people who were good at reading emotions in other people's eyes were also good at working together, even when they were doing so online and couldn't see each other's eyes at all!

This suggests that social perceptiveness must actually be correlated with a much broader range of interpersonal skills that are just as useful online as face-to-face. For instance, the kind of social intelligence that lets you read emotions in people's faces might also help you guess what other people are feeling based on what they type and help you predict how they will react to various things you might type back.

In other words, the social skills and social intelligence that are so important in a face-to-face world may be at least as important in the increasingly online world of our future.

COGNITIVE DIVERSITY MATTERS, TOO

In another study,[13] we looked at diversity of *cognitive style*—differences in how people habitually think about the world. Based on previous research on this topic, we considered people with three different cognitive styles: *verbalizers*, *object visualizers*, and *spatial visualizers*.[14] Verbalizers are good at reasoning with words; object visualizers are good at dealing with the overall properties of images (like paintings); spatial visualizers are good at analyzing images part by part (as in an architectural blueprint). Loosely speaking, these three cognitive styles are typical of students in the humanities, the visual arts, and engineering, respectively.

When we analyzed the collective intelligence of groups with various mixes of these cognitive styles, we found that the most collectively intelligent groups were those with an *intermediate* level of cognitive diversity. In other words, groups where the members had very different cognitive styles weren't as smart, perhaps because they couldn't communicate effectively with one another. And groups where all the members had the same cognitive style weren't as smart, either, perhaps because they didn't have the range of skills needed to do the different tasks. The best combination seemed to be groups in the middle, perhaps because there was enough commonality to communicate effectively and enough diversity to solve a range of different problems.

DO COLLECTIVELY INTELLIGENT GROUPS LEARN FASTER?

One of the most important characteristics of individual intelligence is that it predicts not just what people can already do but also how quickly they can learn new things. Is the same true for collective intelligence? Does a group's collective intelligence predict how fast the group will learn?

As a first step in answering this question, we gave some of the groups in our original studies another task after they had completed the collective intelligence test. We asked them to play a game that the game's developers called the minimum-effort tacit coordination game.[15] In each round of this game, each player had to pick one of five numbers. The number of points players earned was determined by the number they chose as well as by the numbers the other members of their group chose. In order to help them make a choice, the players could each see a "payoff matrix" (see chart) showing how many points they would receive individually based on the number they chose and the minimum number chosen by anyone in the group.[16]

Somewhat like the well-known prisoner's dilemma game, the minimum-effort tacit coordination game requires players to make

Minimum of All Group Member Choices

Individual's Choice	0	10	20	30	40
0	2,400				
10	2,200	2,800			
20	1,600	2,600	3,200		
30	600	2,000	3,000	3,600	
40	−800	1,000	2,400	3,400	4,000

their moves simultaneously and independently. They weren't allowed to talk to one another about their choices, and the only way they could coordinate was by watching what the other members of the group had done in previous rounds. But unlike prisoner's dilemma, this game strongly rewards players for cooperating, not competing. Their individual rewards were maximized if, over the 10 rounds of the game, they all picked the same choice (the number 40). But this choice was a risky one, because if you picked 40 and someone else in the group picked 0, you lost points. With all the other choices, you could never lose points, regardless of what the other group members did.

Most groups didn't do very well in this game for the first few rounds, but we found that, over the 10 rounds of the game, the groups with higher collective intelligence learned more rapidly how to implicitly coordinate with each other based on what they had done in the previous rounds, and their point totals were significantly greater than those for the other groups. So at least by this measure, groups that are more collectively intelligent also—as we hoped—learn faster.

WHAT ELSE DOES COLLECTIVE INTELLIGENCE PREDICT?

In another set of studies, we translated our collective intelligence test into German and Japanese, and we studied groups taking it in their respective languages in the United States, Germany, and Japan. As further confirmation of our original results, we found that the same kind of collective intelligence factor as in our original study emerged across all three countries and across various group communication modes: face-to-face, voice, video, and text.

We also found that scores on our collective intelligence tests predicted how well student groups performed on a class project and how well laboratory groups performed on a task where they had to select items that would be most important to their survival if they crash-landed in the desert.[17]

Perhaps an even more important question is whether collective intelligence predicts how well groups will perform on tasks whose outcomes matter in the real world, not just in the laboratory or the classroom. As a first step in this direction, we found some intriguing results in the world of video games. We studied teams in one of the most popular online video games in the world: League of Legends. In this game, players typically form teams of five that work together to capture the opposing team's base, killing monsters and meeting other challenges along the way. Even though this is a simulated combat environment, team members have to cooperate, much as they would in a real-life military setting.

Many of the teams consist of people who play together repeatedly over an extended period of time, and the game gives rankings to these teams—similar to the rankings of expert chess players—based on how well they have fared in their matches.

In cooperation with the game's developers, Riot Games, over 200 of these teams took our collective intelligence test online. As we hoped, we found that the teams' collective intelligence scores were significant predictors of their performance in the game, both at the time they took the test as well as six months later, which indicates that the effect is fairly long-lasting.[18] So just as individual intelligence predicts many kinds of real-world performance for individuals, collective intelligence predicts this kind of real-world performance for groups.

MEASURING COLLECTIVE INTELLIGENCE

Before proceeding, it's worth pausing for a moment to reflect on what we have just seen. The combination of all these studies provides a strong basis for concluding that:

1. Human groups have a kind of collective intelligence that is directly analogous to what is measured by individual intelligence tests.
2. This kind of collective intelligence is what we called general intelligence in chapter 1: the ability to perform well on a wide range of very different tasks.
3. This kind of collective intelligence is affected by
   - the individual intelligence of the group members,
   - the ability of the group members to work well with others (as measured by their social perceptiveness), and
   - the cognitive diversity of the group members.
4. The test my colleagues and I developed for measuring this kind of collective intelligence predicts how well groups will perform
   - on a variety of tasks in laboratories, classrooms, and online games;
   - using face-to-face and online forms of communication; and
   - across different languages and cultures.

These results raise some interesting questions about how collective intelligence tests can be applied. Could we give a short test like ours to a sales team to predict how effective their efforts will be over the coming months? Would the scores of a top management team or a board of directors predict how well they will meet the challenges they face? We don't know the answers to these questions for sure yet, but we expect that they will be yes.

Another interesting possibility involves *increasing* the collective intelligence of a group—making it a more intelligent supermind. We know that individual intelligence is hard to change after a young age, but it seems quite possible to change the intelligence of a group. At a minimum, it certainly seems possible to change a group's intelligence by replacing enough of its members. And in later chapters of this book, we'll see many other ways to increase a group's intelligence.

HOW ELSE COULD WE MEASURE COLLECTIVE INTELLIGENCE?

Though we were pleased with its results, the method my colleagues and I developed for systematically measuring the intelligence of a group has its limits. For one thing, this test is designed for relatively small groups. We are using a version of it as I write this for groups of up to 40 people, and we are very interested in pushing the limits to see how large a group we can test with this method. But we expect that when groups get large enough, some other method of testing will be necessary.

On an even more basic level, in order to use the test we developed, we have to *intervene* in a group, getting its members to do something they wouldn't otherwise do: take the test. For many groups in the real world—such as large companies, markets, and democracies—it would be very difficult indeed to convince everyone in the group to take the time to spend even a few minutes on a special test like this. It would be ideal if instead we could just *observe* a group doing what it ordinarily does and use those observations to accurately estimate the group's intelligence.

Fortunately, there are a number of ways to measure a group's collective intelligence by either intervening or observing and by using either of the definitions of intelligence in chapter 1.

You Can Observe a Lot by Watching

One way to measure a group's specialized intelligence is just to pick a goal and then observe how well a group achieves that goal. For instance, you can measure how well a business achieves its financial goals by

using metrics like profit, productivity, and return on investment. Or you can measure other aspects of a business's performance with metrics like the percentage of revenue that comes from products introduced in the previous five years (a measure of product innovation), how many jobs it creates, how well employees rate it as a place to work, and how often executives at other companies express admiration for it.

You can measure the performance of a society as a whole by using economic metrics like gross domestic product (GDP) or social metrics like crime rates, literacy rates, and quality-of-life surveys. And you might measure the performance of markets with metrics like how liquid the market is, how volatile it is, and how rapidly it adjusts prices based on new information.

In some cases, you can also observe a group's collective general intelligence. To do this, you need to be able to observe the group in enough different situations to see how flexible or adaptable it is.

For example, we often think of the inventor Thomas Edison as a genius, but in an important sense, the company he helped create, General Electric (GE), may have been even more of a genius as an organization. GE is the only company included in the original 1896 Dow Jones Industrial Average that is still included today.[19] To survive and prosper for over a century, in many different industries and many economic environments, GE had to have been extremely flexible and adaptable. Of course, it may well have benefited from good luck and other factors, too, but it certainly seems reasonable to say that GE has had a high level of collective general intelligence.

More recently, Apple has revolutionized at least three whole industries: personal computing, music, and mobile telephones. Many people would attribute much of this success to a single individual, Steve Jobs, but even since Jobs's death, the company has continued to prosper. Whatever the causes of its success in all these industries, I think it's fair to say that Apple has exhibited a great deal of collective general intelligence.

In general, economists have found that there is often a surprising amount of persistence in the performance of companies—high performers tend to stay successful and low performers tend to linger at the bottom of the pack.[20] For example, one study of manufacturing plants in the United States found that 61 percent of plants that were in the top fifth of all plants in terms of productivity in 1972 were still there five years later, and 42 percent were still there after 10 years. At the bottom end of the scale, 38 percent of the plants in the bottom fifth were still there 10 years later.[21] Whole fields of management and economics are attempting to determine what causes these differences, but this stability of performance over time suggests a kind of collective intelligence in these plants, high in some and low in others.

In addition to measuring the same variables over an extended period of time, it is also possible to measure the general intelligence of a group by observing many different variables at once. For instance, the country of Bhutan focuses a great deal of attention on what they call gross national happiness, a measure of societal well-being that combines a wide variety of indicators, such as health, living standards, education, and psychological well-being. If a society does well on all these different measures, then we could say the society has more collective *general* intelligence than if it just does well on one or two.

Sometimes You Have to Do Something

To measure the collective intelligence of a group by intervening, you need to pick some aspect of the group's performance that you can test by seeing how the group responds to your actions. This is often difficult with large groups because you either have to convince everyone in the group to participate in the intervention or you have to have enough resources to change the group's environment.

For instance, if you had huge resources, you could intervene in an organization's environment by putting the organization in all kinds of different situations—maybe starting a competing organization or

giving it greatly discounted prices on some of the raw materials it needs. Watching how the organization responds to such drastic actions could certainly tell you interesting things about the organization's intelligence. But, of course, there are limits to doing such large-scale experiments.

Small-scale interventions can also be useful, however. For instance, many businesses use "mystery shoppers" to evaluate the performance of employees who deal with the public in retail stores, restaurants, and customer-service call centers. The mystery shoppers use an organization's services just as any customer would—eating a hamburger, buying clothes, or calling a telephone help line. The employees of the organization being evaluated think the mystery shoppers are just ordinary customers and presumably treat them as they would anyone else. But unlike typical customers, these mystery shoppers are paid to carefully note and report what kind of service they receive.

Using mystery shoppers is often a good way of evaluating an organization's specialized intelligence for achieving goals, like promptly greeting and politely serving customers. And if interacting with the mystery shoppers requires employees to perform many different kinds of tasks, this could be a (partial) way of measuring the organization's collective general intelligence.

For instance, you could recruit a broad range of mystery shoppers—old and young, male and female, well educated and not, angry and polite—and ask them to call smartphone vendors' customer-service lines with a broad range of problems—hardware problems, software problems, and simple failures to understand the product. If some companies perform consistently well, you could say their customer-service operations are high on collective intelligence, and if others do badly, you could say their collective intelligence is lacking.

It would be interesting to see whether a statistical analysis of these results would reveal a single factor that predicts a substantial amount of the variation in performance across all the types of problems—

similar to what we found in our small working groups. I wouldn't be surprised if that were the case.

So what does all this mean? We now know that applying the concept of intelligence to groups is not just a poetic metaphor. For *general intelligence*—good performance across a wide range of goals—we've seen that intelligence emerges statistically for groups of people just as it does for individuals. And *specialized intelligence*—effective performance on a specific goal—provides a useful way of comparing group performance on a single goal across many different groups.

We also learned some tantalizing hints of what makes some groups smarter than others: just having smart individuals isn't enough. The individuals also need to be able to work together effectively.

Part II

How Can Computers Help Make Superminds Smarter?

Christopher Hookway, "Pragmatism," in *The Stanford Encyclopedia of Philosophy*, https://plato.stanford.edu/archives/sum2016/entries/pragmatism/.

In other words, we are saying that a scientific theory (such as our theory of superminds) includes how the theory is interpreted in practice and whether these interpretations are useful.

This means, from our point of view, that it doesn't really make sense to ask whether a supermind *exists*. What matters is whether a particular interpretation of the world that includes that supermind is *useful*. One could similarly say that theoretical concepts in physics (like force and energy) and in economics (like supply and demand) exist only in the context of how they are interpreted by observers in particular situations and how useful those interpretations are.

4. *Encyclopedia Britannica*, s.v. "intelligence" (cited by Shane Legg and Marcus Hutter, "A Collection of Definitions of Intelligence," technical report no. IDSIA-07-07, IDSIA, Manno, Switzerland, 2007, https://arxiv.org/pdf/0706.3639.pdf); Howard Gardner, *Frames of Mind: Theory of Multiple Intelligences* (New York: Basic Books, 1983).
5. Linda S. Gottfredson, "Mainstream Science on Intelligence: An Editorial with 52 Signatories, History, and Bibliography," *Intelligence* 24, no. 1 (1997): 13–23.

CHAPTER 2

1. The first person to document this was Charles Spearman, and it is arguably one of the most replicated results in all of psychology. See Spearman, "'General Intelligence,' Objectively Determined and Measured," *American Journal of Psychology* 15 (1904): 201–93.
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   Some researchers have proposed that there may be a "general factor" for personality, as there is for intelligence (e.g., Janek Musek, "A General Factor of Personality: Evidence for the Big One in the Five-Factor Model," *Journal of Research in Personality* 41, no. 6 [2007]: 1,213–33), but there is not yet a consensus in the field that this is true. If there comes to be a general consensus that there *is* a general personality factor, the point made in the main text is still valid: it's

certainly not *preordained* that there would be a general factor, either for intelligence or for personality.

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11. An adapted version of this figure was published in Anita Williams Woolley and Thomas W. Malone, "Defend Your Research: What Makes a Team Smarter? More Women," *Harvard Business Review* 89, no. 6 (June 2011): 32–33.

    The collective intelligence scores are normalized with 0 as the average across all scores.
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    The statistics reported here count plants *weighted by their employment numbers*. The more workers plants employed, the more heavily they were weighted.

CHAPTER 3

1. The Google statistics are from Craig Smith, "270 Amazing Google Statistics and Facts (August 2017)," *DMR*, modified August 13, 2017, http://expandedramblings.com/index.php/by-the-numbers-a-gigantic-list-of-google-stats-and-facts/.

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    The photograph is from the above paper and is available online at https://tangible.media.mit.edu/project/soundform, where you can also see a fascinating video of the system in operation. Photograph © Tangible Media Group, MIT Media Lab. Reprinted with permission.

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