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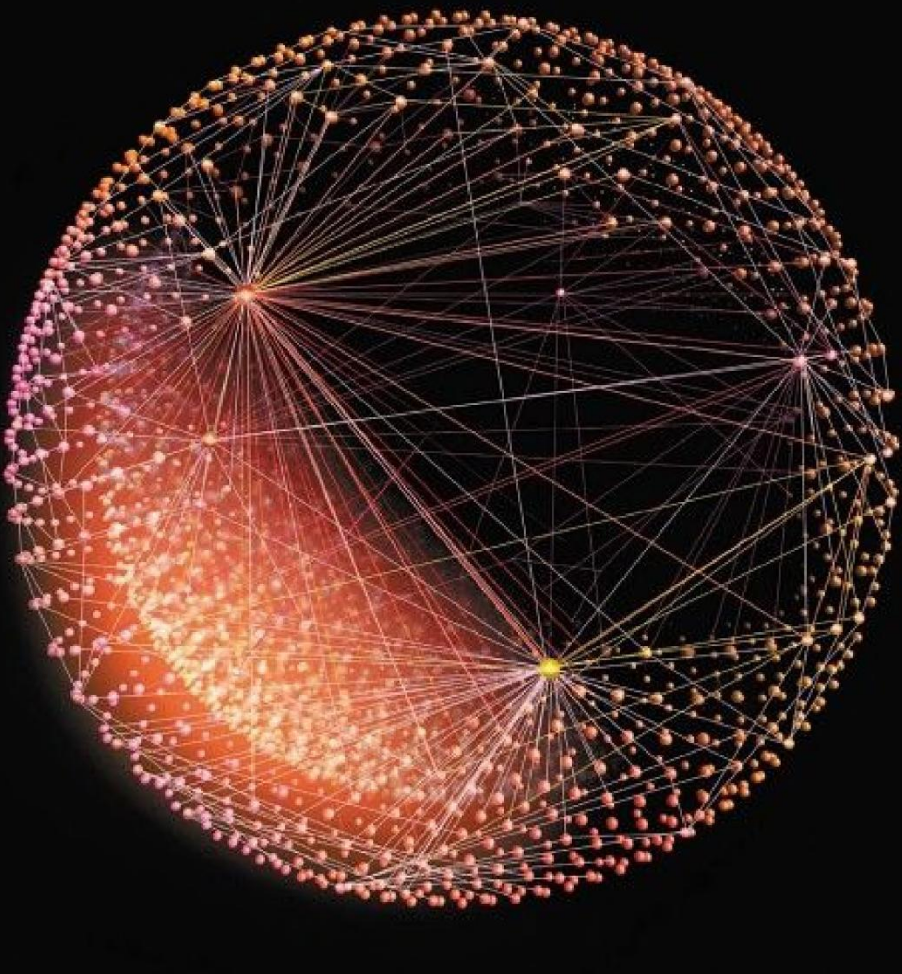
Superminds



THE SURPRISING POWER OF PEOPLE AND COMPUTERS THINKING TOGETHER

THOMAS W. MALONE

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To my parents, Ernest and Virginia Malone

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LITTLE, BROWN SPARK

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Preface

Supermind is an English word that means “a powerful combination of many individual minds.”[1] This book is the story of superminds on our planet. We’ll see that the history of humanity is largely the history of human superminds, of how humans in groups—like hierarchies, communities, markets, and democracies—accomplished things that individual humans could never have done alone.

More important, we’ll see how crucial computers will be for the superminds in our future. For a long time, the most important contribution of computers won’t be artificial intelligence; it will be *hyperconnectivity*—connecting human minds to each other in new ways and at unprecedented scales. But over time, computers will also do more and more of the complex kinds of thinking that only humans do today.

This book is not primarily about how computers will do things people used to do. It’s about how people and computers together will do things that were never possible before. It’s about how human-computer superminds will be smarter than anything our world has ever seen. And it’s about how we can use these new kinds of collective intelligence to help solve some of our most important problems in business, government, and many other parts of society.

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Introduction

In January 2009, Tim Gowers posted a blog entry that would make history. Gowers is a mathematics professor at Cambridge University, and he proves mathematical theorems for a living. If you're like most people, you probably haven't proved a theorem in your life, or at least not since high school geometry class. But the rigorous, logical thinking that is captured in mathematical proofs is at the heart of many of humanity's most important scientific and technological achievements.

Usually, proving theorems requires hours of solitary work, trying to figure out how to do just one piece of one subpart of a complex proof. In 2009, Gowers decided to try a different way of doing things. He wanted to see if a large group of people on the Internet could prove a theorem together.[1]

In a blog post titled "Is Massively Collaborative Mathematics Possible?" Gowers invited anyone on the Internet who was interested to collaborate in proving the theorem.[2] He speculated that this kind of large-scale collaboration might be useful for at least three reasons. First, in many kinds of problem solving (including mathematical proofs), luck often matters. Having many people working on a problem increases the chances that at least one of them will get lucky and have an important idea.

Second, different people know different things. So even if everyone just contributes ideas that seem obvious to them, the group as a whole can bring to bear much more knowledge

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than one or two individuals ever could alone.

Finally, different people think differently. Some are good at coming up with new things to try, others at finding the faults in someone else's ideas, still others at putting together lots of pieces into a coherent new picture. As Gowers summarized, ". . . if a large group of mathematicians could connect their brains efficiently, they could perhaps solve problems very efficiently as well."

The post went on to suggest ground rules to make the collaboration easier, such as keeping discussion respectful and making only bite-sized, focused contributions. In a subsequent post, he gave his group the task of proving the Hales-Jewett theorem, which is part of an esoteric branch of mathematics that has applications in computer science and other fields.

Other mathematicians quickly took up his challenge. Within seven hours after Gowers put up his blog post, the first comment was made by Jozsef Solymosi, a mathematician at the University of British Columbia. Fifteen minutes later, Jason Dyer, a high school mathematics teacher in Arizona, made the next comment. Three minutes after that, another comment came from Terence Tao of UCLA (a winner, like Gowers, of the Fields Medal, the equivalent of a Nobel Prize in mathematics).

By mid-March, the participants had solved the core of the problem. By the end of May, there had been over 1,500 comments in which 39 different people made substantive contributions. And in October, the group submitted the first of several articles describing their results, all of which were attributed to "D. H. J. Polymath," a pseudonym for the whole group.[3]

With all the famous mathematicians involved, you might wonder whether this was really a group project or whether the key work was done by a handful of the most prestigious contributors. It's true that some members of the group contributed much more than others, but a detailed analysis of

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the complete working record of the project shows that almost every one of the 39 substantive participants contributed influential content.[4]

In other words, the Polymath project made history as the first example of a real contribution to mathematics from a loosely organized group of dozens of people on the Internet, many of whom didn't even know each other before the project started.

WHAT'S OLD HERE?

The Polymath project was successful because it used new information technology (IT) to connect people in ways that would never have been possible before. We'll see many more such stories in this book: vast online groups creating an encyclopedia (Wikipedia), solving difficult scientific problems (Foldit), entertaining each other with gossip (Facebook), and responding to humanitarian disasters like hurricanes (Ushahidi).

But in a sense, these digital-age accomplishments are all just examples of one of the oldest stories in the history of humanity. The story goes like this: "There was a problem. Different people worked on different parts of it. Together, the group solved the problem better than any of the individuals could have solved it alone."

In fact, it's not too much of an exaggeration to say that almost *all* our important problems are solved by groups of people rather than by individuals alone. For instance, it may be a common shorthand to say that Steve Jobs created the iPhone, but of course the iPhone was really designed and made by thousands of people all over the world who in turn built upon a vast edifice of technological inventions that came before them. Even making the turkey sandwich I had for lunch today required hundreds of people to grow, transport, and prepare the meat, bread, lettuce, mustard, and other ingredients.

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Compared to "simple" problems like these, trying to solve big societal problems like what to do about climate change, crime, war, poverty, health care, and education is far more complex and requires far more people.

One name for the ability to solve problems well is *intelligence,* and we usually think of intelligence as something that individuals have. But as all these examples make obvious, intelligence—in the sense of solving problems well—is something that groups can have, too.

We'll call the intelligence of groups *collective intelligence,* and this book is the story of that ubiquitous—but often invisible—kind of intelligence. We'll see that it was the collective intelligence of human groups, not the intelligence of individual humans, that first differentiated our human ancestors from all their animal relatives. We'll see that human progress has been mostly a story of what groups of people—not individuals—have accomplished. And we'll see that, over time, information technologies—like writing and the printing press—allowed groups to become dramatically larger and more intelligent.

Most important, we'll see that we are now in the early stages of another dramatic change in collective intelligence, this time enabled by new electronic information technologies. But before imagining the future of collective intelligence, it's useful to think briefly about its past.

A SHORT HISTORY OF COLLECTIVE INTELLIGENCE

Here's a thought experiment: Imagine that you've been transported by a time machine to an African rain forest in the year 45,000 BC. You know everything you know today, but you are all alone. It's hot, humid, and there are lots of strange sounds coming from all around you. If you're lucky, you might be able to survive on fruits, nuts, dead animals left behind by other carnivores, and maybe the occasional fish or grasshopper you manage to catch. But you will be somewhere

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in the middle of the food chain, living in constant fear of predators more powerful than you are.[5] If you stumble upon a hungry lion, for instance, you'll probably end up as his lunch, not the other way around.

That's the situation our distant human ancestors faced, with one major difference: ancient humans weren't alone; they lived in groups. In fact, their brains were hardwired to help them connect with each other. Relative to what a similar animal of their body size would need, humans have by far the largest brains in the animal kingdom. And much of that extra brain volume appears to be devoted to what you might call social intelligence.[6]

If you look at the whole range of primates, including monkeys, apes, and humans, the species whose brains have larger neocortex regions also form larger social groups.[7] And that ability to participate effectively in larger social groups was one of the most important evolutionary advantages of our bigger brains.

Perhaps the most important reason was that groups could protect themselves from predators much more effectively than individuals could.[8] A few people in a group can watch for lions while the others eat mangoes. A lion is also less likely to attack a large group of people in the first place, because he knows that even though he could easily overpower a single human, he would probably lose a fight with a dozen of them. Large groups can also be much more effective as predators themselves. For instance, a group of dozens of people could surround an entire herd of wild horses, chase them into a gorge, and then butcher them all.[9]

Along with their greater social intelligence, early humans also developed much richer ways of communicating than other animals. These human languages could be used not only to coordinate hunting but also to share innovative ideas like how to control fire, how to make bows and arrows, and how to build boats.

Even the Albert Einsteins of fire making—whoever they

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were—wouldn't have made much difference in the world if they had been unable to communicate their techniques to other people. Their innovations were powerful only because their ideas were shared with groups of humans who could apply and develop them further.

By around 30,000 to 70,000 years ago, our human ancestors had bodies and brains that would be indistinguishable from those of modern humans,[10] and they used their abilities to move up in the world. For instance, about 45,000 years ago, humans reached the shores of Australia. Within a few thousand years of their arrival, all but one of the other 24 largest animal species on the continent were extinct.[11]

We don't have any eyewitness reports of the slaughters, but somehow our hunting-and-gathering ancestors had finally reached the top of the food chain. And it was human *groups*—not individual humans—who had become the apex predators.

Agriculture

A similar story was repeated in each of the other two major stages of human development: the Agricultural Revolution and the Industrial Revolution. By about 12,000 years ago, humans began to systematically cultivate wheat, corn, cows, and many other plants and animals. This allowed humans to increase their global population from about 2 million to 600 million by 1700 and to further solidify their dominance over the rest of nature.[12]

But agriculture required much more coordination in large groups than hunting and gathering did. Farmers raised food, but they usually didn't build their own houses by themselves. The carpenters who built houses needed food from the farmers. So people traded what they had for what they needed in markets. As agricultural societies developed, crops and houses also needed protection from invaders and thieves.

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For this, they usually relied on governments ruled by kings and emperors.

None of these achievements could have been made by single humans alone; they all depended on the collective intelligence of human groups and their technologies. Information technologies such as writing were particularly important, since they allowed communication over time and distance that would have otherwise been impossible.

Industry

Starting in the 1700s, division of labor and more complex kinds of coordination went much further as humans developed the factories and machines of the Industrial Age. New technologies coupled with new ways of organizing work allowed vastly increased productivity. For instance, the Scottish economist Adam Smith famously used the example of a pin factory to illustrate the power of division of labor. In this factory, what was formerly the task of a single pin maker was divided into 18 separate tasks, like cutting wires and sharpening points, each done by a different specialized worker. Dividing up the work in this way, among a larger group of people, led to a vast increase in productivity.

In addition to larger versions of markets and governments, the Industrial Age also saw the rise of larger-scale communities—like the world scientific community—which enabled new kinds of interaction. These changes relied on further information technology developments, including the printing press and, eventually, all the forms of electronic communication we know today. The result of all this progress was that world population increased again, this time from 600 million to over 7 billion in only the last 300 years. And human domination over the planet has been so successful that humans themselves are now perhaps the greatest risk to our planet's future.

Once again, these developments weren't just the results of individual human intelligence. Probably no single human

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ever said, “I want human population to increase as much as possible so humans can rule over nature.” Instead these outcomes—for better or for worse—are the result of collectively intelligent *groups* of people and their technologies.

WHO ARE THESE COLLECTIVE INTELLIGENCES?

Thinking about groups of people and computers as a kind of superorganism might seem like just a poetic metaphor. But we’ll see many ways in which this view is quite concrete. It turns out that groups have scientifically measurable properties, just as individual humans do. We’ll see research that shows how the same statistical techniques psychologists use to measure individual intelligence can also be used to measure the intelligence of groups. When we do this, we see that some groups are just smarter than others, and we get a much more precise understanding of why.

We’ll also see research where a colleague and I took a method developed by neuroscientists to measure consciousness and used it to analyze the interaction patterns in groups of people and computers. We found that the groups who were most effective were also the ones whose interaction patterns more closely resembled those in conscious human brains. Does this mean that those groups were really “conscious”? No. But we’ll see a number of reasons why it may not be silly to think of them that way.

And we’ll see, time and again, how a group can have a will of its own that’s different from that of the individuals in the group. It’s no surprise, for instance, to say that companies often do what’s good for their own profits even when that’s not what’s good for their employees. Democratic governments often make choices that many of their citizens don’t like. And markets ruthlessly allocate food, houses, and all kinds of other resources to the people who can pay the most for them, even when that leaves others with almost

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nothing.

So in important senses, these collectively intelligent creatures do have lives of their own, beyond the individuals in them. We'll call these creatures superminds. By *super,* here, we don't necessarily mean "better"; we just mean "more inclusive." In other words, just as a superorganism (like an ant colony) includes other organisms (like individual ants), a supermind (like a company) includes other minds (like those of the people in the company).

Like individual plants and animals, superminds can be categorized into species. We'll get to know four important species especially well:

- *Hierarchies,* where people with authority make decisions others are required to follow. Found in businesses, nonprofit groups, and the operational parts of governments.
- *Democracies,* where decisions are made by voting. Found in governments, clubs, businesses, and many other groups.
- *Markets,* where decisions are made by mutual agreement among trading partners. Found wherever people trade money, goods, and services.
- *Communities,* where decisions are made by informal consensus or shared norms. Found throughout human life, from local neighborhoods to professional groups to national cultures.

All these different types of superminds are constantly interacting: sometimes cooperating, sometimes competing, sometimes destroying each other altogether. When you look at the world this way, you can see that today's news is mostly about the adventures of these different types of superminds.

Here are just a few examples: *Hierarchical* companies, like Apple and Samsung, fight for dominance in the world's smartphone *market.* Liberals and conservatives in the

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American *democracy* argue about whether health-care problems would be better solved by free *markets,* government *hierarchies,* or some combination of the two. The *hierarchical* government of China tries (and mostly fails) to control its stock *market* to prevent a dramatic fall in prices.[13] The US Supreme Court (a somewhat *democratic* part of a *hierarchical* government) rules on Citizens United, which helps large *hierarchical* corporations use their money to influence elections in *democracies*. Local *communities* resist attempts by *hierarchical* governments to control which restrooms transgender people can use.

All these dramas occur in the context of the final type of supermind, the one that encompasses all the rest:

- *Ecosystems,* where decisions are made based on who has the most power and the greatest ability to survive and reproduce. Found wherever there are no overall frameworks for cooperation, such as in the conflicts among the different types of superminds we've just seen.

Like ecosystems in nature, ecosystem superminds operate on the law of the jungle and survival of the fittest. They simply reward what works.

That means that, whether we like it or not, the kinds of individuals and superminds that are present in an ecosystem at any given time are those that were powerful and successful enough in the past to survive or reproduce. This drive for survival is, perhaps, the most important reason why superminds have wills of their own, independent of their members. But we'll also see how—surprisingly often—what's good for the supermind is also good for the individuals in it.

As individuals, we usually have to rely on various kinds of superminds to solve the big problems our world faces. But we can sometimes influence the superminds that already exist or create new superminds to work on problems that are important to us. When we do that, we should place our bets

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on the superminds that are best suited to the problem at hand. And to help do that, we'll examine some of the key advantages and disadvantages of the different species of superminds.

HOW CAN INFORMATION TECHNOLOGY MAKE SUPERMINDS SMARTER?

To think clearly about how IT will change the world, we need to understand the superminds that run the world today. But we also need to understand how new electronic information technologies will profoundly transform these superminds.

Many people today believe that the most important new kind of information technology will be *artificial intelligence* (AI), embodied in robots and other software programs that do smart things only humans could do before. It's certainly true that machines like Amazon's Alexa and Google's self-driving cars are getting smarter, and it's possible that someday, in the future, we will have artificially intelligent machines that are as smart and broadly adaptable as humans.

But most experts estimate that, if this happens, it probably won't be for at least several decades and quite possibly much longer. In the meantime, we will need to use AI in combination with humans who provide whatever skills and general intelligence the machines don't yet have themselves.

For the foreseeable future, therefore, there is another way of using IT that will be even more important than just creating better AI: creating groups of people and computers that, together, are far more *collectively intelligent* than was ever possible before.

While we often overestimate the potential of AI in doing this, I think we often underestimate the potential power of *hyperconnectivity* among the 7 billion or so amazingly powerful information processors called human brains that are already on our planet, not to mention the millions of other computers that don't include AI.

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It's easy to overestimate the potential for AI because it's easy for us to imagine computers as smart as people. We already know what people are like, and our science fiction movies and books are full of stories about smart computers—like R2-D2 in *Star Wars* and the evil Terminator cyborg—who act like the kinds of good and bad people we already know. But it's much harder to create such machines than to imagine them.

On the other hand, we underestimate the potential for hyperconnectivity because it's probably easier to *create* massively connected groups of people and computers than to *imagine* what they could actually do. In fact, the main way we've really used computers so far is to connect people. With e-mail, mobile applications, the web in general, and sites like Facebook, Google, Wikipedia, Netflix, YouTube, Twitter, and many others, we've created the most massively connected groups the world has ever known.

But it's still hard for us to understand what these groups are doing today and even harder to imagine how they will change in the future. One goal of this book is to help you imagine these possibilities—and how they can help us solve our most important problems.

We'll see, for instance, how IT can help us create much larger groups, much more diverse groups, groups that are organized in radically new ways, and groups that combine human and machine intelligence to do things that would never have been possible before. In other words, we will ask one of the core questions of collective intelligence:

How can people and computers be connected so that—collectively—they act more intelligently than any person, group, or computer has ever done before?

HOW CAN SUPERMINDS HELP SOLVE OUR PROBLEMS?

For superminds to be useful, they need to solve problems we

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care about. To illustrate some of these possibilities, we'll see examples of how we could use superminds to solve problems in corporate strategic planning, in dealing with climate change, and in managing the risks of artificial intelligence.

We'll also see that there is an obvious end point for the growing collective intelligence on our planet. It is the "global mind"—the combination of all the people, computers, and other kinds of intelligence on the earth.[14] We'll see that, in some ways, the global mind already exists and is getting smarter all the time. And the book will conclude with some reflections on how we can use our global collective intelligence to make choices that are not just smart but also wise.

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Part I

What Are Superminds?

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Chapter 1

Would You Recognize a Supermind If You Saw It on the Street?

When Adam Smith wrote *The Wealth of Nations,* in 1776, he said that buyers and sellers in a market who do what's best for themselves are often "led by [the] invisible hand" of the market to also do what's best for society. For instance, if you can make more profit for yourself by selling mustard ice cream instead of mocha from your ice cream truck, then that's also the way your business can contribute more economic value to society.[1]

Of course, there are certainly situations where maximizing your own profit isn't what's best for society. But Smith's profound realization was that the human interactions in a market can often lead to good overall outcomes that none of the individuals themselves are trying to achieve. Even if you are just selling mustard ice cream to make more money for yourself, you are also—unwittingly—helping to use all the milk, sugar, human labor, and other resources of your whole society in a way that makes more people happy. Smith called this almost mystical property of markets their "invisible hand."

But markets don't just *have* invisible hands; they *are* invisible minds. In fact, they're superminds. Superminds are all around us all the time, but to see them, you have to know how to look. Some superminds, like companies, are usually

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pretty easy to see. Others, like ecosystems, are much harder.

I sometimes play a little game with myself: How many superminds can I see while walking down the street? When I walk out of my MIT office building and turn left, toward Kendall Square, here are some of the things I might see: a construction crew, a bank, stores and restaurants, and a crowded sidewalk full of pedestrians who don't run into each other.

These are all superminds, but to see them as such, we need to look in a very particular way. And to look in that way, we need a definition of *superminds*. Here's the one we'll use throughout this book:

Supermind—a group of individuals acting together in ways that seem intelligent.

We can also define *collective intelligence* as a property that any supermind has:[2]

Collective intelligence—the result of groups of individuals acting together in ways that seem intelligent.

Every word of the definition of *supermind* is important, so let's take the definition apart, piece by piece.

A Group…

To see a supermind, we have to first identify a *group*. That's often easy. For instance, the construction crew remodeling a building near my office is clearly a group of people. So are the employees in the restaurant where I sometimes buy turkey sandwiches.

Some groups aren't quite so obvious. For instance, the people walking on the sidewalk aren't a group you would ordinarily think much about, but when they do their (mostly)

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unconscious dance to avoid running into each other, they become, for a fleeting moment, a kind of supermind.

Of Individuals…

Our definition says that the parts of a supermind are "individuals," but it doesn't specify exactly what kind of individuals. That means the individual parts of a supermind can be very small or very large, and they can include not just minds but also bodies and other resources the minds control.

For instance, we could say that my neighborhood Starbucks coffee shop is a supermind that includes all the individual employees in the shop as well as the tables, chairs, coffeemakers, and coffee beans. Alternatively, we could say that the whole coffee shop itself is an individual that is part of an even larger supermind: the market that includes all the vendors competing to sell coffee in my neighborhood. Or, at a lower level, we could say that a single Starbucks barista is a kind of supermind whose individual parts include all the neurons in the barista's brain—yes, each person's mind is a supermind on its own.

Acting Together…

So are all groups of individuals superminds? Not necessarily. First, a group is a supermind only if its individuals are *acting* in some way. For instance, you probably wouldn't say that a group of four empty coffee cups just lying on the ground is a supermind.

But just because a group is acting doesn't mean it's a supermind, either; the individuals must be acting *together*. In other words, their activities must be connected in some way. Two unrelated people in two different cities, each groggily making coffee on the same morning, are probably not a supermind. But two Starbucks baristas working together to fill all the customer orders in a single shop would be.

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Now, here's an important point: even though the individuals' actions need to be connected, the individuals in a supermind do *not* need to cooperate with each other or have the same goals. A company called InnoCentive, for instance, has online contests where scientists and technologists compete to solve difficult problems, like how to synthesize a particular chemical compound. But even though the problem solvers are competing with each other—not cooperating—their actions are connected because they are all working on the same problem.

In Ways That Seem Intelligent

Finally, it's not enough just to have a group of individuals performing connected actions. To be a supermind, the group also has to be doing something that *seems intelligent.* You may be surprised to see the word *seem* in this definition because it sounds a little wishy-washy. But it is critical because there is an important sense in which superminds—like beauty—exist only in the eye of the beholder.

In fact, all the elements of a supermind—not just intelligence but also individuals, groups, actions, and connections—have to be identified by an observer.[3] And different observers can analyze the same situation in different ways. For instance, if you say that each Starbucks shop is itself a supermind, and I say that each one is part of a larger supermind, we can both be right, but we will get different insights about the situation.

The role of the observer is especially critical in judging *intelligence,* because this is always, to some degree, a subjective judgment. For instance, whether you think an entity is intelligent depends, crucially, on what goals you think the entity is trying to achieve. When students take multiple-choice intelligence tests, we assume they are trying to give the answers the test designers consider correct. But I can easily imagine a girl I knew in high school, who was very

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smart—and very rebellious—taking such a test and deciding to fill in the circles on the multiple-choice answer sheet in the pattern of a pretty flower. If she did that, the usual scoring method for the test wouldn't measure her high intelligence at all!

In order to assess an entity's intelligence, then, an observer always has to make assumptions about the entity's goals. And when evaluating a group's intelligence, it is often useful to consider overall goals for the group that are important to the observer, even if none of the individuals in the group has those goals.

For instance, each of the ice cream truck owners in a city has a different goal: most of them probably want to make as much money as possible for themselves and to have fewer permits issued to their competitors. But if your job for the city's parks department includes determining how many ice cream truck permits to issue for the city parks, you might want to survey park visitors about whether they feel there is enough good-tasting ice cream available at reasonable prices. These surveys would be one way of evaluating the overall intelligence of the supermind that includes all the ice cream trucks in the park.

Finally, it's important to note that we can consider a group a supermind if we observe the group *trying* to do something intelligent, even if it isn't succeeding. For instance, you might well consider a software start-up company a supermind, even if, after all the group's intelligent efforts, its product fails and the company goes out of business.

WHAT IS INTELLIGENCE?

But what do we mean by *intelligence* in the first place? This term is a notoriously slippery one, and different people have defined it in many different ways.[4] For example, the *Encyclopaedia Britannica* defines it as "the ability to adapt effectively to the environment." The cognitive psychologist

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Howard Gardner defines it as “the ability to solve problems, or to create products, that are valued within one or more cultural settings.” And a group of 52 leading psychologists summarized the mainstream view within the field like this:

> Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings—“catching on,” “making sense” of things, or “figuring out” what to do.[5]

For our purposes in this book, we will define two kinds of intelligence, each of which is useful for different purposes. The first kind is *specialized intelligence:*

Specialized intelligence—the ability to achieve specific goals effectively in a given environment.

This definition is equivalent to the definitions above from the *Encyclopaedia Britannica* and Howard Gardner. Basically, it means that an intelligent entity will do whatever is most likely to help it achieve its goals, based on everything it knows. Stated even more simply, specialized intelligence is just “effectiveness” at achieving specific goals. In this sense, then, specialized collective intelligence is just “group effectiveness,” and a supermind is an effective group.

Our second kind of intelligence is more broadly useful and often more interesting:

General intelligence—the ability to achieve a wide range of

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different goals effectively in different environments.

This definition is similar to the definition above from the group of 52 psychologists, and this is the kind of intelligence that intelligence tests measure. Intelligence tests don't just measure your ability to do a few specific tasks effectively. The tasks on these tests are carefully selected so that they predict your ability to do a very wide range of other tasks beyond those you're being specifically tested on.

For instance, people who get high scores on intelligence tests are—on average—better than others at learning to read, write, do arithmetic, and solve many other kinds of problems. Of course, it's quite possible for someone who has been doing a specific task for a long time—like repairing Honda cars—to be much better at that task than someone who is more intelligent but has never opened the hood of a Honda. But in general, people who are more intelligent are better at learning new things quickly and adapting rapidly to new environments.

We'll see much more about this definition in the next chapter, but for now the key point is that the definition of general intelligence requires an intelligent actor to be not just good at a specific kind of task but also good at learning how to do a wide range of tasks. In short, this definition of intelligence means roughly the same thing as "versatility" or "adaptability." In this sense, then, general collective intelligence means "group versatility" or "group adaptability."

The difference between specialized intelligence and general intelligence helps clarify the difference between the abilities of today's computers and the abilities of people. Some of today's artificially intelligent computers are far smarter than people in terms of specialized intelligence. For instance, they can perform specific tasks, like playing chess or Jeopardy, better than humans. But no matter how good they are at these specific tasks, none of today's computers is

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anywhere close to having the level of general intelligence that any normal human five-year-old does. No single computer today, for example, can converse sensibly about the vast number of topics an ordinary five-year-old can, not to mention the fact that the same child can also walk, pick up weirdly shaped objects, and recognize when people are happy, sad, or angry.

So as I walk down the street near my office—or anywhere else—there are lots of superminds to be seen. To recognize them, I need to identify four things: (1) a group of individuals, (2) some actions these individuals 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.

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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

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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

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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

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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

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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

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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

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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

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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 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

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the other choices, you could never lose points, regardless of what the other group members did.

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

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

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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.

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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

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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

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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.

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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.

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