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Collective intelligence, democracy, and governance

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This handbook aims to synthesize key ideas from the **emerging field of collective intelligence** and place them more clearly in the context of public problem-solving. Groups, under certain conditions, can solve problems and accomplish complex tasks in a way that surpasses the abilities of any individual within them. How can we understand this phenomenon, and what are the conditions necessary to bring it about?

The notion of collective intelligence is polysemic, informed by disciplines as diverse as conflict mediation and computer science. This poses challenges as well as opportunities: Though our notions of cognition, collaboration, and citizen engagement are enriched by studies from a diversity of fields, there is also a risk that these fields talk past one another or that crucial links go unexplored.

Our intent in this handbook of collective intelligence for democracy and governance is to add clarity and coherence to the field of collective intelligence as it matures into a scientific discipline in its own right. The increased salience of the field in recent decades may be correlated with some of the key trends of our time, notably the revolution in digital technology that has enabled new modes of large-scale collaboration (McNutt et al., 2016), the growing complexity and interdependence of public problems (Noveck, 2015), and a crisis of trust in public institutions that has inspired a "wave" of deliberative experiments worldwide (OECD, 2020).

The present moment has been described as a transition from **the fourth industrial revolution**, characterized by the increasing automation and interconnection of economic functions (Brynjolfsson and McAfee, 2014), to an upcoming **fifth industrial revolution** centered on the need to make organizations and societies more intelligent (Noble, Mende, Grewal et al., 2022). Authors have referred to this new technological paradigm as the "**deep minds era**," in which deep knowledge is harnessed, and **collective consciousness** created, from both humans and machines (cf. Friedman, 2019). See further Part 7 of the Handbook on Collective Intelligence, Technology and Collective Consciousness.

This fifth industrial revolution encompasses the notion of harmonious human–machine collaborations with a specific focus on the well-being of multiple stakeholders (i.e., society, companies, employees, and customers). For some, this "deep minds era" holds the promise of a revolution in how we learn and think through the leveraging of human–machine

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collaborations – a period of collective thinking and learning, harnessing unconscious and tacit knowledge of humans facilitated by AI and deep learning, yielding better solutions to society's complex problems.

In policymaking, a shift is possible from the old paradigm of **centralized decision-making** and a narrow understanding of expertise, to more **decentralized forms of knowledge creation** where humans and machines think together in symbiosis. A key question for policymakers could become, "**How can the combination of human and machine intelligence help us go further than we've ever gone in serving the public**"? (Friedman, 2019) In this context, we offer an overview of definitions and typologies of the field of collective intelligence as it stands today. In doing so, we hope to clarify and explain some of the most important concepts at the foundation of this handbook, noting some of the emerging trends in politics and governance that could pave the way for a more inclusive and smarter paradigm.

This overview is structured into four sections. The first section presents definitions of collective intelligence offered by some of the field's pioneers. The second section takes a deeper look into the conceptual frameworks around human intelligence and how these have been applied to groups in different contexts, noting especially the key factors that have been identified as reinforcing or hindering group performance. The third section examines key concepts in democratic innovation that will be touchstones for many of the cases in this handbook. The final section looks at the frontier of human and machine intelligence, a burgeoning area of interest for researchers and practitioners alike.

We do not aim here to be encyclopedic in our presentation of these definitions, but rather to provide a structured overview of notions that may be of greatest interest to the reader.

Seminal definitions of collective intelligence

Pre-1970

The notion of collective intelligence has important antecedents prior to the popularization of the term itself in the 1980s. Many of these concepts are explored in greater detail in chapter 1 of this handbook.

Theoretical arguments for collective intelligence may originate with the ancient Greek philosopher Protagoras, who according to Plato argued that ***politikē technē***, or the expertise to govern a city, was found not in exceptional individuals but in the community as a whole (Kenney, 2008; Landemore, 2013). In the third book of his *Politics*, Aristotle makes more detailed arguments for the governing capacity of large groups, who "though not excellent as individuals, nevertheless can, when they have come together, be better than the few best people, not individually but collectively, just as feasts to which many contribute are better than feasts provided at one person's expense" (3.11). Waldron (1995) more recently revived interest in what he characterized as Aristotle's "doctrine from the wisdom of the multitude." An important non-Western antecedent is found in the doctrines of the Chinese philosopher Confucius, whose ethical ideal of *ren* has been translated as "**co-humanity**" (Puett and Gross-Loh, 2016).

In the common era, political and philosophical touchstones for CI include Machiavelli's arguments for the superior wisdom of the masses when compared with single rulers (Mansfield, 2001); Ibn Khaldun's notion of *'asabiyah* or "group spirit" as the key driver of political change (Irwin, 2018); Spinoza's argument that aggregated judgments are more likely to produce rational outcomes the larger the body of citizens (Tractatus Theologico-Politicus 16.16; see Landemore, 2013); J. S. Mill's arguments on the superior power of representative

government to create a framework for diverse ideas to compete, thereby advancing the knowledge available to all (Mill, 1865; Gray, 2013); and Dewey's (1927) argument that on any public issue, the cognitive capacities of the concerned population are essential to identifying and defining the problem before technical expertise can be applied.

Two antecedents to the field of CI deserve special mention. In the 18th century, the mathematician and statesman **Nicolas de Condorcet** was the first to offer a mathematical justification of the arguments for aggregative intelligence prefigured by Aristotle, Machiavelli, and Spinoza. His "**Jury Theorem**" (1785) proposes that under certain conditions, the majority opinion of a group whose individuals have only slightly better-than-average accuracy approaches a probability of 1 as the size of the group increases. Condorcet has the distinction of being a democratic theorist who attempted to put his ideas into practice, as co-author of the Girondin proposal for the French constitution in 1792, which emphasized the role of participatory local assemblies, a free press, and mass public education (Miller, 2018). The second is **Francis Galton**, an English polymath whose 1907 article on a crowd's accurate prediction of the weight of an ox is perhaps the most cited early reference in the field (see the discussion in chapter 1 of this handbook).[1]

It should be noted that despite their foundational importance to the concepts in this handbook, the term "collective intelligence" is not found in any abovementioned text. Mulgan (2018) notes that the phrase "appears to have first been used in the nineteenth century by a doctor, Robert Graves, referring to the advancing state of medical knowledge, and separately by a political philosopher, John Pumroy, to refer to popular sovereignty." If true, it is noteworthy that these two early references correspond to two principal forms of collective intelligence discussed herein: cumulative collective intelligence (the body of shared knowledge that accumulates within a given society), and the synchronous collective intelligence of a group engaged in a common task at a given time.

1970 to 2010

It was in the information age that "collective intelligence" as such became an object of study. Describing the goal of a digital conferencing system, Hiltz and Turoff (1978) defined collective intelligence as "a **collective decision capability** [that is] at least as good as or better than any single member of the group." Douglas Engelbart, whose team at Stanford Research Institute invented the mouse, hyperlink, video conferencing, and document co-drafting (among much else), coined the term "**collective IQ**" to refer to the potential of computers to enable large groups to solve increasingly complex tasks (Engelbart, 1995).

Kierstead (1974) may have been the first to use the term "collective intelligence" in the context of **democratic theory**. In his doctoral thesis, he used the term to characterize Dewey's theories on civic participation as a form of experiential education for citizens (often called "learning by doing"). Greater and higher-quality civic participation, in the Deweyan view, is not merely a form of consultation, but is rather a mechanism for society to develop its intelligence at the largest scale. Though theorists such as Habermas (1985), Mansbridge (1983), and Cohen (1986) would develop a range of arguments for more deliberative and inclusive forms of democracy from the 1970s, until Landemore and Elster (2012) these theorists largely did not refer to "collective intelligence" as such, nor engage closely with the field of human–computer interaction (for discussion, see Spada, chapter 5). Nevertheless, arguments developed in favor of participatory and deliberative democracy in this period – including the benefits to society from diversifying its store of ideas and combining them in new ways – remain important touchstones for the field of CI as it relates to democracy and governance.

Lévy's book *Collective Intelligence: Mankind's Emerging World in Cyberspace* (1997) theorized collective intelligence principally in the context of the internet and its possibilities. His definition of collective intelligence as "an intelligence distributed everywhere and constantly valorized," whose goal is "the recognition and mutual enrichment of people," carried Engelbart's optimism to near-utopian heights.

The text that introduced the idea of collective intelligence to a global audience was Surowiecki's *The Wisdom of Crowds: Why the Many Are Smarter than the Few and How Collective Wisdom Shapes Businesses, Economies, Societies and Nations* (2004). He centers his book on "a simple but powerful truth…: under the right circumstances, groups are remarkably intelligent, and are often smarter than the smartest people in them." Opening his book with the Galton study, and using illustrations from business, prediction markets, and deliberative democracy, Surowiecki proposes a concise list of key drivers of group intelligence: independence of judgment, decentralized information, diversity of opinion, a fair and accurate aggregation mechanism, and shared trust. While digital platforms feature in Surowiecki's account, he does not qualify collective intelligence, like Lévy, as a novel phenomenon of the internet age. Collective intelligence, for Surowiecki, is deeply ingrained in human societies that various forms of organization can hinder or unlock.

Sunstein (2006) in *Infotopia: How Many Minds Produce Knowledge* explores the human potential to pool information and to use it for public good. He gives special attention to the emergence of wikis, open-source software, and prediction markets, highlighting the astonishing productivity and accuracy of these tools while also pointing to the risks of group polarization and "echo chambers" that often emerge online. Howe (2006) coined the term "crowdsourcing" in his article for *Wired* entitled "The rise of crowdsourcing". According to Howe, crowdsourcing is an act whereby an organization or institution takes a function which was once performed by employees and outsources them to a broader network, generally in the form of an open call.

2010 to present

Landemore and Elster's co-edited volume **Collective Wisdom**[2] (2012) was a watershed moment that brought democratic theorists, cognitive scientists, and technologists into a common conversation on the dynamics of group intelligence. Enriched by the pioneering work of Hong and Page (2004) on cognitive diversity, the authors argue that CI should be understood not merely as the intensification or amplification of individual intelligence, but as "an emergent phenomenon that cannot be traced simply to individual minds, but rather to the interaction between those minds and between them and their constructed environment." Landemore's *Democratic Reason: Politics, Collective Intelligence, and the Rule of the Many* (2013) develops these arguments in the context of democratic innovation and gives a genealogy linking Protagoras, Aristotle, Condorcet, Dewey, and others to contemporary developments in the field.

In their *Handbook of Collective Intelligence* (2015), Malone and Bernstein survey the research frontiers of the emerging field of CI, drawing principally from the disciplines of computer science, biology, economics, and psychology. They present a stripped-down definition of collective intelligence: "groups of individuals acting collectively in ways that seem intelligent." Though noting that this phenomenon has existed "for a very long time," they posit that with the rise of digital technologies, a "**new kind of collective intelligence has emerged**."

In her book *Smart Citizens, Smarter State: The Technologies of Expertise and the Future of Governing*, Noveck (2015) argues for a transformation in governance "that takes seriously the

capacity, intelligence, and expertise of all people and forges institutions that know how to marshal and use that capital." Drawing on her own expertise in the Obama Administration creating open innovation challenges, she proposes "crowdlaw" – organized citizen input at all stages of policymaking – as a way both to address society's most complex problems and to ease the "pandemic of distrust" in government.

The field of cultural evolution has added an important perspective on group intelligence: how knowledge can accumulate over many generations. In *The Secret of Our Success: How Culture Is Driving Human Evolution, Domesticating Our Species and Making Us Smarter* (2015), Henrich observes that

> the striking technologies that characterize our species, from the kayaks and compound bows used by hunter-gatherers to the antibiotics and airplanes of the modern world, emerge not from singular geniuses but from the flow and recombination of ideas, practices, lucky errors and chance insights among interconnected minds and across generations.

Just as the "**collective brain**" of a society can augment its intelligence through greater size, interconnection of group members, and sociality (the motivation of any member to share what she knows), Henrich argues, so too can it lose its intelligence if those conditions go unmet.

Mulgan's *Big Mind: How Collective Intelligence Can Change Our World* (2017) synthesizes work from several domains to propose new conceptual frameworks for the field. He defines collective intelligence as "the capacity of groups to make good decisions – to choose what to do, and who to do it with – through a combination of human and machine capabilities." The type of tasks taken on by that group – observing, prediction, generating ideas, and so on – are called in this handbook its "core functions" (see Mulgan, chapter 4), and "functional capabilities" in the earlier text. Those functions are supported in turn by collective intelligence "infrastructures" (tools, objects, common rules, and institutions) and organizational models that can favor or hinder group integration and learning. Mulgan concludes that solving 21st-century problems will require a new generation with skills in "intelligence design," creating "assemblies" of the above elements adapted to the needs of a given problem.

Andersen and Hallin's (2017) book on "Global strategic responsiveness: Exploiting frontline information in the adaptive multinational enterprise" presents tools to help design responsive and intelligent organizations. The book provides models to inform strategic decisions through the crowdsourcing of **frontline information**. The subsequent "A network of brains" (Andersen, Hallin and Fredens, 2018) presents ideas on how organizations can draw on distributed knowledge to make better decisions and more quickly adapt to a changing environment.

In his ***Superminds*** (2018), Malone – founder of the MIT Center for Collective Intelligence – suggests that human and artificial intelligence (AI) will be combined in increasingly complex ways, yielding exponentially more powerful forms of cognition.

As part of Britain's public innovation agency, the NESTA Centre for Collective Intelligence Design (co-founded by Mulgan) supports the use of collective intelligence on complex social problems. They currently define collective intelligence as something "created when people work together, often with the help of technology, to mobilize a wider range of information, ideas and insights to address a social challenge" (Peach et al., 2019). The range of disciplines seeking to understand the mechanisms of collective intelligence has thus

become vastly richer, with important insights from computer science, information science, political science, management, mathematics, social psychology and neuroscience.[3]

Foundational concepts of collective intelligence

The definition of human intelligence is continuously evolving. Definitions have ranged from a mental quality that consists of abilities to learn from experience, to the ability to adapt to new situations, understand and handle abstract concepts, and to the use of knowledge to create new knowledge and to be able to manipulate one's environment (Britannica, 2022). Broadly speaking, human intelligence can be understood as a toolkit of intellectual capabilities marked by complex problem-solving behaviors and high levels of self-awareness (Tirri and Nokelainen, 2011). Correlations have been posited between higher levels of intelligence and better life outcomes (Brown and Wai, 2021).

What is individual intelligence (and how do we measure it)?

Over the past century, psychologists have made progress in defining and systematically measuring general intelligence. Spearman (1904) found that intelligence can be measured using different kinds of IQ tests adapting a variety of test tasks in experiments. **The "*g* factor**," also referred to as the general intelligence, general mental ability, or general intelligence factor, is a variable that summarizes positive correlations among different cognitive tasks, reflecting the fact that an individual's performance on one type of cognitive task tends to correlate with performance on others. Spearman labeled this correlative trend a "positive manifold" (Spearman, 1904).

Over the last century, scholars have emphasized different aspects of the intelligence construct. For example, in a 1921 symposium, the American psychologist Terman stressed the ability to **think abstractly, while his colleague Torndike emphasized learning and the ability to give good responses to questions**. Later in the century, a variety of other tests were introduced to probe intelligence from different angles, starting notably with the Torrance tests of creative thinking in the 1950s (Runco et al., 2010) to the more recent Cognitive Reflection Test (CRT), which seeks to measure people's ability to override instinctive responses in order to arrive at the correct answer (Frederick, 2005).

Psychologists have generally agreed that **human adaptation** to the environment is the key to understanding both what intelligence is and what it does (e.g. Greenspan, 1979). Such adaptation may occur in a variety of settings: a citizen learns to access an online public consultation and respond to questions of relevance to her community; a physician treating a patient with unfamiliar symptoms learns about the underlying disease; or a member of a creative crowd reworks an online painting to convey a more coherent impression. For the most part, adaptation involves changing one's own behaviors and strategies to cope more effectively with the environment, but it can also mean changing the environment or finding an entirely new one.

For the purposes of this handbook, we follow Mulgan (2018) in conceiving of intelligence "not just as a matter of extraordinary memory or processing speeds," but rather as "our ability to use our brains to know which path to take, who to trust, and what to do or not do." As Mulgan notes, the Latin roots of the word – *inter*, "between," and *legere*, "to choose or gather"– suggest the essence of the idea of intelligence as **a "gathering together" of information from our environment and experience**, combining diverse cognitive capacities in a manner that enables us to make choices favorable to our survival.

Types of individual knowledge

Individual intelligence can be aided by **explicit (codifiable)** and **tacit (unconscious) knowledge** (see the introduction to Part 3 for a review).

Explicit knowledge is defined as conscious knowledge that is independent of the individual and contains identifiable facts, information, procedures, and routines, which can be codified, processed, stored, and easily exchanged. Explicit knowledge (facts, procedures, and routines) can be articulated, codified, stored, and processed (Nonaka, 1991).

Tacit knowledge is defined as subconscious knowledge that is within the individual and contains habits, experience, skills, emotions, intuition, sensing, and intuition, which is difficult to codify and make explicit and communicate to others (e.g., how to drive a car). The term "tacit knowledge" was introduced in 1958 by Michael E. Polanyi. He later characterized tacit knowledge with the maxim "we can know more than we can tell," referring to the difficulty in systematically expressing much of what we know, such as how to ride a bicycle (Polanyi, 1966). Such tacit and unconscious processes generate intuitive thoughts that are "the end product of an implicit learning experience" (Reber, 1989). In other words, intuitive processing and judgments are the product of one's tacit knowledge stock, which is stored subconsciously, and intuition and tacit knowledge are thus interconnected in creating judgments (Shirley and Langan-Fox, 1996).

Embodied knowledge is defined as the constant flow of senses, actions, and experiences that encodes how the bodies should act without representation in a given situation. All together our bodies acquire the knowledge that resides within the body or is gained through the body (Nagatomo, 1992), when senses, emotions, experiences, and action flow within an individual, grasping and embodying in the individual cognition, knowing how to act without thinking, for example, using the motor skills necessary for the given circumstances, such as moving fingers while typing, or pedaling while riding the bike (Tanaka, 2011). As Tanaka (2011) describes, embodied knowledge is visible during the performance and has no "verbal explanation," as our bodies act, and act competently, prior to our conscious awareness.

Types of organizational knowledge

Distributed knowledge is knowledge dispersed within a group, organization, network, or community. Distributed knowledge may take the form of tacit, explicit, or embodied knowledge shared among and across the members. According to Ågotnes and Wang (2017), this is the segmented knowledge dispersed across a group. When combined, these segments comprise the full shared knowledge of the group, just as the pieces of a puzzle together create a full picture. Critically, individual segments may have only partial knowledge of the others, limiting the potential for knowledge to be combined in ways that benefit the whole. Distributed knowledge is typically "situated," meaning that it is dependent on the contextual understanding, culture, language, time, location, and other variables that make up our individual knowledge, subject to our own mental models (Haraway, 1988). Collective intelligence, therefore, may emerge from distributed knowledge when agents aggregate what they know to solve a common challenge. Knowledge can also be distributed not only among many minds, but different **cognitive artifacts** – such as language, books, tools, and maps – capture information and help tackle complex tasks.

Collective intelligence emerges not only when distributed knowledge is brought together to solve a problem, but also when a symbiotic relationship is created between distributed

and centralized knowledge. Andersen and Hallin (2017) argue that sustainable organizational performance is achieved when decision-makers coordinate processes anchored in emerging opportunities from the frontline (e.g., citizens) with forward-looking activities by decision-makers (e.g., policymakers). The fast and emergent processes performed by actors at the frontline observe and respond to environmental stimuli that form distributed knowledge and the slow processes initiated by decision-makers interpret events and reasons about updated actions. Current insights from the fast response processes can be aggregated systematically from the distributed knowledge and fed into the slow process of reasoning for policymaking. When the fast and slow processes interact, they form a dynamic system that adapts organizational activities to changing conditions and the problems that emerge from them.

Collective intelligence

For the purposes of this book, we define collective intelligence as **the capacity of groups to outperform individuals in problem-solving, innovation, prediction, creativity, and other cognitive tasks**. This capacity, in turn, can be derived from the various kinds of knowledge listed above: explicit, tacit, centralized, distributed, or embodied.

A recent empirical study of a collective intelligence "*c* factor" shows that a group's general ability to perform a wide range of tasks expands the areas of human intelligence research applying similar methods and concepts to groups (Woolley et al., 2010). The "*c* factor" they identify adopts a similar definition and methodology as the psychometric approach of general individual intelligence **"*g* factor."** These studies have shown that a **"**c factor" can explain between-group differences in performance as well as other potential causes such as task structure or group composition (Woolley, Aggarwal, and Malone, 2015). The original 2010 study demonstrates that the smartest groups, controlling for individual intelligence, were distinguished by three factors: by the average social sensitivity of group members, the equality in distribution of conversational turn-taking, and the proportion of females in the group (Woolley et al., 2010).

The **wisdom of crowds**, while often used synonymously with collective intelligence, most typically describes a specific instance of synchronous CI (further explained in the next section) in which the predictions or estimations of a crowd outperform its average (or, alternatively, its best) member. Such was the case in the famous Galton experiment with which Surowiecki (2005) opens his work. Condorcet's Jury Theorem (1785) is often cited as the first mathematical demonstration of crowd wisdom; the three conditions he gave for the effect are described in the section above. A more recent contribution to the understanding of this effect is Hong and Page's (2004) Diversity theorem, sometimes called "Diversity Beats Ability." It proposes that for any group, the squared error of a collective prediction equals the squared error of the average member minus the diversity of predictions. The theorem predicts the counterintuitive outcome that a crowd can be made collectively wiser by adding members who are individually *less* accurate than the average as long as their contributions increase the overall diversity of ideas in the pool. This perhaps unexpected benefit of cognitive diversity has since been demonstrated empirically (see Servan-Schreiber chapter 32 in this handbook).

Do other species demonstrate collective intelligence? Opinions are divided. Some have asserted that intelligence is a uniquely human quality, in that only our species can manipulate symbols and recombine ideas in a manner that is deliberate and self-aware (Pinker, 2010). Others point to a range of collective behaviors in terms of **swarm intelligence**

whose highly complex outcomes far surpass the ability of individual members. Such behaviors include the capacity of honeybee colonies to select among alternative hive sites (Seeley and Buhrman, 1999); army ants to construct bridges (Reid et al., 2015); and birds to synchronize migration choices over great distances (Sliwa, 2021). Regardless of whether these animal and swarm behaviors rise to the level of intelligence, they are impressive demonstrations of the powerful capacities that emerge from the efforts of seemingly powerless individuals. Humans are indisputably unique in their ability to create **cumulative culture**, that is, for each generation to make deliberate improvements in the tools and processes they inherit (Henrich, 2015). This special capacity, which Henrich links to physiological and social changes that followed the domestication of fire by early hominids, has turned culture into a "second track" of our evolution alongside the genetic selection that produced the behaviors described above.

The term "collective wisdom" has been used somewhat loosely in the literature to date. It can suggest a depth and durability of intelligence that goes beyond the capacities of a single group on a single problem (to which the phrase "wisdom of crowds" is commonly applied). In their co-edited volume on **collective wisdom**, Landemore and Elster explain that they privilege the term "wisdom" over "intelligence" because the former is "a more encompassing notion than the apparently more technical concept of intelligence." Wisdom also "evokes a larger temporal horizon," suggesting "the intelligence of a collective extending not just through space (including many people) but through time as well (including many generations)..." Finally, Landemore and Elster suggest that the term wisdom goes beyond matters of formal correctness or verifiable fact to include moral or political questions on which there may not be a universally satisfactory answer.

Taking a holistic approach to highly complex moral problems, based on a wealth of diverse experience, are elements that have characterized wisdom in many human cultures (Grossman, 2017; see the discussion in Baum case, chapter 27 in this handbook). Alternatively, Sternberg (2000) suggests that wisdom can be understood as a subset of intelligence related to solving practical problems, as opposed to theoretical ones. For the purposes of this handbook, then, we understand intelligence to refer to the ability to solve a given problem or accomplish a given task, drawing on the accumulated culture and diverse abilities mentioned above. In complementary fashion, wisdom can be understood as the sedimentation of learnings from many instances of intelligence over time, its successes and failures, our own and those of our community and ancestors. For our purposes, collective intelligence thus describes the capacity to solve a public problem currently facing us, and collective wisdom the treasury of past intelligence, especially of a moral or ethical kind, that we may draw upon.

How collective intelligence works

A potentially important distinction arises regarding the different time scales on which collective intelligence can operate.

Tomasello (2019) proposes that the knowledge-sharing functions of human culture can be seen along two dimensions: a **"coordinative dimension"** of culture, including the range of cooperative structures and conventions we use to collaborate synchronously (i.e., focusing on the same problem or task at the same time); and what he calls a **"transmittive dimension"** of culture, in which members of a group pass along skills and knowledge to its junior members, potentially creating a "ratchet effect" where each generation improves on the technologies and institutions of all previous ones. This "ratchet effect" is a main

feature of Muthukrishna and Henrich's (2016) arguments concerning the "collective brain" of a society that each member draws from and to which each may contribute (see also Vale et al., 2012).

Within this "coordinative dimension" an additional nuance can be applied: Members of a group can collaborate on the same problem or task asynchronously, that is, make a sequence of contributions that are combined toward a single main goal. Mapping the human genome, for example, was a highly complex task requiring the intelligence of a large community to operate, some performing actions synchronously (such as a laboratory team conducting a single study), and others asynchronously (several teams adding pieces of information regarding a certain gene). And each of these teams benefit from the transmission of a huge store of accumulated scientific knowledge from previous generations, transmitted via peer-reviewed journals, embodied in laboratory equipment, and so on.

We can see, therefore, how collective intelligence operates in three modes:

1. **Synchronous** collective intelligence, where members of a group interact to solve a problem or accomplish a task, or where members make individual contributions at the same time[4] and those contributions are aggregated (e.g., a prediction contest).
2. **Asynchronous** collective intelligence, where members of a group make a sequence of contributions for a given problem or task (e.g., 700 attendees making guesses about the weight of an ox over the course of a day).
3. **Cumulative** collective intelligence, where members of a group create and transmit knowledge across time (e.g., how to build a compound bow, treat an illness, or manage a project spreadsheet).

In the context of democracy and governance, as in all forms of human collaboration, these three modes of collective intelligence work in combination. In preparing their recommendations, for instance, the 99 members of the Irish Constitutional Assembly of 2012–2014 thought together synchronously (during meetings in which members proposed and recombined their ideas); they thought together asynchronously (the input for their work were eight agenda items established by the Oireachtas Éireann, Ireland's bicameral parliament), and benefitted in their work from the accumulated expertise of civil servants, advocates, and academics. Among the results was a national referendum legalizing same-sex marriage (a synchronous moment of decision), which many hailed as a breakthrough after decades of political stalemate (Elkink et al., 2017).

As described above, synchronous collective intelligence can be produced whether or not the members of a group know one another or interact in any way. Thus, another potentially useful distinction arises.

On the one hand are **aggregative methods** of collective intelligence, in which individuals contribute independently to a common task and the sum total of these contributions produces a level of accuracy or performance that surpasses the average (or even the best) individual. Such was the case in the Galton experiment, in which 787 attendees of the county fair produced a collective estimate of the ox's weight far more accurate than the average individual guess, without knowing or interacting with one another. Since the scale and diversity of the crowd are two principal factors in producing this "wisdom of crowds," digital technologies like prediction markets often draw upon aggregative methods to produce intelligent outcomes.[5]

On the other hand are **deliberative (or synergistic) methods** of collective intelligence whose effectiveness depends on the quality of interactions among the members of a group.

The Irish Constitutional Assembly of 2012–2014 presents an exemplary case: Of the 99 members, 66 were selected randomly from the general population, balanced by age, gender, and region, and 33 were members of parliament selected across various parties. As Farrell and Suiter (2019) explain, citizens' assemblies have been able to produce groundbreaking policy outcomes because citizens are welcomed into a framework within which they can share knowledge, explore differing perspectives, and bring tacit knowledge to the surface in a collaborative and non-judgmental way. On questions of deep moral complexity, from marriage to reproductive rights, it is the high quality of interactions among assembly members that enables new insights to emerge, relationships of trust to form, and proposals for public good to be defined. We may contrast this outcome with another national exercise on a similarly divisive issue, that of Britain's referendum on membership in the European Union in 2016. In this superficially "democratic" exercise, a lack of informed deliberation among citizens of differing views produced an outcome that has not only deepened the nation's divides but has produced at least as many policy challenges as it has resolved (Clarke et al., 2017).

Drivers of collective intelligence

The past two decades have seen a remarkable series of advances in our understanding of how group intelligence is produced. Several conditions have been identified that can make a group smarter than the sum of its parts, or conversely, that can hinder collective intelligence from taking shape.

Based on our analysis of the different contributing fields, we propose that the factors driving collective intelligence can be usefully divided into three categories, each of which answer one of the following questions: (1) "**Who** should be in the group?," (2) "**How** should the group be organized?," and (3) "**How many** should be in the group?"

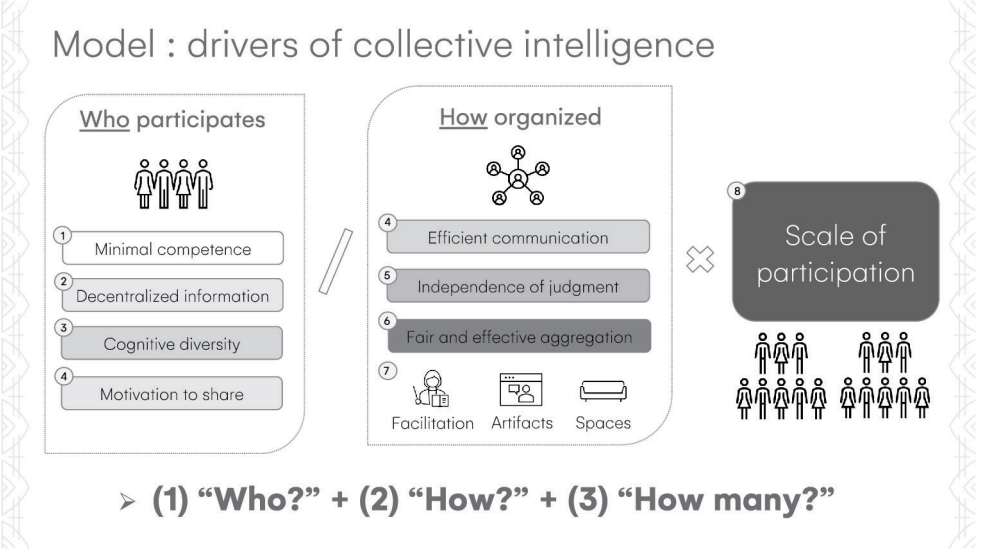

Figure 6.1 Principal drivers of collective intelligence.

Source: Authors' synthesis.

(1) The "who"
   (a) Members should be at least **minimally competent for the task at hand**. Condorcet (1785) theorizes that the judgment of the average member of his "wise jury"[6] will need to be at least slightly better than random. Similarly, Hong and Page (2004) affirm that collective performance will grow either as the crowd becomes more diverse or as the competence of its individual members improves. Following Dewey (1927), Noveck (2015) argues that "competence" in public affairs is often misconstrued as requiring special credentials or technical expertise, whereas even citizens who are not themselves "expert shoemakers," to borrow Dewey's metaphor, can nevertheless be good judges of "whether the shoe fits and how it fits."
   (b) Members should have access to **decentralized sources of information**. Hayek (1945) argued that markets are superior to centralized planners in producing desired social outcomes because they simply and rapidly synthesize a vast quantity of decentralized information held by local actors in a single form: the market price. As Surowiecki (2005) observes, high-performing organizations have tended to be good aggregators of the distributed knowledge and local information of their members (see also Argyris, 1995). Conversely, if members of a diverse and competent group are all using the same flawed information source, collective intelligence will suffer.
   (c) The group should be **cognitively diverse**. Implicit in Aristotle's metaphor of the "feast to which many contribute" (Politics, 3.11) is the argument that certain types of tasks are better accomplished by a group that combines diverse preferences and talents. If the previous category considers the variety of information sources available to a group, cognitive diversity refers to the variety of ways a group can interpret and use that information. Page (2017) proposes that each member of a group brings their "cognitive repertoire" to group tasks, a unique package of mental models, representations, and heuristics that can be applied to a given type of problem. A group becomes potentially more intelligent in proportion to the variety of the cognitive tools at its disposal. Importantly, this kind of diversity is linked to, but distinct from, other indicators of diversity such as age, gender, and ethnicity. Page argues that a group that is diverse according to these measures may indeed be cognitively diverse, given the range of life experiences and cognitive skills that can arise from those differences. So too, however, can a group that "looks" diverse actually think in similar ways – for example, if they share a similar educational or professional background.
   (d) Members should be **motivated to contribute what they know.** Even the most diverse, competent, and well-informed group will not be intelligent if individual members do not share what they know. Motivation for a given activity can be either **intrinsic**, that is, meaningful based on one's values or identity, or **extrinsic**, derived from external rewards or consequences (Ryan and Deci, 2000). A feeling of shared identity and responsibility can be a powerful motivator (Van Bavel and Packer, 2021). Alternatively, aggregative methods like prediction contests often rely on monetary or prestige-based incentives to motivate participants (see Servan-Schreiber case, chapter 27 in this handbook). Gamification methods are increasingly used by governments to stimulate citizen engagement based on the enjoyment linked to solving puzzles, amassing points, and/or engaging in friendly competition (Sgueo, 2018).

(2) The "how"
   (a) Members must be able to **communicate efficiently and at a reasonable cost.** As Raymond (1999) posits in his study of open-source communities, the rise of peer-to-peer platforms dramatically lowered the costs of collaboration, making it

possible for entire operating systems to be created by large groups of volunteers. Conversely, processes that are inaccessible to certain populations or require too much time from each member are unlikely to gain a critical mass (Noveck 2015). An effective CI method makes it easy to access the common task; critical factors may include choosing the right language, time, and physical spaces, as well as planning for different levels of digital literacy and connectivity.

(b) Members should be able to **form judgments independently** and share them without fear. One of Condorcet's (1785) three conditions for his "wise jury" was that the judgment of each member should be free from influence by the others. In aggregative methods such as the Galton example, or in prediction markets today, the existence of a prize can incentivize participants to bring their best thinking to bear, regardless of if their ideas diverge from others. Nevertheless, as Kahneman (2011) and others have shown, anchoring effects, information cascades and a range of unconscious biases can diminish our independence of judgment, putting collective intelligence at risk. In other contexts where the impulse to conform may be even stronger, a climate of psychological safety has been shown to be critical in bringing good ideas to the fore, especially when these challenge the conventional view (Edmonson, 1999).

(c) There should be **a fair and effective method to aggregate contributions.** Such aggregation methods can be low-tech, such as the basket and pieces of paper in the Galton case (Surowiecki, 2004), or high-tech, such as the software for evaluating team contributions to the Netflix prize (Page, 2017), or the Pol.is platform used to map policy preferences in Taiwan (see Taiwan case, chapter 7 in this handbook). Deliberative methods of CI typically require substantial facilitation to assure the quality of interaction within the group, such as in Deliberative Polls (Fishkin et al., chapter 13 in this handbook) or citizens' assemblies (Lironi, chapter 8 in this handbook; Farrell and Suiter 2019). Regardless of the degree of facilitation or technology required, participants' contributions should be reflected accurately, and similarly situated participants should be given equal opportunity to contribute.

(d) Collective thinking is often enhanced by specially designed **spaces and artifacts**. From neighborhood maps to whiteboards to circular amphitheaters, well-designed spaces can enhance group interaction and well-chosen objects can usefully focus group attention (see Bergman, chapter 35, in this handbook). Paul (2021) gathers a range of studies of "**embodied cognition**" and "**situated cognition**," that is, how thinking may be conditioned and potentially enhanced by the tools and spaces available to the thinker. Many of these recent studies have drawn on Clark and Chalmers' (1998) arguments for the "**extended mind**", that is, an understanding of our cognitive processes not strictly limited to the neurochemical activities of our brains; according to this view, human thinking can be understood as incorporating our bodies, tools, spaces, and other minds. This is an emerging and contested area of cognitive science (see Colombo et al., 2019), with much to offer to theorists and practitioners of CI.

(3) The "how many"

(a) Larger groups can be more intelligent…but not always. In classical demonstrations of crowd wisdom, if all other variables are held constant, a larger group will outperform a smaller one. Servan-Schreiber (2018) notes the statistical outcome of higher group intelligence but with diminishing returns: for example, each new member of a Condorcetian jury improves collective performance, but in smaller and smaller increments. For ideation or problem-solving tasks, on the other

hand, scaling up could make it more likely that a specific problem is spotted (the "many eyes" effect, see Raymond 1999), or that a "needle-in-a-haystack" solution is identified. This capacity of larger groups (n=20 to n=200) was demonstrated by Mercier and Claidière (2022) regarding the quality of answers to factual problems, where members were able to discuss with one another. In many cases, digital technologies have radically lowered the costs of adding participants, especially for aggregative CI methods; this has enabled prediction markets such as Hypermind[7] or citizen-science platforms like Zooniverse[8] to aggregate large numbers of estimations or contributions at very low cost. Large-scale participation can itself be an important goal of a collective intelligence process, such as when the target population has been marginalized or excluded from such participation in the past (see Du Bois, 1920; Gret and Sintomer, 2005; Tawa-Lama, chapter 20 in this handbook); or when the goal is to raise awareness of a larger set of issues, as may be the case for citizen science initiatives (see Kragh, chapter 38 in this handbook). Deliberative methods, unlike aggregative ones, have proven notoriously difficult to scale (see Hartz-Karp and Sullivan, 2014). Maintaining a high-quality deliberative experience has proven challenging in online settings, since these settings do not easily capture the full range of gesture and tone that are critical to human communication (Tannen, 2005). Three of the cases in this handbook show promising approaches to maintaining a high-quality deliberative experience using scalable online tools (see Fishkin, chapter 13; Spada, chapter 5; Liu, chapter 7). Cognitive biases such as **groupthink, information cascades,** and **conformity bias** may also be harder to mitigate at larger scales, which can lead to disastrous results (Sunstein, 2007). Strategies to preserve independence of judgment can include facilitation techniques such as asking participants in a workshop to write down their opinions before group deliberation begins. Edmonson (2019) proposes a series of strategies to favor psychological safety in group settings where the predominance of a "majority view" risks stifling constructive dissent.

Finally, some processes, such as visioning processes in a small community (Baum, chapter 27 in this handbook) or citizens' assemblies, do not require large-scale participation for group intelligence to emerge. In such cases, resources are more appropriately invested in maximizing interaction quality among a smaller number of participants. Where appropriate, therefore, scaling up participation can be an important lever for augmenting collective intelligence; nevertheless, any scaling strategy should account for these potential risks and costs.

Core functions of collective intelligence

One way of understanding the capacities that underlie human intelligence is to answer the question: What did these capacities enable us to do? How did their development allow certain individuals and groups to outcompete their peers and transmit these capacities, genetically and culturally, to their descendants?

Feldman Barrett (2021) argues that from an evolutionary perspective, "brains are not made for thinking." Rather, the first animal brains evolved to coordinate allostasis, that is, managing the balance of energy needed to keep a body alive and functional. As the perceptive and motor abilities of early animals developed hundreds of millions of years ago, these coordinative tasks expanded to include analysis and decision-making – "Is that a threat?" "Is this food?"[9] – and to execute the proper motor response. More complex forms of thinking such as memory and prediction – "Is this likely to be food? Was it good to eat last

time?" – were selected for because these modes of thinking helped reduce the depth of analysis needed in everyday situations, conserving energy and thus better managing allostasis.

Tomasello (2019) picks up the evolutionary story to explain how and why humans developed unique capacities for cognition in a highly competitive environment. Based on a wealth of experimental data comparing responses of chimpanzees and human children on a range of collaborative tasks, he proposes that it was through the development of **shared intentionality** – the ability to conceptualize a common task and play complementary roles in achieving it – that our unique form of collective intelligence emerged. Unlike other social mammals, who live together but collaborate only when direct benefits are possible for each individual, humans developed "**ultrasociality**," including the ability to sacrifice individual interests for the sake of group success and transmit bodies of cultural knowledge to the next generation (Haidt, 2012). Along the same lines, the works of Haidt (2012), Boehm (2009), and Henrich (2015) trace how the core functions of intelligence of our early animal ancestors – observing the environment, predicting the probable outcomes of different courses of action, making and executing decisions, and learning from them – became functions that humans took on collectively, causing a re-arrangement of human societies that made us look very different from our primate cousins.

In this sense, our complex language, social institutions, abstract concepts, and moral values are all adaptations that have allowed this evolutionary "bet on collaboration" to pay off. Whether the rise of *Homo sapiens* has been a good thing for our planet is a separate matter; nevertheless, our spectacular success from an evolutionary perspective cannot be denied, and collective intelligence lies at its core.

Building off these advances in the cognitive and evolutionary sciences, Mulgan (2018) proposes the following "core functions" of collective intelligence[10]:

1. **Observing or gathering data** on a given problem or need.
2. **Modeling and predicting** the likelihood of risks and the probability of different scenarios coming to pass.
3. **Generating options** for action, based on past experience or creating new approaches that have not yet been tried.
4. **Filtering** better potential courses of action from worse ones, **deliberating** on the relative virtues and risks of the better options, and **deciding** which option to adopt.
5. **Implementing** the decision by mobilizing the necessary resources and taking action.
6. **Learning** from the results of the actions taken by **making sense** of the resulting data, **remembering** the lessons learned, and synthesizing past lessons into **wisdom** that can be transmitted to others.

To put this in the context of previous sections, if the drivers of collective intelligence are the answers to the question, "What makes a group smart?", these core functions can be understood as answering the question, "What task will that group accomplish?" The answers to the latter question will, in turn, guide the answers to the former one: *Who* should be in the group; *how* should it be organized; and *how many* individuals will be needed for the task at hand.

Impediments to collective intelligence

Not all crowds are wise. The seminal studies of Mackay (1841), Le Bon (1905), Janis (1982), and Sunstein (2006) have shed light on some of the factors that can hinder group intelligence or, at worst, transform otherwise intelligent people into an unthinking mob.

In this and the next sections we will analyze impediments to CI that are intrinsic to group behavior and groups' information processing. We should keep in mind that there are many other factors beyond the scope of this chapter that might hinder the implementation of a CI process. Examples include the role of political competition, corruption, and capture often discussed in the field of community-driven development (Mansuri and Rao, 2012). Other examples can be found in studies of public policy, economics, and political science analyzing the difficulty of implementing reforms in public administrations (Cairney, Akkila, and Wood, 2019; Acemoglou et al., 2008; Rodrik, 2018; Mayka, 2019). Lastly, within the field of organizational management lies an entire subfield on managing change, a body of research that gives important insights for those interested in reforming or reinventing government (see, for instance, Stouten, Rousseau, and De Cremer, 2018). Additional details on the barriers to effective implementation of collective intelligence processes can be found in the chapter on measuring impacts (see chapter 5) and in chapter 3 in relation to political obstacles to CI.

While genetic and cultural evolution has bestowed us with powerful cognitive tools, so too has it resulted in mental "shortcuts" which conserve precious energy but can also produce bad reasoning. Such **cognitive biases and heuristics** include the use of stereotypes, confirmation bias, and motivated reasoning, among many others (Kahneman, 2011). Enhancing collective intelligence often requires becoming aware of, and taking steps, to mitigate the effects of such biases on collective thinking.

Several case studies in this handbook illustrate the difficulties of bringing together all the principles above to foster collective intelligence.

Groupthink and **polarization** might become manifest in the cognitive mode of action. This is because humans are generally **homophiles**, which means that people prefer to link up with others who are similar to them (i.e., in terms of race, nationality, ideology, gender, age, etc.). This human trait can manifest itself most visibly when many people are involved. Groupthink and polarization are especially common in large groups. "The term [groupthink] refers to a deterioration in mental efficiency, reality testing and moral judgements as a result of group pressures" (Janis, 1971). Groupthink is the result "when the members' strivings for unanimity override their motivation to realistically appraise alternative courses of action" (Janis, 2008). Groupthink is especially prevalent when group cohesiveness is high, that is, when members share a "we-feeling" of solidarity and desire to maintain relationships and status within the group. In the course of collaborative work, therefore, it is key to create conditions where individuals of large groups maintain **independence of judgment** and are protected from these unhelpful forms of peer influence.

Sunstein (2006) presents, among others, the key notions of **echo chambers** (in which beliefs are reinforced or amplified inside an insulated circle of participants), **information cascades** (when people form judgments based solely on information provided by others without verifying or questioning it) and **groupthink**. As a remedy to such "jumping off a cliff in unison," Sunstein (2005) insists on the importance of nurturing a culture of **healthy dissent**.

Gammelgaard and Hallin (2018) show that barriers to effective crowdsourcing processes can include the following:

Ambiguity: Lack of common language and shared understanding leading to sparse common ground.

Multiplicity: A diverse set of practices and approaches producing a lack of coordination and consistency.

Complexity: Poor insight into one's own organization tied to a lack of innovation management and governance processes.
Inconsistency: Lack of combined efforts and priorities leading to imprecise objectives and poor implementation.
Uncertainty: When crowdsourcing is associated with conditions of risk.

Problem complexity

A core argument for the importance of collective intelligence in governance is that increasingly complex public problems require diverse sources of information and expertise to be combined and mobilized. In fact, the world is said to become increasingly volatile, uncertain, complex, and ambiguous (**VUCA**) (Mack et al., 2016). As the Covid-19 pandemic illustrates, globally disruptive events unfold ever faster, the outcomes of different types of events are unclear, the interdependence between actors is greater, and, even when we have information, it is difficult to interpret. A conventional riposte is that it is the very complexity of problems like public health or fiscal policy that disqualifies the average citizen from making a useful contribution. Rather, public decisions of greatest import should be left to technocrats or elected officials of outstanding abilities (presuming such to exist). Others identify precisely in this complexity the reasons why more inclusive forms of democracy may yield better decisions. Babbitt (2012) exemplifies this view, arguing that "properly understood, democracy can address many of the problems arising from governing a world increasing in complexity."

Different ways of characterizing the complexity of public problems include:

Dynamic complexity, meaning a systematic distance or delay between cause and effect in space or time. The dynamic complexities of climate change are a clear example, as there is a distance and delay between the decisions of climate solutions and the effect. According to Scharmer and Kaeufer (2010), dynamic complexity often goes along with social complexity.

Social complexity is the result of diverse interests, preferences, and mental models among the stakeholders concerned by a given problem. The greater the social complexity, the more important is the multi-stakeholder approach to real problem-solving. The cooperation of all the relevant stakeholders is vital to include the interests of all.

Emerging complexity "is characterized by disruptive change", according to Scharmer and Kaeufer (2010). It is characterized by the fact that it does not occur until a certain unpredicted event happens, and conditions for solving the problem are unknown, often the problem changes its form and makes it difficult to define both the problem statement and key stakeholders. "The greater the emerging complexity, the less we can rely on past experiences." Furthermore, as we unfold new solutions, the problem and the diagnosis keep evolving, therefore, such problems require more cognitive and coordinative CI actions.

Wicked problems, as coined by Rittel and Webber (1974), are those for which each attempt to create a solution changes the understanding of the problem. As is the case with many social and political issues, wicked problems may have several competing definitions; their sub-causes may be deeply interconnected, meaning that any intervention will ramify through the system in unexpected ways; their manifestations may change rapidly and continuously; and stakeholders may disagree on what a

> good solution looks like. Because of these characteristics, wicked problems like poverty or climate change are unlikely to ever be solved "once and for all." Rather than applying a linear model of problem-solving, therefore, wicked problems demand methods of continuous learning and experimentation (see Noveck 2021). Organizational learning requires groups to be able to reflect not only on the new data arising from the field, but also on their own capacities to model and interpret this data, "learning how to learn." This approach of "**learning loops**" has been developed and refined to help organizations and communities address problems of this complexity.
>
> *(Argyris, 1995; Edmondson, 1998; Mulgan, 2018)*

Surowiecki (2005) proposes that collective intelligence is especially effective in resolving three types of problems:

> **Cognitive** - These are problems that concern matters of local knowledge and insights, where there is a right and a wrong answer, for instance how will infectious diseases evolve (as in Servan-Schreiber and Larmanou, Handbook). Large crowds can be surprisingly smarter at producing the right information than smaller groups of individuals.
>
> **Coordinative** - This is when a group of people is better at coordinating behaviors than individuals. For example, what matters is not where people work in a hybrid work environment, but who performs the tasks and how the tasks are coordinated by the team in order to finish tasks (Riedl, Kim, Gupta, Malone, Woolley, 2021).
>
> **Cooperative / collaborative** - This is when a group wishes to work together to find and assess solutions. Whereas coordination can happen organically - like pedestrians naturally self-regulating on the sidewalk - and the resolution of cognitive challenges will be served by actors sharing their knowledge independently, collaboration requires the active interaction of the group members.

Policymakers may be facing all types of problems, therefore requiring a diversity of CI skills and approaches throughout the policy cycle. However, the cooperative / collaborative type tends to be particularly frequent, imposing on policymakers to pay particular attention to the conditions for quality deliberation set out by Fishkin.

Design principles and frameworks

In 2010, Malone, Laubacher, and Dellarocos published a paper entitled "The Collective Intelligence Genome" in the *MIT Sloan Management Review*. The article gathered nearly 250 examples of web-enabled collective intelligence, such as Threadless, Wikipedia, and Innocentive. After examining the examples in depth, the authors presented the following framework for designers of collectively intelligent system:

1. **What is being done by the crowd?** That is a question about the purpose of the task. The many organizational tasks encountered in collective intelligence systems can be boiled into two basic genes. One gene is aiming at creating something new, such as a piece of software or a T-shirt design. The other gene is related to how the actors evaluate and select alternatives, such as deciding on whether a new module should be included

in the next release of Linux open-source software, which T-shirt to manufacture, or deciding which Wikipedia article to delete.

2. **Who is doing it?** This question relates to who undertakes the task on the platform. Here are two sub-questions to be addressed: Is it the **crowd who decides** or is it **a hierarchy**? If it is the crowd, the task is undertaken by a member of a large group who has chosen to do so. However, if the task is performed by the hierarchy, it is typically identical to a traditional hierarchical organization with few decision-makers (e.g., policymakers) on the top of the hierarchy and answered when they assign a crowd to perform a certain task for policymaking.
3. **Why are they doing it?** This question concerns what motivates the crowd to take part in the activity? And what incentives are at work for the crowd? Examples of high-level motivations are money and the promise of financial gains by fulfilling the task. It could also be the feeling of love by being motivated from their intrinsic enjoyment of an activity, love for the community and because they contribute to something social or to a good cause larger than themselves. A third motivator is glory in the sense that one becomes recognized for one's performance within a crowd or community.
4. **How is the task being done?** In traditional organizations, the *how* question is typically responded to by describing the organizational structures and processes. The question concerns insight into four components to be evaluated related to the *how* genes for crowds:
   (a) **Collection** occurs when the crowd performs tasks independently from each other, such as creating a video or suggesting an idea on a crowdsourcing platform happens independently among the crowd members. It could also be in the form of an idea contest among the crowd members.
   (b) **Collaboration** takes place when members of a crowd work together to create something, where the individuals are dependent on each other to reach an outcome, such as when participants create a new Wikipedia page together and build on each other's contributions.
   (c) **Group decision** occurs when inputs from members of the crowd are assembled to make a decision that concerns the group as a whole. It could be a deliberation of a political issue by a crowd on a platform. Other variations of group decisions are *voting, consensus, averaging, and prediction markets,* examples of which will be presented throughout this handbook.

Mulgan (2018) also suggests the following five key principles for those seeking to orchestrate collective intelligence:

1. **Autonomous commons** – Create shared resources open to all group members that capture past learnings and allow for information, ideas, and arguments to flow freely and be organized for later use.
2. **Balanced use of core functions** – Identify which core function or functions are most critical to the task at hand and choose tools and processes most likely to support those functions.
3. **Focus and right granularity** – Adopt tools and facilitation methods that help the group focus on the most important elements of the task, avoid potential distractions and ask no more from group members than what is needed.

4. **Reflexivity and learning** – Keep in mind that knowledge production is a dynamic flow ("knowledge needs knowledge about knowledge") and that refining a thought process may require learning and sense-making in iterative loops.
5. **Integrate for action** – Combine tools, methods, participants, and commons in the manner most suited for the task at hand, being ready to abandon past methods and adopt new ones as needed for the circumstances at hand.

These frameworks are not exhaustive, as their proponents admit. Rather, they are intended to serve as potential sources of inspiration for designers of collectively intelligent systems, to be augmented by new and emerging frameworks such as those represented in this handbook.

Innovations in democracy and governance

In a growing number of political systems, there is an emerging awareness of the benefits of large-scale participation in decision-making processes, the allocation of public resources, and the resolution of disputes. These activities can be organized such that they are performed by an individual, a designated subset of the community, or the whole community. In developing governance innovations, different democratic principles can also be applied to any scale of community and decision-making process for organizations, according to Malone (2004). He distinguishes between the following forms of power distribution in the decision-making process:

> **Democracy**: A system of government, organization, or any type of community, where all eligible members of the respective society contribute, typically through elected representatives with the majoritarian principle.
>
> **Loose hierarchies**: Delegation of the decision-making power to the subordinates with the bottom-up process, where the managers and leaders approve the final decisions.
>
> **Free market principle**: Internal trade of the ideas and decisions in the large-scale involvement.

Today, democracy is often equated in people's minds with the practice of elected officials making public decisions, executed by unelected bureaucracies, in which the mass of citizens has limited power beyond voting periodically – "uploading one bit of data every four years," as Taiwan's Digital Minister Audrey Tang puts it – and voicing their opinions, which have no binding force in the public debate, with the excuse that large-scale participation justifies a limited form of representation and delegation of power. CI designs can be applied to many forms of power distribution and use the frameworks laid out by political theorist Robert Dahl (2020) to strengthen democracy's five essential principles:

> **Effective participation**: In an ideal democracy, before a policy is adopted by the association of citizens, all its members must have equal and effective opportunities for making their views known to the other members as to what the policy should be.
>
> **Equality in voting**: When the moment arrives at which the decision about policy will finally be made, every member must have an equal and effective opportunity to vote, and all votes must be counted as equal.

Gaining enlightened understanding: Within reasonable limits as to time, each member must have equal and effective opportunities for learning about the relevant alternative policies and their likely consequences.

Exercising final control over the agenda: The members must have the exclusive opportunity to decide how, and if they choose, what matters are to be placed on the agenda.

Including all adults (a criterion largely unapplied in the case of women before the 20th century).

Many stories in this handbook demonstrate efforts to address each of these pillars of democracy, focusing primarily on effective participation and gaining enlightened understanding; examples range from the *jan sunwai* consultations and the Mobile Vaani phone voice response device in India to the crowdsourcing platform in the Danish town of Slagelse. Other dimensions in fact invite further developments. Fishkin (2018) notes in particular how efforts to involve citizens in policymaking have so far been limited when it comes to binding impact on the policy agenda.

With today's historic model of representative democracy being challenged, this handbook explores a variety of **democratic innovations**. Although they are attracting significant academic interest, there is considerable debate as to what can be qualified as a democratic innovation. Elstub and Escobar (2017) define democratic innovations as "processes or institutions developed to reimagine and deepen the role of citizens in governance processes by increasing opportunities for participation, deliberation and influence." We will understand them as new approaches to decision-making being explored around the world and designed to increase, diversify, and deepen opportunities for citizen participation in governance, policy, and public administration processes.

In understanding how different democratic innovations and CI approaches can help strengthen democracy, it is useful to consider how they might play out at different phases of the policy cycle. Mulgan (2018) usefully distinguishes between the following six stages of the democratic process:

- **Problem framing**, or, in Mulgan's words, "framing questions and determining what is worthy of scarce attention and through what lens it is to be seen." Gitte Kragh, chapter 38 in this handbook, tells us how participatory citizen science can help understand the magnitude and speed of climate change, which ultimately helps society decide what is the issue at hand and how much of a problem it is. The Hypermind platform similarly provides an example of collective prediction applied to disease outbreaks (see Servan-Schreiber chapter 32 in this handbook).
- **Agenda-setting**: "Identifying and nominating issues that might be amenable to action." In this handbook, the story of the International Panel on Climate Change illustrates how we try, collectively, to define what is the policy agenda on climate change based on current scientific knowledge, while the Fab Global City Initiative shows how we can purposefully elicit collective stories of our shared challenges to create the momentum for collective action to tackle them.
- **Ideation**: "Generating options to consider." The example of the Danish Alternative party, of the German Agora Energiewende stakeholder platform, of an early 20th century public challenge in Australia, of the Danish Sager der Samler collaborative, or of the UN's

UNLEASH innovation lab are all examples in this book of assemblies designed to foster new solutions, on climate change and other topics.

- **Deliberation**: "Scrutinizing options." Many CI formats presented here focus precisely on enabling careful examination of policy options from a variety of angles, from school participatory budgeting to online deliberative polls and civic tech platforms.
- **Decision**: "Deciding what to do" is complex and paramount to policymakers' job. Some will focus on creating the right context for open-minded dialogue, as in the examples here of the Open European Dialogue or of Helmut Kohl's "gastrosophy," while the Scottish administration sought to enable "collectively brave" decisions thanks to the Theory U approach.
- **Evaluation**: "Scrutinizing what's been done and judging whether it's working" may be less common, but reflecting on performance, accumulating and sharing knowledge of the experience gained is crucial to developing better solutions together, as exemplified here, for instance, by the case of the "zero long-term unemployment" experiment in France.

While common sense invites us to consider how to foster collective intelligence at each step of the policy cycle, complexity invites us to be recursive in our approach. In the complex, often confusing world we live in, the **OODAL loop** – which stands for Observe, Orient, Decide, Act & Learn (Boyd 2018) – proposes a five-step approach to help decision-makers filter available information, put it in context, and quickly make the most appropriate decision while also understanding that changes can be made as more data becomes available. Applying this recursive examination of CI devices at each step of the policy cycle should become central to public administration's mandate.[11]

These activities are organized via different participatory practices, such as:

> **Representative practices** include those where decisions are made, resources allocated, or disputes resolved by an individual or body selected by the community for this purpose.
>
> **Administrative practices** include those where decisions are made, resources allocated, or disputes resolved by an individual or team that is employed by the state.
>
> **Participatory practices** include those where the entire community (as construed by the rules of that community) are invited to contribute to making a decision, allocating a resource, or resolving a dispute. These can include actions taken by the community as a whole, or by a subset that chooses to participate. (Examples: town halls, participatory budgeting, the *jan sunwai*…).
>
> **Deliberative practices** include those where a subset of the community (or the entire community, in smaller-scale societies) gathers to consider an issue, weigh arguments, and make decisions or recommendations. In contemporary usage, as well as in ancient societies such as Athens, such groups can be chosen by sortition to create a resemblance with the community as a whole. (Examples: citizens' assemblies, consensus conferences, citizens' juries, deliberative polling).

Participatory democracy thus gives citizens an opportunity to take a direct role in political decisions and policies that affect their lives, rather than through elected representatives.

Deliberative democracy focuses instead on developing the conditions by which the considered judgment of a "mini-public" (a representative sample of the population) can

be brought to bear on a public issue (Landemore, 2013). As such, deliberative democrats insist on the quality of the deliberation leading up to those considered judgments, evaluating the pros and cons of different alternative views, and are often less concerned with maximizing the total number of people taking part in the process. **Direct democracy**, in the famous "ladder of citizen participation" sketched out by Sherry Arnstein (1969), can be understood as any mechanism which grants the electorate power to decide on policies without the intermediation of elected representatives. Referenda and plebiscites are often criticized, however, for the manipulation of facts and superficial debates which often characterize these exercises, and the fact that they are suspiciously popular among anti-democratic movements and regimes (Mounk, 2018). Some scholars evaluate democratic innovations not through the lens of whether a given process is deliberative or participatory but rather if it increases the system's **overall deliberativeness** (Mansbridge and Parkinson, eds., 2012). This could be the case, for instance, with a protest initiated by a trade union elite. Overall, adapting the adage that with greater power comes greater responsibility, we would say that with greater delegation of power comes greater responsibility for ethical and neutrally informed deliberation. Landemore (2017) argues that it is important to create the proper conditions for effective deliberation, including creating an alignment around common goals and constraints, and facilitation techniques that depersonalize ideas, allowing better arguments to naturally come to the fore. Fishkin (2018) identifies five key conditions for quality deliberation:

Quality information: The extent to which participants are given access to reasonably accurate information relevant to the issue at hand.

Substantive balance: The extent to which arguments offered by one side or perspective are answered by considerations offered by those who hold other views.

Diversity: The extent to which all major positions taken on the issue in the public sphere are represented by participants in the discussion.

Conscientiousness: The extent to which participants sincerely weigh the merits of the arguments.

Equal consideration: The extent to which arguments offered by all participants are considered on the merits regardless of which participants offer them.

The examples provided in this handbook suggest that some policymakers are exploring new ways of including external voices – citizens, experts, professionals… – in their decision-making and governance, predictions and innovation. Both participatory and deliberative processes are visible in the handbook, from participatory budgeting in schools to rich dialogue formats at community, national and even transnational level (see Ringler, in this handbook, chapter 31). As pointed out by Mulgan (2018), "If we see democracy not only as an expression of popular views but also as a collective thinking process, then (...) the quality of deliberation matters as much as the quantity of people involved." As this new paradigm takes shape, our understanding of democracy could increasingly be oriented toward methods and processes that harness collective intelligence, supported where appropriate by machine intelligence, to strengthen accurate and innovative policymaking.

Elstub and Escobar (2017), drawing upon a variety of authors, invite us to examine such democratic innovations with the following questions.

	Low			*High*
SELECTION How are the participants selected and how **inclusive** is the process?	Election	Purposive selection / sampling	Sortition	Self-selection
MODE OF PARTICIPATION How do the participants communicate with each other and how intense is the **participation**?	Observation	Listening	Voting	Asking questions, making comments, engaging in deliberation
INVOLVEMENT How are participants involved and how intense is their **contribution**?	No decision	Aggregation of preferences	Bargaining / negotiation	Deliberation
AUTHORITY & POWER How much **influence** do the participants have over what public authorities do?	Personal benefits: Citizens have no influence but may gain personal benefits	Advise and consult: Participants provide advice and consultation for public authorities who retain decision-making power	Co-governance: Citizens do not formally influence decisions but may informally influence them and public opinion can be transformed through the process	Direct authority and co-decision: Citizens join public officials to make decisions

Table 6.1 Collective intelligence methods for democracy and governance

Core Functions	*Methods and Tools*
Observing/ gathering data	• Crowd-mapping • Crowd deliberation and participation on platforms • Citizens' assemblies or juries • Open data • Citizen science • Participatory Action Research • Data mining • Prediction markets • e-petitions • Crowd surveys (off-/online)
Modeling and predicting	• Prediction and forecasting methods: prediction markets, contests, swarm intelligence, future studies, scenario building (e.g., Futurecasting, transformative scenario planning, delphi method, future workshop, causal layered analysis, etc.) • Collaborative mapping • Predictive modeling, predictive analytics • AI functions such as NLP • Lean and prescriptive analytics, behavioral insights, ethnography
Generating options / creativity	• Open calls for creative solutions • Open government • Participatory budgeting • Citizens' assemblies or juries • Collaborative platforms • Hackathons • Design thinking (e.g., living labs, etc.) • Public challenges and other challenge mechanisms • Ideation techniques (e.g., design sprints, hackathons, creative problem-solving, etc.) • Policy labs • Think tanks • Citizen juries
Filtering/ deliberating/ deciding	• Mini-public deliberations (Citizens' assemblies or juries, deliberative polls, planning cells, etc.) • Focus groups • Opinion surveys • Data collaboratives • Decision matrix, multi-criteria decision analysis • Transformative scenario planning • Door-to-door canvassing • Citizen hearings • Participatory Budgeting
Implementing/ pooling labor	• Nudging and monetary incentives • Mutual aid networks • Pol- /Legal-/Sup-tech • Regulatory sandboxes and innovation hubs • Randomized control trials

Table 6.1 Cont.

Core Functions	*Methods and Tools*
Learning/sense-making/ memory/wisdom	• Wikis • Communities of practice • Collective learning and sense-making • Community science • National archives • Research, training • Serious games • User committees

The democratic innovations encountered in this handbook usually demonstrate hybrid combinations of these different options. Generally speaking, democratic innovation is eminently, as evidenced in all the stories, characterized by hybridity and experimentation: We see mini-publics selected by lot combined with self-selected participants online and referenda in the case of Iceland's constitutional crowdsourcing initiative. We have examples of collaborative governance combined with crowdsourcing, deliberation, and digital participation, for instance, in the municipality of Slagelse.

The following table similarly categorizes some of the most commonly encountered collective intelligence methods according to the schema of "core functions" of group thinking as described by Mulgan (2018). Of course such categories are overly simplified, as some methods can contribute to more than one function, which is why you will find some methods listed in more than one line. A number of devices, such as participatory budgeting or citizens assemblies can have several functions depending on how they are implemented.

This evolving toolbox is being constantly enriched due to new abilities provided by machines working with humans.

Humans and machines thinking together

Hybrid intelligence

Hybrid intelligence (HI) is **the combination of human and machine intelligence, expanding human intellect instead of replacing it**. HI takes human intelligence and intentionality into account when making meaningful decisions and performing appropriate actions, together with ethical, legal, and societal values.[12]

Artificial intelligence can facilitate the surfacing of collective tacit knowledge for policymaking in numerous ways (cf. Peeters et al., 2021). Examples of such hybrid forms of intelligence include Amazon Mechanical Turk (AMT) for workflow, MIT's Superminds, and other crowdsourcing platforms such as CitizenLab that enhance citizen participation in democratic processes through natural language processing (NLP) features or AI algorithms.

Peeters et al. (2021) suggest the following ways in which artificial intelligence can function in a symbiotic relationship with human intelligence and thereby advance decision-making:

> **In a dyadic way**, a policymaker can ask a decision support system what the right decision would be under a given context and for a given problem.

At the team level, an example could be a swarm of public drones that perform sensing surveillance of floods and then transmit data to a platform on the ground used by rescue teams to help move people from potential flood areas.

At the organizational multi-team level, such as when policymakers carry out new policy reforms but tap into different groups' judgments using CI methods, such as swarm intelligence when each participant connects to the server and is allocated a controllable graphical magnet that allows the user to freely apply force vectors on the puck in real-time (Rosenberg, 2015). It could also be citizens' deliberation on participatory platforms, supported by natural language processing (NLP) to sort and categorize the open-text contributions of interested citizens.[13]

At the societal and cultural level, such as when multiple systems collaborate and interact with one another supported with AI. Collective intuitions of policy questions can be transformed into hypotheses that are testable using AI. For example, collective intuitions and predictions by citizens can point in the direction of a potentially remarkable discovery for humanity.

A rapidly expanding variety of technologies and algorithms can help to harness the vast amount of information contained in collective intelligence and to make sense of it to transform it into knowledge that carries meaning and which is actionable. For instance, readers may come across the following concepts in this and other handbooks:

- **Artificial intelligence** and **machine learning** (an AI technology that allows computers to learn beyond their initial programming), in particular due to **neural networks** (groups of algorithms inspired by the human brain), with specific developments such as **convolutional neural networks**, a type of artificial neural networks in which the pattern of connections between neurons is inspired by the visual cortex of animals.
- **Predictive analytics**, which is a branch of advanced analytics that makes predictions about future outcomes using historical and big data combined with statistical modeling, data mining techniques and machine learning. This discipline also includes methods such as **lagged causal relationships** from time series, which is a way to infer causal relationships between two time series.
- **Heuristic search**, which is a type of search performed by AI that looks to find a good solution, not necessarily a perfect one.
- **Logistic regression**, **decision trees,** and **logic trees** are all statistical models that help study the relationship between various groups of variables that are particularly common for machine learning.
- In data science, **Bayesian networks** are a type of probabilistic graphical model that uses Bayesian inference for probability computations, and **backpropagation** is a method to train neural networks.
- **Data mining** uses sophisticated mathematical algorithms to segment data and assess the likelihood of future events. Data mining is also known as **knowledge discovery** in data.
- **Sentiment analysis** (or **opinion mining**) is an NLP technique used to determine whether data is positive, negative, or neutral.
- **Natural language processing**, which we encounter in two stories in this handbook, refers to the ability of a computer program to understand, create patterns, and sort human language as it is spoken and written.

These technologies may be supported by human–computer interaction principles and methods that act as aggregators of collective intelligence:

> **Civic and gov-tech platforms**: Citizen feedback, proposals, discussion forums, complex deliberation, voting. "Civic technology" is a nascent force in the relationship between governments and communities. Elements of the civic technology ecosystem include "open data, related information and communications technology (ICT) innovations and the organizational boundary-spanning practices of civic technology" (McNutt et al., 2016).
>
> **Crowdsourcing platforms**: Crowdsourcing is a "blend of bottom-up open, creative process with top-down organizational goals" (Brabham, 2013). It is also described as "a process of accumulating the ideas, thoughts or information from many independent participants, with the aim to find the best solution for a given challenge" (Guazzini et al., 2015). Crowdsourcing is also defined as the act of submitting a task or problem to the public for completion or solution (e.g., Howe, 2006), such as knowledge commons in the form of wikis, Quora, user communities, StackOverflow, etc. Such platforms can be enhanced by gamification features. Crowdsourcing is a model for integration of the "creative energies of online communities into day-to-day operations" in order to "leverage the collective intelligence" of the online communities (Brabham, 2013).

In recent years, crowdsourcing has been noted as the preferred search tool for harnessing collective intelligence (Certomá, Dyer, and Pocatilu, 2017) and has been seen as a point of cost-effective value creation through collecting relevant knowledge for improving policy and citizens engagement in policymaking (Aitamurto and Chen, 2017).

Collective consciousness

Emile Durkheim was the first to introduce the theory of collective consciousness in his 1893 book *The Division of Labor in Society*. Later, he would also rely on the concept in other books, including *Rules of the Sociological Method*, *Suicide*, and *The Elementary Forms of Religious Life*. In these books, he explains that the phenomenon is "the totality of beliefs and sentiments common to the average members of a society." Durkheim based his theory on observations that in traditional or primitive societies, religious symbols, discourse, beliefs, and rituals fostered the collective consciousness. In such cases, where social groups were quite homogeneous, the collective consciousness resulted in what Durkheim termed a "mechanical solidarity" – in effect an automatic binding together of people into a collective through their shared values, beliefs, and practices.

Collective consciousness has its roots in shared awareness. The word "conscious" derives from the Latin *cum* ("with") and *scire* ("to know"). In the original sense, two people who know something together are said to be conscious of it "to one another." Combining the two terms "collective" and "consciousness" means shared ideas by individuals relating as interdependent elements within groups or larger structures (Smith and Thomasson, 2005).

In the Durkheimian perspective, collective consciousness can be created from intentional human interactions and learning. When such consciousness is absent, members of a community fail to see the context for their actions; as a result, behaviors become automatic and more

difficult to adapt to new conditions. Conversely, communities become collectively conscious through processes of self-reflectivity and meta-cognition (see Paulson in this handbook, ch. 1), and can use these learnings to alter negative patterns that stand in the way of collective goals (Pór, 2017).

According to Hallin, collective consciousness can be identified and congregated from the following levels and dependent on the common course of collective intelligence for each level, such as the individual level, in dyad relationships, in groups, in organizations, in the neighborhood, in the community, for the city, for the country/shire, for the state/province, network, and global brain (e.g., the whole internet). (See the introduction to Part 7 on collective intelligence, technology and collective consciousness)

As the cases of this handbook show, democratic innovation is as its core a redistribution of power outward, where participation, inclusiveness, and diversity are each core drivers of collective wisdom. Moreover, technological progress combining collective intelligence and AI provides opportunities to create learning processes that allow a community to become more self-aware, and therefore potentially more resilient and fulfilled.

This chapter on foundational definitions of collective intelligence has sought to provided a selection of the key definitions and concepts in the emerging field of CI as they relate to democracy, governance, and public problem-solving. Testing these concepts in real-world conditions, exploring the impacts achieved and lessons learned, is the aim of the case studies which follow.

Notes

1 It should be noted that from the perspective of democracy and governance, the body of Galton's career as a whole is abhorrent: the coiner of the term "eugenics," Galton was an unabashed racist who argued for the weeding out of "undesirable traits" from the English population.
2 The conceptual distinctions between "collective knowledge," "collective intelligence," and "collective wisdom" are interesting and still somewhat unsettled. We take up this point in Section 2.4 infra.
3 NESTA blog, "Using machine learning to map the field of collective intelligence research", Nov. 22, 2018. www.nesta.org.uk/blog/mapping-collective-intelligence-research/, accessed July 3, 2022.
4 The phrase "at the same time" is, of course, dependent on circumstances and context.
5 Again, depending on one's understanding of "at the same time," prediction markets could either be considered a synchronous or asynchronous mode; regardless, the drivers and overall outcome are the same.
6 Our phrase, not Condorcet's.
7 See www.hypermind.com/.
8 See www.galaxyzoo.org/.
9 Of course the "thoughts" of these early animals were not expressed in the form of human language; these are illustrations only.
10 As noted above, Mulgan in this handbook adopts the term "core function" in place of his earlier term "functional capabilities" (Mulgan, 2018).
11 It is interesting to note here how public administrations around the world are creating spaces to evaluate, learn, and improve on new governance approaches, from the UK What Works centers, to the EU's Competence Centre on Participatory and Deliberative Democracy, or the French "Direction interministérielle de la transformation publique," among many other examples.
12 For an overview on this matter, see the introductory chapter to Part 3 on the collective intelligence society and the use of collective tacit knowledge and artificial intelligence for policymaking.
13 Examples of this are the stories included in this handbook on the Danish municipality of Slagelse as well as on deliberative polling online.

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