Cognitive technologies

A technical primer

Cognitive technologies are now impacting almost every aspect of people's lives. Not only are these technologies an emerging source of competitive advantage for businesses and the economy, but they also have the potential to improve societal well-being.[1]

They can be a disruptive force in the way work gets done and employers interact with workers, customers, and suppliers, as well as the trade-offs that conventionally govern the relationship between speed, cost, and quality.

This primer aims to help readers understand these technologies and the emerging landscape better, illustrate their transformational potential, and demonstrate how business and government leaders can adopt them in driving smarter insights and stronger organizational outcomes.

First, let's get the basics right

There is no single definition of cognitive technologies. This primer, however, will define cognitive technologies as those technologies that can "perform and/or augment tasks, help better inform decisions, and accomplish objectives that have traditionally required human intelligence, such as planning, reasoning from partial or uncertain information, and learning."[2] This primer treats the terms cognitive technologies and artificial intelligence (AI) as interchangeable. Currently, four major cat-egories of cognitive technologies seem to be expand-ing exponentially (table 1)

What drove the progress in cognitive technologies?

Since its first use in the 1950s, the field has been marked by periods of high expectations alternating with setbacks. However, since the beginning of the 21st century, some cognitive technologies have pro-gressed significantly. Four key factors appear to be driving this:[5]

Table 1. Cognitive technology categories and select application examples

Categories	Descriptions	Application examples
Robotic process automation (RPA)	"A combination of artificial intelligence and automation" that's able to "sense and synthesize vast amounts of information and can automate entire processes or workflows, learning and adapting as it goes."[3]	• Process automation and configuration • Graphical user interface (GUI) automation • Advanced decision systems
Cognitive—language technologies	A set of statistical techniques that enable the analysis, understanding, and generation of human languages to facilitate interfacing with machines in written and spoken contexts, that is, to convert human (natural) languages into machine languages and vice-versa	• Natural language processing and generation • Semantic computing • Speech recognition • Speech synthesis • Sentiment and text analytics
Cognitive—machine learning (ML)	A set of statistical techniques that automate analytical model-building using algorithms that iteratively learn from data without the need for explicit programming	• Supervised learning • Unsupervised learning • Deep learning
Cognitive—computer vision	Automatic extraction, analysis, and understanding of useful information from a single image or a sequence of images, thereby modeling, replicating, and, more importantly, exceeding human vision using computer software and hardware[4]	• Image recognition • Video analysis • Handwriting recognition • Voice recognition • Optical character recognition

Source: David Schatsky, Craig Muraskin, and Ragu Gurumurthy, *Demystifying artificial intelligence*, Deloitte University Press, November 4, 2014; Tiffany Dovey Fishman, William D. Eggers, and Pankaj Kishnani, *AI-augmented human services*, Deloitte University Press, October 18, 2017; and Deloitte analysis.

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1. **Moore's Law:** The exponential growth in computing power at a given price has facilitated advances in computer systems that may not have been practical a few years ago.

2. **Big data:** The rapid increase in the volume of data available has been a boon for some cognitive technologies. AI techniques that use statistical models to determine probabilities related to data can now improve their performance by training on large data sets.

3. **The Internet and the cloud:** The rise of the Internet and cloud computing technology has enabled humans to collaborate with each other to train AI systems.[6]

4. **New algorithms for machine learning:** Increasingly sophisticated algorithms have improved the performance of machine learning (which is the underlying technology for many other cognitive technologies such as computer vision) by improving the accuracy of data pattern identification and predictions. Many of these algorithms are available on an open-source basis.

Riding the cognitive technology wave: Guidelines for organizations

Despite the benefits that cognitive technologies offer, the decision to become a cognitive organization should be well-considered and grounded in reasonable expectations. While there are no hard and fast rules, some high-level guidelines can be of help to stakeholders as they consider their cognitive plans:

- Understand each cognitive technology—what it does well and how it is limited
- Leverage the current organizational strengths in big data and analytics; form internal teams dedicated to cognitive applications
- Create a portfolio of value opportunities matched to processes and tasks after evaluating data bottlenecks, scaling challenges, and computing power

- Create pilots or proofs of concept for projects with potentially high business value
- Recognize that the more ambitious the project and the more unproven the technology, the greater the likelihood of failure (as is true of other technologies)
- Perhaps, most importantly, consider the *full* range of benefits that cognitive technologies may provide. Cognitive technologies are not just about cost-cutting automation applications; they are as much, if not more, about smarter, better predictive insights.

Where is the cognitive world heading?

Industries are deploying cognitive technologies in their products, processes, and services. Between 2017 and 2021, global spending on AI-focused systems—including AI-focused hardware, software, and services—is expected to grow at a CAGR of 50 percent—reflecting some $200 billion in cumulative spending across an array of sectors including health care, retail, banking, and manufacturing.[7] Top use cases are expected to be in object identification, image classification, and data processing.[8] Beyond the projected $200 billion in cumulative *direct* spending on AI-specific hardware, software, and services are the larger economic benefits made possible by cognitive technology deployments. We will discuss these later in this primer.

Broadly speaking, three types of players operate in cognitive technology:[9]

Platform companies provide the virtual cloud environment in which reams of user data are stored and analyzed and from which insights are drawn. Leading players in this space typically include large search engine and online retail entities.

Application companies provide the AI applications or programming to optimize the user data in the cloud environment to achieve some end objective. Common AI applications include process

optimization, image recognition, and predictive maintenance.

Capabilities companies are the players that actually work with the data housed on the AI platforms to drive actionable insights.

Brace yourself for hurdles when you begin

Despite the hype, most organizations are at a nascent stage in adopting cognitive technologies in their processes and offerings. Even among organizations within the same industry, adoption levels vary.[10] Some factors that could explain the disparity between expectations and adoption levels include:

- **Challenges in integration:** One hurdle to adoption is integrating cognitive technology with existing systems.[11] Respondents to Deloitte's 2017 survey on cognitive technologies identify integration with existing systems and workflows as the single biggest hurdle that companies face in adopting cognitive technologies.[12] Considering that cognitive technologies perform individual tasks and not complete processes, organizations should consider the feasibility of integrating them with existing systems.[13]
- **Lack of understanding of cognitive technologies:** In Deloitte's survey on cognitive technologies, 40 percent of respondents cited a lack of understanding about how to use cognitive technologies to meet business needs as a key challenge.[14] On the contrary, most organizations that *are* successful in adopting cognitive systems have a good understanding of these technologies, including what can be accomplished, the data required for training the algorithms, and the training processes involved, among other factors.
- **Shortage of technical talent:** Another barrier that many organizations continue to struggle with according to Deloitte's survey is the lack of talent with technical skills and experience.[15] Organizations that lack the required in-house talent can rope in external cognitive service provid-

ers for short-term needs. For long-term needs, training employees on the required skill set can help in developing a pool of technical experts.

- **Change management challenges:** Almost invariably, technology transformations are accompanied by a flurry of change management challenges, since most require work redesign. Adoption of automated systems can often lead to lower employee morale and reduced satisfaction and productivity, which in turn could alienate the workforce. Workers may need to acquire new skills. Thus, it's important to roll out upskilling programs to promote continuous improvement and for learning needs to become "business-as-usual" for organizations.[16] Many respondents to the 2017 survey say they are already offering such programs.

Other commonly cited challenges in adopting cognitive technologies include their cost and state of "maturity" to drive competitive advantage.[17]

What's possible with cognitive technologies today?

Despite challenges, many organizations across industries are using cognitive technologies to relieve various business pain points and realize the benefits that they bring. Based on how cognitive technologies can support business needs, we tend to organize them under three broad categories:

Robotics and cognitive automation: Essentially the coupling of RPA and data science, robotics and cognitive automation involves the automation of repetitive manual tasks and workflows by allowing machines or RPA bots to replicate human actions and judgments (figure 1). Well suited for time-consuming, routine, and information-intensive tasks such as invoice processing and claims settlement, process automation is the least expensive of automation technologies and the easiest to implement. It often results in headcount reduction and accompanying bottom-line cost savings. Pro-

Figure 1. Benefits of robotics and cognitive automation

Benefits	Pain point reviewed

Reduce cost Increase speed   Backlogs   Paperwork burden
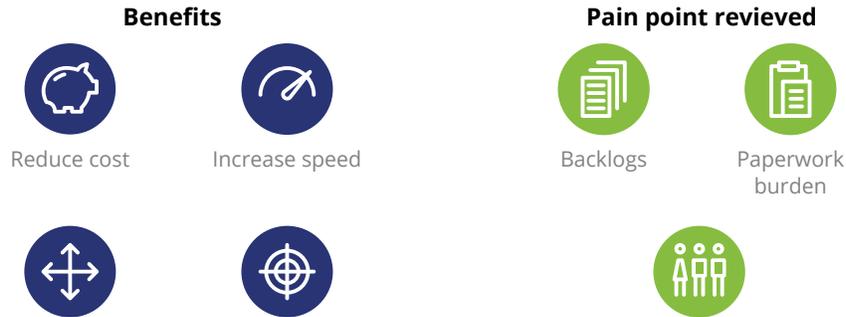
cess automation also allows organizations to reap significant productivity gains relatively easily "without undergoing a major process redesign," as well as greater process consistency and quality.[18] Besides, this approach can free up employees to focus on higher-value work that entails uniquely human capabilities such as empathy or emotions.[19]

Process automation used with cognitive technologies would make it possible to achieve previously unachievable speed, scale, and volume. Take, for example, e-discovery (electronic document discovery) used in the discovery phase of legal cases, which allows lawyers to sift through large document dumps to locate relevant cases. E-discovery can locate 95

percent of the relevant documents against humans' 50 percent, in a fraction of the time.[20]

Cognitive insights: Cognitive technologies such as machine learning (ML) and natural language processing (NLP) can find complex patterns in data that are not easily identifiable by humans and help organizations make better decisions and more accurate predictions (figure 2). For example, organizations can predict consumer purchases, recognize fraudulent credit card activity, automate personalized targeting of digital ads, and identify promising drugs in pharmaceuticals. When embedded with sensors and cameras, these cognitive technologies can allow tracking and reporting of structured and unstructured information in real time.

Figure 2. Benefits of cognitive insight applications

Benefits	Pain point reviewed

More accurate prediction   Anomaly detection   Real-time tracking   Manual pattern detection

Improve resource allocation   Better decision making   Increase effectiveness   Missing key Patterns

Source: Deloitte analysis.

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Figure 3. Benefits of cognitive engagement applications

Source: Deloitte analysis.

Some are potentially life-saving, such as physiological monitors that assist medics in prioritizing treatment by gauging the likely seriousness of wounds.[21]

Companies are even using cognitive insights applications to make available new data for better analytics. A large company, for example, is using ML-based probabilistic matches to integrate supplier data and thereby eliminate redundancies and maintain parity in business negotiations. This effort has helped it save about $80 million in the first year itself.[22]

Cognitive engagement: From answering customer queries to providing technical support to employees, an increasing number of applications are now available that enable businesses to provide language- or image-based personalized information and services, with minimum or no human involvement (figure 3). Commonly known as chatbots or intelligent agents, these applications use cognitive technologies such as NLP to perform these tasks. This category also includes the use of machine vision to increase engagement, such as with a smart retail catalog application.

Chatbots have progressed from simply answering customer queries through a chat window to gauging customer mood while answering queries

and even acting as a virtual counselor to help people cope with depression.[23] Furthermore, some organizations are adopting chatbots for internal enterprise and business-to-business applications. For example, one state government is piloting a chatbot to help internal IT helpdesk employees in password resets, which comprise about 80–90 percent of tickets, freeing state government employees for more strategic tasks.[24]

While these three categories look at cognitive technologies through the lens of business capabilities, we also look at the current and upcoming industry-specific applications of these technologies (table 2).

All set to reap the benefits of these technologies?

Organizations in many sectors are using cognitive technologies in diverse business functions. But what is driving the interest in these technologies across industry and functional boundaries? One possibility is the potential business benefits emanating from cognitive technologies that go *beyond* cost savings.

Table 2. Industry-specific applications of cognitive technologies

Industries	Current applications	Potential applications on the horizon
Financial services	• Automated fraud detection in credit cards, insurance, etc. • Automated execution of stock trades[25]	• Improve performance of funds[26] • Detect market manipulation[27]
Health care	• Transcribing/interpreting notes dictated by physicians • Automated medical imaging and mammography[28]	• Automated and more accurate diagnosis[29] • Predicting and analyzing treatments[30]
Life sciences	• Drug discovery and development[31]	• Smart supply chains[32]
Public sector	• Answering citizen queries through chatbots[33, 34] • Disease surveillance[35]	• Predictive emergency management[36] • Predictive policing[37]
Oil and gas	• Locate energy and mineral deposits[38] • Predictive equipment and asset[39]	• Optimizing energy flow out of batteries and points of consumption[40]
Manufacturing	• Identify product defects, conduct quality checks, detect causes of incidents, and analyze incident trends[41]	• Automated planning of business operations[42]

Source: Deloitte analysis.

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Deloitte's survey on cognitive technologies points to some of these benefits that users are already enjoying beyond automation and cost cutting: Enhanced product performance, better and faster decision-making, improved outcomes, optimal resource allocation, greater efficiency, product and service innovation, and quicker scaling of operations.[43] In addition, the survey suggests that the adoption of cognitive technologies is instilling greater worker freedom and creativity.[44] Cognitive technologies also present the opportunity to transform how organizations *get work done* by breaking the trade-offs between speed, cost, and quality.[45]

As Deloitte's survey suggests, cognitive technologies are already changing how work gets done, how decisions are made, and how machines drive interactions and outcomes for many organizations of all sizes and in all industries. And as time passes, the story of how cognitive technologies bring about process efficiencies and better insights will likely only evolve in ways we can barely fathom today. This means that starting now, senior business and public-sector leaders should consider reflecting on how their organizations could be impacted by the use of these technologies and the repercussions of being left behind in the race.

Final thoughts

There is no single way in which organizations will or should adopt cognitive technologies. Much depends on what an organization is trying to achieve and the culture within which it operates. Some could choose to take a measured approach, perhaps cautious about the still early stages of development that mark cognitive transformations. Others may go all in, accustomed to the uncertainties that often

accompany early-stage emerging technologies. The larger point, though, is that cognitive technologies are here and the advantages they offer are real and diverse, extending well beyond traditional applications like process automation and headcount reduction. As the cognitive story evolves in the years ahead—and the benefits that ensue become ever richer in their variability—the companies that aggressively adopt it today may well enjoy a leg up on those that wait until tomorrow.

Finally, as organizations adopt cognitive technologies, it's important to remember that technology alone does not create competitive advantage. While cognitive technologies can replace some human tasks and decision-making, sustainable competitive advantage is likely to be achieved by augmenting and amplifying human capabilities—not just replacing or replicating them.

ENDNOTES

1. Erik Brynjolfsson, Daniel Rock, and Chad Syverson, "Artificial intelligence and the modern productivity paradox: A clash of expectations and statistics," *NBER*, November 2017.

2. David Schatsky, Craig Muraskin, and Ragu Gurumurthy, *Cognitive technologies: The real opportunities for business,* Deloitte University Press, January 26, 2015.

3. David Schatsky and Vikram Mahidhar, *Intelligent automation: A new era of innovation,* Deloitte University Press, January 22, 2014.

4. BMWA, "What is computer vision?," accessed January 19, 2018.

5. Schatsky, Muraskin, and Gurumurthy, *Demystifying artificial intelligence.*

6. Google, "Google translate community," accessed February 5, 2018.

7. International Data Corporation, "IDC spending guide forecasts worldwide spending on cognitive and artificial intelligence systems to reach $57.6 billion in 2021," September 25, 2017.

8. Tractica, "Top 10 artificial intelligence use cases," Twitter, accessed January 19, 2018.

9. McCafferty & Company, "Artificial intelligence industry primer," May 2017.

10. Deloitte, *2017 cognitive technologies survey: Early adopters speak out on cognitive and AI,* August 2017.

11. Thomas H. Davenport and Rajeev Ronanki, "Artificial intelligence for the real world," *Harvard Business Review,* January–Feruary 2018.

12. Deloitte, *2017 cognitive technologies survey.*

13. Davenport and Ronanki, "Artificial intelligence for the real world."

14. Deloitte, "2017 Deloitte state of cognitive survey."

15. Ibid.

16. Jacques Bughin, Brian McCarthy, and Michael Chui, "A survey of 3,000 executives reveals how businesses succeed with AI," *Harvard Business Review*, August 28, 2017.

17. Deloitte, *2017 cognitive technologies survey.*

18. Davenport and Ronanki, "Artificial intelligence for the real world."

19. William D. Eggers, David Schatsky, and Peter Viechnicki, *AI-augmented government: Using cognitive technologies to redesign public sector work*, Deloitte University Press, April 26, 2017.

20. Anne Kershaw, "Talking tech: Automated document review proves its reliability," *Digital Discovery & e-Evidence 5*, no. 11 (2005), pp. 10–12.

21. Eggers, Schatsky, and Viechnicki, *AI-augmented government.*

22. Forbes, "How AI and machine learning are helping drive the GE digital transformation," June 7, 2017.

23. Will Knight, "Andrew Ng has a chatbot that can help with depression," *MIT Technology Review*, October 18, 2017.

24. Justine Brown, "Chatbots debut in North Carolina, allow IT personnel to focus on strategic tasks," *Government Technology*, October 12, 2016.

25. F McGuire, "JPMorgan to unveil robot to execute stock trades," *Newsmax*, August 1, 2017.

26. Mike Sheen, "Baillie Gifford to leverage AI for fund performance boost," *Investment Week*, August 14, 2017.

27. Fortune, "How artificial intelligence could catch stock market cheaters," October 25, 2016.

28. Stacy Lawrence, "GE, Arterys ready launch for deep learning diagnostic system for cardiac MRIs," *Fierce Biotech*, February 18, 2016.

29. IBM, "Memorial Sloan-Kettering Cancer Center, IBM to collaborate in applying Watson technology to help oncologists," press release, March 22, 2012.

30. Fei Jiang et.al., "Artificial intelligence in healthcare: Past, present and future," *Stroke and Vascular Neurology*, June 2017.

31. Monica Heger, "AstraZeneca launches genomics initiative to drive drug discovery and development," *GenomeWeb*, April 21, 2016.

32. Kim S. Nash, "Merck deploys AI for 'self-driving' supply chain," *Wall Street Journal*, December 20, 2016.

33. Alka Bahal, "USCIS launches a virtual assistant and her name is EMMA," *Immigration View*, December 16, 2015.

34. Frost & Sullivan, "2016 global conversational AI and intelligent assistants technology innovation award," 2016.

35. MathWorks, "Centers for Disease Control and Prevention automates poliovirus sequencing and tracking," 2015.

36. Deloitte, *Augmented government: Transforming government services through augmented reality,* 2013.

37. Matt Meuse, "Vancouver police now using machine learning to prevent property crime," *CBC News*, July 22, 2017.

38. Lindsay Dodgson, "At the speed of thought: Cognitive technology in oil & gas," *Offshore Technology*, May 31, 2016.

39. Sundeep Sanghavi, "Why the time is right for cognitive predictive maintenance in oil, gas," *Hart Energy*, October 4, 2017.

40. Phil Goldstein, "What is the potential for AI in the energy industry?," *BizTech*, October 25, 2017.

41. NIKKEI Asian Review, "Toshiba taps AI to boost productivity at memory plant," June 29, 2016.

42. Brenna Sniderman, Monika Mahto, and Mark Cotteleer, *Industry 4.0 and manufacturing ecosystems*, Deloitte University Press, February 22, 2016.

43. Deloitte, *2017 cognitive technologies survey.*

44. Deloitte, "2017 Deloitte state of cognitive survey."

45. Schatsky, Muraskin, and Gurumurthy, *Demystifying artificial intelligence.*

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