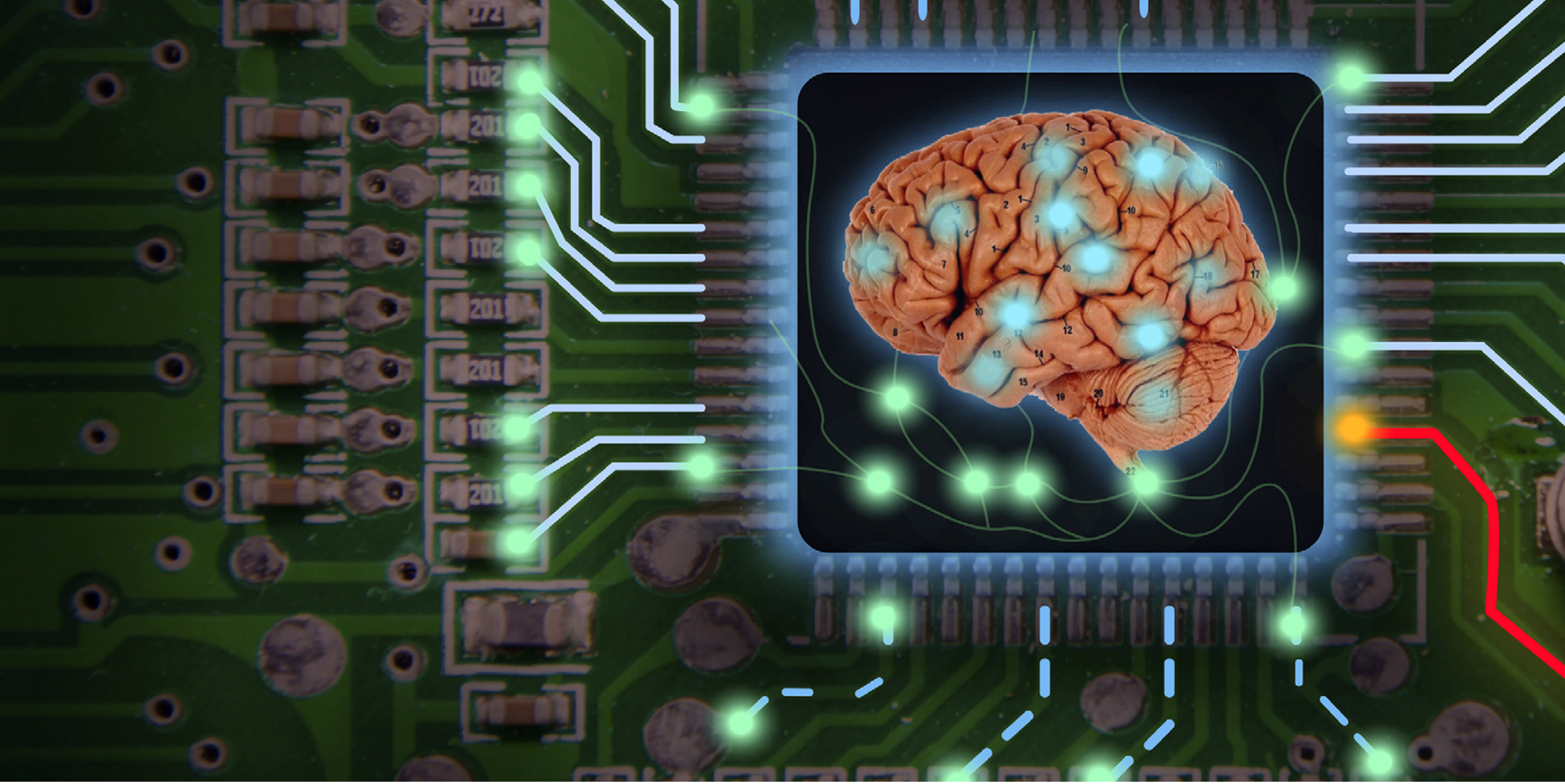


Your cognitive future

How next-gen computing changes the way we live and work

Part I: The evolution of cognitive

IBM Institute for Business Value

IBM Watson

Watson is a cognitive system that enables a new partnership between people and computers that enhances and scales human expertise. For more information about IBM's Watson, visit ibm.com/watson

IBM Strategy & Analytics

The IBM Strategy and Analytics practice integrates management consulting expertise with the science of analytics to enable leading organizations to succeed. For more information about IBM Strategy & Analytics offerings from IBM, visit ibm.com/services/us/gbs/strategy

Why cognitive should be on your radar

Organizations have just begun to scratch the surface of cognitive computing capabilities. From improving customer engagement to enhancing research capabilities that identify new life-saving medical treatments, the potential value is boundless. Through our research, we uncover multiple innovative opportunities across industries, creating chances for early adopters to achieve a substantial first-mover advantage. WinterGreen Research estimates the global healthcare decision support market alone will increase to more than $200 billion by 2019 as a result of new cognitive computing technologies.[1]

Executive summary

For decades, science fiction visionaries have shared their renditions of intelligent machines and computers that could learn and function as humans. Intelligent machines have since moved beyond the lore of science fiction; today, they are a reality thanks to breakthroughs in cognitive computing. Cognitive computing is here – and this innovative capability is becoming ubiquitous in our everyday lives and fundamentally changing how we perform our jobs, engage and interact with others, learn and make decisions. Pioneering organizations across industries and around the world are already leveraging its capabilities to realize significant business value and help solve some of society's greatest challenges.

We are entering a new era of computing. Following the programmable and tabulating systems eras, cognitive computing represents a huge leap forward. This new era brings with it fundamental differences in how systems are built and interact with humans.

In the programmable systems era, humans do most of the directing. Traditional programmable systems are fed data and their results are based on processing that is pre-programmed by humans. The cognitive era on the other hand is about thinking itself – how we gather information, access it and make decisions. Cognitive-based systems build knowledge and learn, understand natural language, and reason and interact more naturally with human beings than traditional programmable systems. The term "reasoning" refers to how cognitive systems demonstrate insights that are very similar to those of humans.

COG · NI · TIVE / käg-nə-tiv

(adjective): of, relating to or involving conscious mental activities (such as thinking, understanding, learning and remembering)

Three areas of cognitive capability are directly related to the ways people think and work.

Six forces will determine adoption and advancement rates for cognitive computing.

Five key dimensions will impact the robustness of future cognitive capabilities.

So what does cognitive computing do?

Cognitive computing…

- Accelerates, enhances and scales human expertise
- Captures the expertise of top performers – and accelerates the development of expertise in others
- Enhances the cognitive process of professionals to help improve decision making in the moment
- Scales expertise by quickly elevating the quality and consistency of decision making across an organization.

Cognitive systems are able to put content into context, providing confidence-weighted responses, with supporting evidence. They are also able to quickly find the proverbial needle in a haystack, identifying new patterns and insights. Over time, cognitive systems will simulate even more closely how the brain actually works.[2] In doing so, they could help us solve the world's most complex problems by penetrating the complexity of big data and exploiting the power of natural language processing and machine learning.

While tremendous advancements have been made over the past 50 years, cognitive computing is virtually in its infancy in terms of how this exciting technology could potentially evolve. Adopting and integrating cognitive solutions into an organization is a journey and not a destination. Therefore, organizations need to set realistic expectations and develop long-term plans with incremental milestones to benefit from the technology's future progression. Based on experience with clients and extensive research, we have identified multiple opportunities across industries for innovative application of cognitive computing today, as well as examined how the technology might evolve in the future.

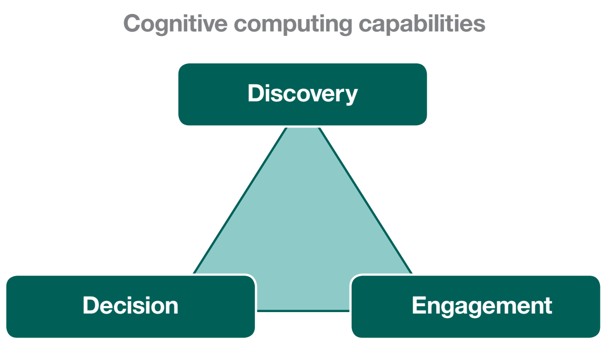
In this, the first in a series of reports based on the IBM *Your cognitive future* research study, we explore three capability areas for cognitive computing. We also discuss how future opportunities will be influenced by the evolution of cognitive computing capabilities, such as advancements in machine learning techniques, and how adoption will be impacted by multiple forces, from societal views to policies and skills. In the second report, we will explore lessons learned from pioneering early adopters and provide insights on how you can prepare to take advantage of cognitive computing solutions.

The three capability areas for cognitive

We see three broad areas of capability for cognitive systems. Opening new doors for innovations, these capability areas directly relate to the ways people think and work and demonstrate increasing levels of cognitive capability. Significant progress has been made across each of these capability areas, and opportunities for future evolutions of capability look promising, as they continue to gain momentum in a number of industries.[3] It is important to note that these capabilities are not mutually exclusive. A specific business solution may in fact leverage one or more of these capability areas.

Figure 1

There are three emerging capability areas for cognitive computing



Source: IBM Institute for Business Value analysis.

"The current capabilities of cognitive computing are just the beginning of what can be."

Dr. Manuela Veloso, Professor of Computer Science, Carnegie Mellon University

Engagement – These systems fundamentally change the way humans and systems interact and significantly extend the capabilities of humans by leveraging their ability to provide expert *assistance* and to *understand*. These systems provide expert assistance by developing deep domain insights and bringing this information to people in a timely, natural and usable way. Here, cognitive systems play the role of an assistant – albeit one who is tireless, can consume vast amounts of structured and unstructured information, can reconcile ambiguous and even self-contradictory data, and can learn. In this partnership, the two – human and machine – are more effective than either one alone.

Much like the human brain, these systems begin to build models of themselves and the world around them. This world consists of the system itself, the knowledge ingested from information corpora and the users of the system. The models include the contextual relationships between various entities in a system's world that enable it to form hypotheses and arguments. As a result, these systems are able to engage in deep dialogue with humans. Significant and proven capabilities have been built around this capability area. In the future, increasingly more domain-specific question and answer (Q&A) systems are expected to emerge. Many of them are likely to be pre-trained with domain knowledge for quick adoption in different business-specific applications. Additionally, future cognitive systems will advance to have free form dialogue and reasoning capabilities.[4] (See *Case study: Leveraging cognitive computing to assist military members in transitioning to civilian life*.)

Case study

Leveraging cognitive computing to assist military members in transitioning to civilian life

USAA, a financial services company, provides banking and insurance services to 10.4 million past and present members of the U.S. Armed Forces and their immediate family members, including veterans making the often difficult transition from military to civilian life. Like any career change, moving from a military to a civilian career presents challenges to members and their families. The process can be complex and intimidating as many do not know which questions to ask and concepts to consider in making the transition. To better service these customers, USAA has implemented an innovative cognitive computing solution leveraging IBM's Watson.

This solution allows transitioning military members to visit usaa.com or use a mobile browser to ask questions specific to leaving the military, such as "Can I be in the reserve and collect veterans compensation benefits?" or "How do I make the most of the Post-9/11 GI Bill?" Starting with 2,000 questions, a team spent more than six months training and educating the system. In addition, the solution analyzed and understands more than 3,000 specialized military transition documents. The system's natural language processing allows it to understand real questions asked in diverse ways and provide expert advice directly to customers. As a result, USAA is able to provide customers comprehensive answers to complex questions in a non-judgmental environmental.[5]

Decision – These systems have decision-making capabilities. Decisions made by cognitive systems are evidence-based and continually evolve based on new information, outcomes and actions. Decisions made by these systems are also bias free; however, certain standards are required for humans to fully trust their decisions. Currently, cognitive computing systems perform more as advisors by suggesting a set of options to human users, who ultimately make the final decisions. (See *Case study: Cognitive computing solution helps support decision making for improved patient care.*) Confidence in a cognitive system's ability to make decisions autonomously depends on the ability to query and have traceability to audit why a particular decision was made, as well as improved confidence scores of a system's responses. A confidence score is the quantitative value produced by a system representing the merit of a decision after evaluating multiple options.[6]

Discovery – Discovery is the epitome of cognitive capability. These systems can discover insights that perhaps could not be discovered by even the most brilliant human beings. Discovery involves finding insights and connections and understanding the vast amounts of information available around the world. With ever-increasing volumes of data, there is a clear need for systems that help exploit information more effectively than humans could on their own.[7] While still in the early stages, some discovery capabilities have already emerged, and the value propositions for future applications are compelling. Advances in this capability area have been made in specific domains, such as medical research, where robust corpora of information exist.[8] (See *Case study: Cognitive computing solution supports new discoveries and insights in medical research.*)

Case study

Cognitive computing solution helps support decision making for improved patient care
WellPoint, Inc., one of the largest health benefits companies in the United States, delivers a number of health benefit solutions through its networks nationwide. Utilization management nurses spend 40 to 60 percent of their time aggregating information that is faxed or mailed to them to decide whether requests for procedures should be approved or denied based on evidence-based medicine and WellPoint medical policies. For complex decisions, patients can often wait weeks for the clinical review to occur, and a lack of available evidence or the ability to process in a timely fashion can delay treatment or lead to errors. Also, it is extremely challenging for medical professionals to keep up with the rapid advancements in medical knowledge.

To address these challenges, WellPoint implemented a cognitive computing solution powered by IBM's Watson that provides decision support for the pre-authorization process. The solution bases recommendations on its ability to interpret meaning and analyze queries in the context of complex medical data and human and natural language, including doctors' notes, patient records, medical annotations and clinical feedback. As the solution learns, it becomes increasingly more accurate. Even if nurses have to do additional research on a request, Watson's ability to aggregate the information and present it to them in a readable, structured format saves a lot of time. Providing decision support capabilities and reducing paperwork allows clinicians to spend more time with patients.[9]

Case study

Cognitive computing solution supports new discoveries and insights in medical research

Baylor College of Medicine, a leading health sciences university, is constantly looking for innovative approaches to advance and accelerate medical research. The time needed for research professionals to test hypotheses and formulate conclusions currently ranges from days to years. A typical researcher reads about 23 scientific papers per month, making it humanly impossible to keep up with the ever-growing body of scientific material available. Biologists and data scientists at Baylor have leveraged a cognitive computing system powered by IBM's Watson in their Baylor Knowledge Integration Toolkit (KnIT) to accelerate research, unlock patterns and make discoveries with greater precision.

The system is trained to "think" like a human research expert by unlocking insights, visualizing possibilities and validating theories at much greater speeds. Leveraging this solution, researchers identified proteins that modify p53, an important protein related to many cancers, which can eventually lead to better efficacy of drugs and other treatments in just a matter of weeks. The solution analyzed 70,000 scientific articles on p53 to predict proteins that turn on or off p53's activity – a feat that would have taken researchers years to accomplish without cognitive capabilities. As a result, cancer researchers have a variety of new directions in which to target their research.[10]

The future evolution of cognitive

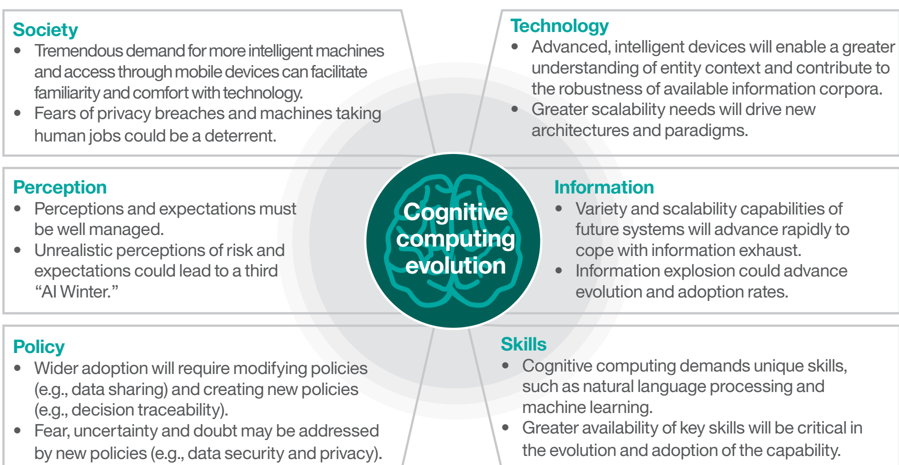
The future of cognitive computing – both how it advances as a technology and the rates of adoption in the public and private sectors – will be greatly affected by external forces, as well as technology evolutionary paths and trends.

Six major forces

Six forces will influence the future of cognitive computing and affect the rate of adoption in both the public and private sectors.

Figure 2

Six forces are impacting the evolution of cognitive computing



Source: IBM Institute for Business Value analysis.

"The degree of data sharing will likely impact the adoption of cognitive computing solutions; however, the technical side is fascinating. Policies can clearly impact technology but the hope is that the capability will still move forward."

Dr. Manuela Veloso, Professor of Computer Science, Carnegie Mellon University

"The traceability of the machine recommendations (i.e., why a recommendation was made) will be important in fostering confidence and trust."

Dr. Francesca Rossi, Professor of Computer Science, University of Padova and Harvard University

Society – At the societal level, there will be two opposing forces at work. One will push toward the technology, as the demand for more and more intelligent machines increases over time, and the desire to access them through personal mobile devices grows as well. This increased access and exposure to cognitive capabilities through mobile devices has the potential to increase both familiarity and comfort with the technology. However, there will still be an opposing force looking to slow adoption as broader understanding and enablement of cognitive computing occurs.

Technology – There is already a strong belief among subject-matter experts that current computer architectures and programming paradigms must advance to take cognitive computing to the next level. Technology advances, including natural language processing, neuromorphic computers, unsupervised machine learning algorithms (i.e., deep learning) and virtual reality devices, may help in this evolution. Advances in intelligent devices (e.g., mobile devices and the Internet of Things [IoT]) will enable greater understanding of entity (e.g., people and assets) context, which can contribute greatly to the robustness of available information corpora available to cognitive systems.

Perception – The value proposition of cognitive computing is compelling, and many pioneering organizations are already realizing economic value. However, perceptions need to be well managed and grounded in reality. Otherwise, the disparity between vastly different views combined with misinformation could lead to another "AI Winter," which refers to a period of reduced funding and interest in artificial intelligence research.[11] Educating the market about the realities and potential value of cognitive computing is crucial to successful perception management.

Information – IDC projects that the digital universe will reach 40 zettabytes (ZB) by 2020. To put this number into perspective, consider that 40 ZB is equal to 57 times the amount of all the grains of sand on all the beaches on earth.[12] This information explosion – driven in part by the rapid growth of mobile devices and social media – has accelerated the growth and application of cognitive computing. It is now nearly humanly impossible across vocations to keep pace with the growing volume and velocity of information available today. As the explosion reaches increasing orders of magnitude, cognitive computing will likely be forced to evolve more rapidly. The variety and scalability of capabilities for future cognitive systems will have to advance rapidly to cope with this information exhaust.

Policy – Wider adoption of cognitive computing across domains will likely require that policies advance (e.g., data sharing, data security and privacy). Additionally, there may be requirements for entirely new policies in response to advancements in cognitive capabilities. For example, in the case of machine autonomous decision making (i.e., "decision" capability area), policies addressing the traceability of the decision-making process may need to be added. Additionally, in response to fear, uncertainty and doubt, authorities around the world should review policies to help ensure they both responsibly progress the capability of cognitive computing and protect citizens.

Skills – A key challenge for the advancement of cognitive computing will be the availability of skilled humans. Advancing cognitive computing capabilities and implementing cognitive systems require unique skill sets, such as those of machine learning experts and natural language processing scientists. These skills are currently in high demand and limited supply.

"There are concerns over another 'AI winter.' Education programs will be key to grow cognitive systems capability, and IBM is doing a significant amount of work in this area."

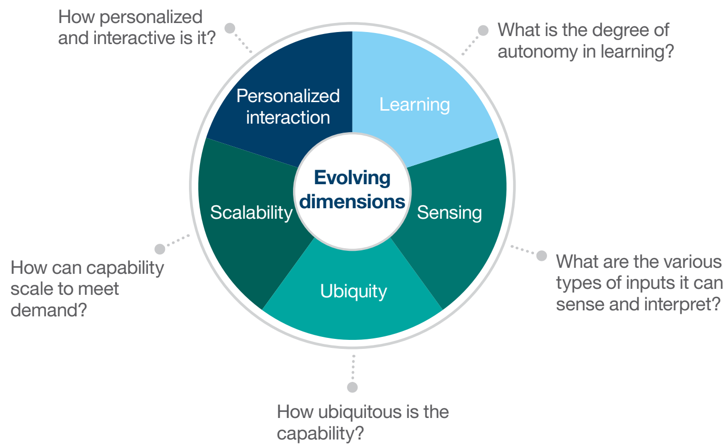
Dr. Jim Spohrer, Director Global University Programs, IBM Research

Five key dimensions

How the three capabilities of cognitive computing evolve will depend on five important dimensions. The evolution path and rate of advancement across these dimensions will impact the robustness of future capability.

Figure 3

There are five evolutionary dimensions of cognitive computing



Source: IBM Institute for Business Value analysis.

Personalized interaction – Current cognitive systems are predominantly passive in nature and require that human beings initiate action to generate an output or response. Often this interaction is through text typed on a computer, mobile app or web portal. Future cognitive systems will increasingly enable enhanced natural interaction with users including voice and visualization. Future systems will become increasingly more interactive and engaging. Significant advancements have already been made to better understand users and deliver responses fit for the user's specific locative and temporal context.

Learning – Current cognitive systems are predominantly trained systems (supervised learning). These systems rely upon humans with domain-specific subject matter expertise to train them. This process can be more labor intensive and time consuming. Future cognitive systems will adopt greater unsupervised learning, which will require much less human interaction in the system training process. The research community is actively looking to make breakthroughs in this area.

Sensing – Current cognitive systems primarily work with natural language text and require natural language processing capability for a particular language. Natural language processing capabilities for English and Western European languages are more advanced today. Future generations of cognitive systems will accommodate a variety of media beyond text (e.g., audio, image, video). Continued advancements in this dimension will be dependent on various disciplines of computer science (e.g., speech and image processing, pattern recognition).

"We're just at the beginning of this cognitive computing era."[13]

Dr. John Kelly, IBM Senior Vice President and Director of IBM Research

Ubiquity – Cognitive systems are increasingly being deployed to be widely available and accessible over web portals, mobile apps and cloud. In the future, as the adoption of cognitive-based systems increases, they will eventually spread to become ubiquitous. This future could include a marketplace with millions of cognitive agents or avatars, driven in part by the explosive adoption of mobile devices, the IoT and the upsurge of machine-to-machine interaction. Tomorrow's cognitive computing fabric will be interwoven into technology (such as social media), thereby touching our daily lives.

Scalability – Cognitive systems need to continue to increase in scalability to support wide applicability. In 2011, the version of IBM's Watson system that beat the reigning champion on the U.S. television game show Jeopardy! required 90 IBM Power 750 servers. By January 2014, Watson was 24 times faster, had a 2,400 percent improvement in performance and was 90 percent smaller.[14] In the future, cognitive systems may be offered as a fabric. IBM has already made its Watson technology available as a development platform in the cloud, which is spurring innovation and fueling a new ecosystem of entrepreneurial software application providers.[15] WayBlazer, a travel inspiration, recommendation and planning platform that provides consumers with more personalized, relevant and valuable information, is one example of a partner realizing value in this ecosystem model. WayBlazer uses a standards-based cognitive cloud powered by IBM Watson technology to recommend targeted travel insights and commerce offers that are tailored and customized for each consumer's experience.[16]

Ready or not? Ask yourself these questions

- What opportunities exist to create more engaging and personalized experiences for your constituents?
- What data aren't you leveraging that – if converted to knowledge – would allow you to meet key objectives and business requirements?
- What is the cost to your organization associated with making non-evidence-based decisions or not having the full array of possible options to consider when actions are taken?
- What benefit would you gain in being able to detect hidden patterns locked away in your data? How would this accelerate research, product development, customer services and the like?
- What is your organizational expertise skill gap? What would change if you could equip every employee to be as effective as the leading expert in that position or field?

Cognitive computing has the potential to provide significant business and economic value to organizations across industries. Stay tuned for the next in the series of reports from the IBM *Your cognitive future* study, where we will explore lessons learned from pioneering early adopters and provide recommended steps for your organization to gain first mover advantage and begin creating new opportunities.

For more information
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Study approach and methodology

In the summer of 2014, the IBM Institute for Business Value initiated a study focused on addressing three questions related to cognitive computing:

1. What is the current state of cognitive computing and how is it expected to evolve?
2. What lessons can be learned from pioneering organizations that have implemented cognitive computing solutions across various industries?
3. What are the key strategy and planning considerations and what steps can leaders take to make cognitive computing a reality in their organization?

To address these questions, we conducted interviews with dozens of global subject matter experts (SMEs) in various areas related to the emerging field of cognitive computing. SMEs included members of industry with experience in implementing real-world cognitive computing solutions across multiple domains (e.g., program executives and technical leaders of cognitive computing system implementations) and members of industry and academia focused on cognitive computing research and development across multiple research areas (e.g., professors of computer science at leading universities, members of the Association for the Advancement of Artificial Intelligence [AAAI]). Interviews focused on gaining insights on the future of cognitive computing and the forces likely to impact the direction of this technology, as well as harvesting lessons learned from real-world systems being implemented by pioneering organizations.

About the study executive leaders

Jay Bellissimo is the General Manager of Watson Transformations in IBM's Watson Group. Jay is responsible for helping drive the next era of computing – cognitive computing – by creating markets, transforming industries and helping clients explore new business models to take advantage of the many benefits of cognitive computing. He can be reached at joseph.bellissimo@us.ibm.com.

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