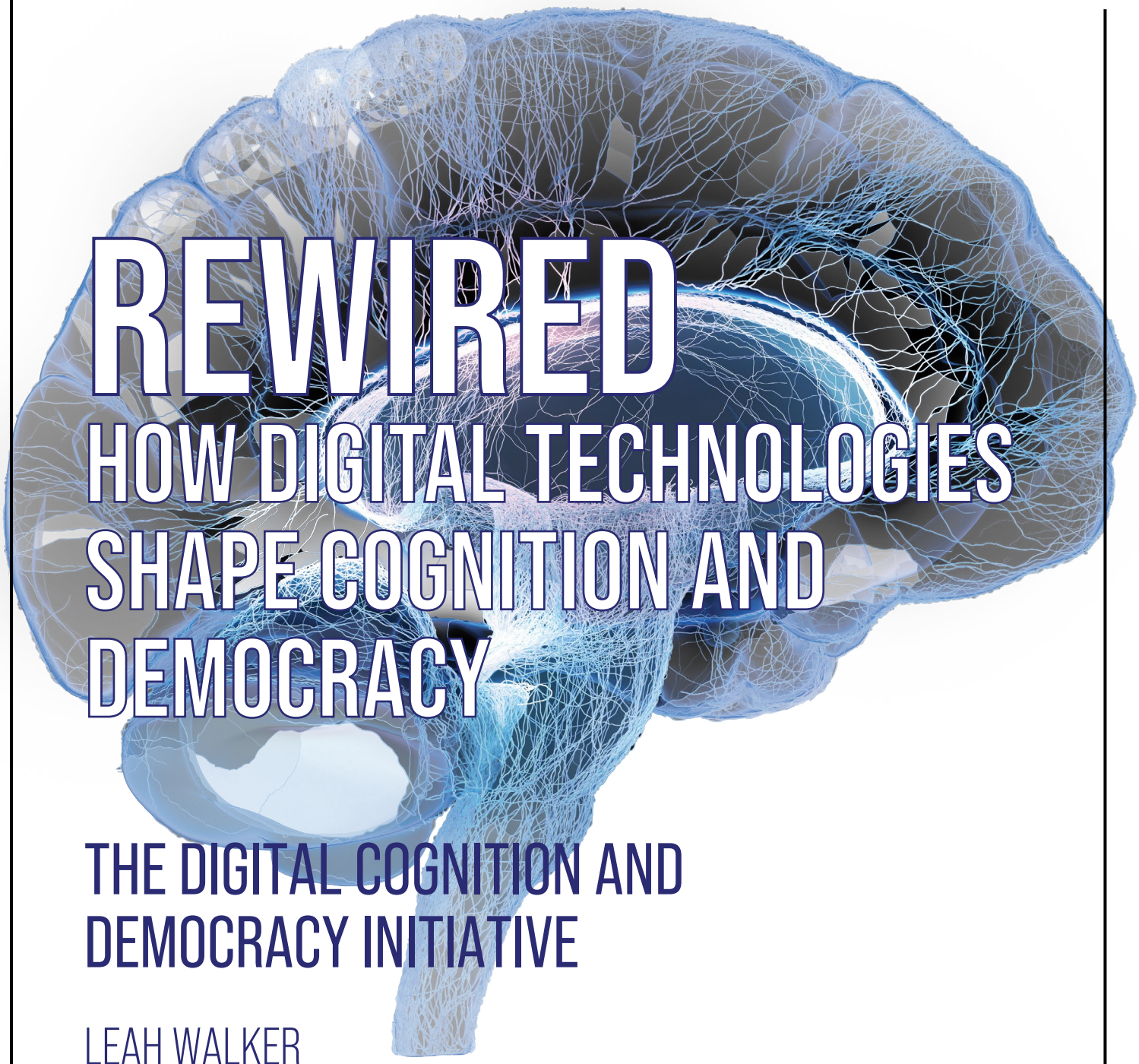
DIGITAL COGNITION AND DEMOCRACY INITIATIVE



REWIRED

HOW DIGITAL TECHNOLOGIES SHAPE COGNITION AND DEMOCRACY

THE DIGITAL COGNITION AND DEMOCRACY INITIATIVE

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IST Institute for SECURITY + TECHNOLOGY

Rewired: How Digital Technologies Shape Cognition and Democracy
The Digital Cognition and Democracy Initiative

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IST

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As new technologies present humanity with unprecedented capabilities, they can also pose unimagined risks to global security. The Institute for Security and Technology's (IST) mission is to bridge gaps between technology and policy leaders to help solve these emerging security problems together. Uniquely situated on the West Coast with deep ties to Washington, DC, we have the access and relationships to unite the best experts, at the right time, using the most powerful mechanisms.

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Acknowledgments

The Digital Cognition & Democracy Initiative is a robust coalition of concerned practitioners, researchers, and technologists seeking to understand how digital technologies affect human cognition and what those effects mean for democracy, to identify mitigation strategies for potential risks posed, and to blunt the negative impacts of disinformation on our societies. The Initiative started in Summer of 2020, as a follow-on project to the Institute for Security and Technology's (then Technology for Global Security) 2019-2020 Future Digital Threats to Democracy (FDTD) project, a collaboration with the Center for a New American Security (CNAS).

Together with an exceptional Advisory Committee and a powerful coalition of more than 50 experts, IST has been conducting research, convening working groups and workshops with interdisciplinary experts, and developing analysis and publications.

DCDI Advisory Committee

DCDI Advisory Committee (cont.)

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Thank you to all those involved in this initiative to date, from the coalition members to those who granted us interviews and technical insights. We thank everyone who participated in our working groups and workshops, who agreed to be interviewed, and who have contributed to making this initiative possible. We particularly thank our Advisory Committee, who has provided this initiative, and the IST team, with their invaluable time, counsel, and guidance.

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Executive Summary

The Digital Cognition and Democracy Initiative (DCDI) is dedicated to understanding how digital technologies influence human cognition, and how that in turn has implications for democracy. As political differences increasingly erupt into violence, the democratic social fabric is arguably at greater risk today than it has been in generations.

DCDI is driven by a key question:

> *How do digital technologies affect our cognition in a way that makes us more susceptible to disinformation, affective polarization, and anti-democratic behavior?*

IST has spent two years researching and convening experts across multiple disciplines, including neuroscience, psychology, social science, and tech policy, among others, to better understand the nature of this new techno-cognitive reality. This report summarizes our assessments based on the work of the DCDI coalition over the last 10 months.

To illustrate these findings, this analytical report takes an escalating three-tiered approach: examining how effects of digital technologies on cognitive processes then affect the individual and society.[1] At Tier 1, the most basic cognitive level, we hone in on the processes of memory, attention, and reasoning. At Tier 2, taking into consideration the combinatorial implications for individuals, we focus on critical thinking, trust, and emotions. Finally, at Tier 3, the analysis delves into how these insights drive societal level issues, namely the susceptibility to disinformation and affective polarization. We attribute these negative effects to two forms of digital technologies: 1) **those**

1 This is not to say that technology does not affect society or the individuals directly, nor should this be taken as an assertion that those effects do not in turn influence cognition. Rather, for the scope of this paper, the focus lies in better understanding how digital technologies affect individuals, cognition, and society.

that affect and manipulate cognition, and 2) **those that outsource cognitive functions**.

To develop a model for understanding these effects, we propose a **Framework on Techno-Cognitive Risks** that identifies the precise elements of digital technologies that may lead to areas of concern or vulnerability from the fundamental cognitive level up to the societal level. This framework identifies 12 risks (see page 39) that emerge from 4 main features of technology in our increasingly digital world: **1) Design and Gamification**; **2) Unnaturally Immersive and Easy Experience**; **3) Lack of Friction**; and **4) Information Overload**. It is through the identification of these specific risks within these technology-driven domains that focused efforts can work to mitigate the threats to democracy we see today.

This report also reviews the background of the DCDI initiative, the research and convening processes, the focus areas, the findings, and lastly, additional resources and next steps in the research.

Introduction: Why Digital Cognition and Democracy?

While disinformation, affective polarization, and anti-democratic behavior have always existed, the growing scale of these problems, aided in part by the evolving Internet landscape, poses novel threats to democracy. It is our belief that as our reliance on digital technologies grows, we become increasingly susceptible to the first two issues, which in the most extreme cases can lead to the third. While we may never be able to fully combat the existence and spread of malign information, we do believe that understanding factors that make humans increasingly susceptible to disinformation and affective polarization will empower us to devise policies and technical solutions to foster a more resilient democratic society.

Over the past several decades, digital technologies have rewired the patterns of building, sharing, and disputing the information that fuels democratic government. In a culture that embraces “hacking” everything from nutrition to mental health, digital tools increasingly alter how individuals participate in democratic societies, creating an ever tightening feedback loop of digitally-influenced change. Some of these changes can be good. Digital communications platforms can increase access to information, help society build networks across larger geographic areas, and increase accountability for government officials. But some changes present threats to democracy, including those discussed in the prior Institute for Security and Technology publication series, "Future Digital Threats to Democracy," from the monetization of attention, to “reality apathy,” to weaponized information.[2]

2 "Future Digital Threats to Democracy," *Institute for Security and Technology*, accessed September 15, 2022, https://securityandtechnology.org/ist-policy-lab/in-the-works/future-digital-threats-to-democracy/; Alexa Wehsener, "Digital Threats to Democracy: Pay Attention," *Institute for Security and Technology*, July 2020, https://securityandtechnology.org/wp-content/uploads/2020/07/CNAS-Report-FTTD-Pay-Attention-3.pdf; Alexa Wehsener, "Digital Threats to Democracy: Comfortably Numb," *Institute for Security and Technology*, May 2020, https://securityandtechnology.org/wp-content/uploads/2020/07/cnas_report-fttd-comfortably_numb.pdf; M. Nina Miller, "Digital Democracy: A Double-Edged Sentence," *Institute for Security and Technology*, May 2020, https://securityandtechnology.org/wp-content/uploads/2020/07/cnas_report-hti-double-edged_sentencev.pdf.

Digital tools generate such effects by exploiting and even changing the way people think, feel, opine, believe, judge, reason, and trust.

Although researchers have long recognized that digital technology has a range of effects on cognitive processes, to date there have been few efforts to understand the scope and scale of the problem and how these tools impact every level of democratic information-processing. It is particularly important to understand how effects on cognition might aggregate up from individuals to broader society. Such an understanding is increasingly urgent, as proponents of democracy work to prevent further polarization, radicalization, and violence.

While there is an asymmetry of power between the largest technology platforms and the individuals who are influenced by these new curators of information, and some would argue even between the companies and our lawmakers, individuals are not helpless. The DCDI approach assumes that although digital tools are uniquely disruptive to cognition and democracy, people can take steps to adapt to and mitigate these harms. Given the wide range of effects of digital technologies we explore here, it is imperative that we ensure that our defenses are up, and that we learn how to evolve with the tools we adopt.

At the same time, simply understanding the transformation is insufficient without an effort to protect and improve human resilience to new technologies and to address core human vulnerabilities. The Digital Cognition and Democracy Initiative aims to prepare individuals, society, and relevant government institutions for the current and future digitally-mediated information environments.

A Different Information Revolution

A frequent response to those highlighting the impact of digital technologies on democracy is that information revolutions have occurred before and that democracy has survived. Those with this point of view argue that the current digital revolution is no different from those arising from the printing press, the telegraph, the telephone, and the Internet itself. Each of these events, however, caused important and often destabilizing social and political changes. And although previous generations were able to adapt using new social and institutional patterns of engaging and using information, those processes took generations—and sometimes resulted in widespread violence and even war. It is a logical leap to assume inevitably beneficial adaptation to digital technologies.

Additionally, major differences between today's digital technologies and earlier information revolutions revolve around velocity, scale, and precision—namely, microtargeting. Inventions like the telegraph and even the early Internet presented specific capabilities at single points in time. But in one human lifetime, computers transitioned from building-sized, plodding calculating machines to pocket-sized devices that process terabytes of information in milliseconds. In one decade, touch-screens went from novelty to ubiquity. Now, digital tools are updated in intervals of weeks or days. Information flows are algorithmically individualized based on hoards of behavioral data. People are regularly targeted with powerful, intentionally manipulative messaging. Humanity has never before seen the time-compressed convergence of so many disruptive, exponential changes that we are living through today.

Users are also not the only ones struggling to keep up. The very makers of these ubiquitous technologies are themselves unable, and sometimes unwilling, to monitor, much less moderate all the information in circulation today. Facebook, for example, has a 193,000:1 user to content moderator ratio.[3] The result is an often-unchecked, ever-growing content pool that even companies with enormous resources cannot adequately understand—all while our precious and bounded human cognitive processes work to adapt and catch up.

3 Facebook says that they have 15,000 moderators. See: Ana Dascalescu, "Facebook Moderators: A View Into The Lives of People Curating Your Newsfeed," *TechTheLead*, October 28, 2021, https://techthelead.com/facebook-moderators-a-view-into-the-lives-of-people-curating-your-newsfeed/.

Research Scope, Methods, and Concepts

Any effort to understand the interactions between digital technologies, cognition, and democracy must define its scope carefully to ensure that it produces precise, actionable insights. This analytical effort is not a complete examination of all interactions and subsequent effects among digital technologies, human cognition, and democracy. Rather, we seek to understand how the effects that digital technologies have on cognition can have second- and third-order effects on individual and societal information-processing. In particular, the DCDI research team examined how digital tools impact individual and collective ability to understand and process information, and to identify and manage dis- and mis-information. We also wanted to examine the technologies themselves and to understand the key challenges to which digital technologies expose our minds, influence and shape our behaviors, and drive our capacity for self-government.

Given the scope of this project, we began with a key research question and, from there, developed several supporting questions, each an attempt to specify aspects of the overall chain of effects we suspected we would find.

Research Questions

Key Question: *What are the relationships between digital technologies, cognitive capabilities, and disinformation, affective polarization, and anti-democratic behavior?*

- **Do digital technologies affect or change human cognitive processes; and if so, how?**
- **How do digital technologies affect how we process information?**
- **How do digital technologies affect our memory, attention, and reasoning? Which types of digital technology most affect these cognitive processes?**
- **How do digital technologies affect our critical thinking abilities? And how can digital technologies be used by actors to manipulate critical thinking?**
- **How do digital technologies affect human emotions?**
- **What are the consequences of digitally-influenced cognition for democracy?**

Methods

The wide scope of the research lends itself to a hypothesis-building exercise, drawing on existing scientific knowledge and emerging experiential insights to draw a picture of the relationships between cognition, individual action, and democratic choice. To do so, the IST team turned to an interdisciplinary coalition of scientists, doctors, technologists, academics, and policy experts. Over a series of 8 working group sessions with coalition members over seven months, as well as plenary meetings, focus groups, and interviews, the DCDI coalition identified the key insights discussed below. IST researchers coupled these expert insights with reviews of the literature on several key cognitive processes: memory, attention, reasoning, critical thinking, trust, and emotions.

This report is informed by guidance from IST coalition members, and derived from past and current interdisciplinary research findings relevant to the human

relationship with digital technologies. It is not a synthesis of all available research on technology, cognition, and governance. Rather, it is a selection of literature that best captures how digital technologies impact cognitive processes in ways that are in turn important for a healthy democracy.

Concepts and Key Terms

The phenomena at the core of this study are cognition, democracy, and the digital technologies driving change at each level of analysis. We define these key concepts as follows:

Cognition

In the simplest sense, cognition is another term for thinking. It refers to operations by the human brain and mind to acquire and use information, but also to interpret and even generate new information. Such operations are processes, and for this report, we focus on three cognitive processes in particular: attention, memory, and reasoning.

Democracy

There is rich scholarly literature on the various kinds of democracy, including debates about the essential elements of democratic governance. We assume that democratic systems rely on a society with access to critical information and the capacity and freedom to interpret that information to make collective choices. For a democracy to function appropriately, citizens also have to trust in the social contract, mainly that those collective choices result in legitimate authority of the state to govern all citizens.

Digital Technologies

Digital technology is often defined as any electronic technology tool or system that generates, processes, or stores data. Such technologies are based on computing and often come in the form of small electronics.[4] These devices not only present users with raw data, but also refine and mediate that data selectively and even interpret it for users to make sense of the world. For this reason, DCDI considers digital tools to be brokering information, not just data.

4 Ananth Indrakanti et al., "Gadget Addiction," *Sutardja Center for Entrepreneurship & Technology*, accessed October 2022, https://scet.berkeley.edu/reports/gadget-addiction/.

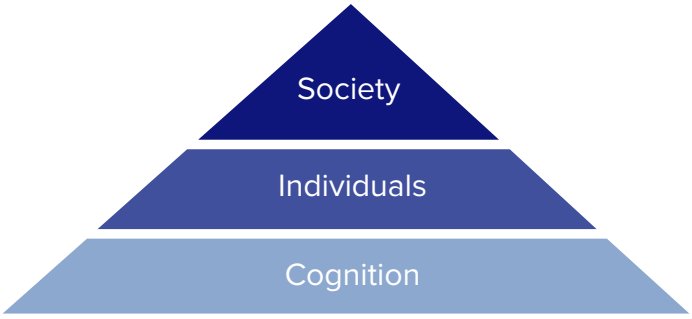
DCDI also focuses on technologies that individual consumers use. Therefore, not all digital technologies fit into the DCDI problem set. A digitized component of a power plant, for example, is not likely to have an effect on an individual's cognitive operations. But our scope of digital technologies is not limited to social media platforms, either. Apps for e-commerce, investing, and gaming play a role.

The technologies of primary interest to the DCDI coalition are those that **play the role of "trusted intermediaries."** These are the technologies people rely on to facilitate daily actions and interactions, such as mapping programs, weather applications, communications platforms, banking applications, and medical records.

The Digital Pyramid: Cognition, Individuals, and Society

In coalition conversations, we observed that cognition and democracy are connected primarily at three levels of analysis: the cognitive level, the individual level, and the societal level. Although the cause-and-effect mechanisms between these levels of analysis are not always perfectly clear, the associations between cognition, individual behavior, and societal impact were persistently evident.

VISUALIZING THE DIGITAL PYRAMID



Tier 1: Cognition

The foundation of the DCDI project is the inquiry into how people think and process information, and how digital technologies affect human cognitive processes. In early sessions with coalition members and interviewees, three cognitive processes stood out as particularly vulnerable to digital influence: memory, attention, and reasoning. Each specific cognitive process is detailed in supporting research papers, and the key findings are summarized below.

MEMORY

> "Without memory, there is no culture. Without memory, there would be no civilization, no society, no future." — *Elie Wiesel, "A God Who Remembers"*[5]

When it comes to information and democracy, memory is a foundational cognitive process. Memory "allows people to encode, store, and retrieve information."[6] It is critical for retaining knowledge and personal histories, and therefore has a strong relationship with learning and social engagement.

Our review of the literature revealed three types of memory: sensory, short-term, and long-term. Some argue that these three types also reflect the sequential nature of information storage.[7] First, sensory memories occur and hold information for the duration of one second.[8] Next, short-term memory is activated when information is held for over one second but still for a brief period of time, typically to support cognitive tasks.[9] Short-term memory is commonly understood as "the system or systems that are assumed to be necessary in order to keep things in mind while performing complex tasks such as reasoning, comprehension and learning."[10] It is important to note that short-

5 Elie Wiesel, "A God Who Remembers," *NPR*, April 7, 2008, https://www.npr.org/2008/04/07/89357808/a-god-who-remembers.

6 E. Bruce Goldstein, *Cognitive Psychology: Connecting Mind, Research and Everyday Experience,* 4th ed. (Boston: Cengage Learning, 2014).

7 Eduardo Camina and Francisco Güell, "The Neuroanatomical, Neurophysiological and Psychological Basis of Memory: Current Models and Their Origins," *Frontiers in Pharmacology* 8 (2017): 438.

8 Ibid.

9 Richard C. Atkinson and Richard M. Shiffrin, "Human Memory: A Proposed System and its Control Processes," in *Psychology of Learning and Motivation*, vol. 2 (Cambridge: Academic Press, 1968): 89-195.

10 Alan Baddeley, "Working Memory," *Current Biology* 20, no. 4 (2010): R136-R140.

term memory is but one component of this family of cognitive abilities which support everyday tasks. The working memory system rests on and interacts with other cognitive processes, particularly attention and reasoning. Lastly, long-term memory refers to information that has transitioned from short-term to indefinite storage.

Examples of digital technologies' influence on memory include:

- The "Google effect," which can disincentivize the commitment of information to memory—one can always "Google it" later—leading to diminished ability to recall information accurately.[11]
- The "Google effect," which can lead to the misattribution of general "Internet knowledge" to oneself as one's own knowledge.[12]
- The "GPS effect", which shows that those who use a navigational application tend to have a diminished ability to retrace their route unaided by GPS when compared to those who had used a paper map.[13] That is, navigational memory seems to be more poorly constructed in the mind when using GPS.

CLICK TO VIEW "MEMORY: HOW DIGITAL TECHNOLOGIES INFLUENCE COGNITIVE INFORMATION STORAGE"

> "First, the Internet does not place any responsibility on the user to retain unique information for others to draw upon (as would typically be required in human societies). Second, unlike other transactive memory stores, the Internet acts as a single entity that is responsible for holding and retrieving virtually all factual information, and thus does not require individuals to remember what exact information is externally stored, or even where it is located." *— Joseph Firth et al., "The "online brain": how the Internet may be changing our cognition."*[14]

11 Adam L. Alter et al., "Missing the Trees for the Forest: A Construal Level Account of the Illusion of Explanatory Depth," *Journal of Personality and Social Psychology* 99, no. 3 (2010): 436-461.

12 Adrian F. Ward, "People Mistake the Internet's Knowledge for Their Own," *Proceedings of the National Academy of Sciences* 118, no. 43 (2021): 5.

13 Masashi Sugimoto et al., "Online Mobile Map Effect: How Smartphone Map Use Impairs Spatial Memory," *Spatial Cognition & Computation* 22, no. 1-2 (2022): 161-183.

14 Joseph Firth et al., "The "Online Brain": How the Internet May Be Changing Our Cognition," *World Psychiatry* 18, no. 2 (2019): 122.

The Digital Memory Bank

One cognitive psychologist interviewed for this project made the case that "technology is, in a way, allowing us to have infinite memory, with everything being recorded." Having an external memory bank, though seemingly advantageous, may lead to partial atrophy of the internal one. Humans are driven by convenience, and the simple knowledge that one can always return to a place to find information reduces the incentive to truly learn it. While that convenience and permanence can be found in encyclopedias and dictionaries, search engines provide the ability to search more quickly and more specifically.

Such an example from the literature would be "Focused Search and Retrieval: The Impact of Technology on Our Brains," which examines the effects of Google search on encoding memory.[15]

ATTENTION

Attention is essential for learning and memory formation. Contemporary cognitive science still operates with William James's 1890 definition of attention: "It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Concentration of consciousness is of its essence. It implies withdrawal from some things in order to deal effectively with others."[16] Cognitive psychology has since systematically substantiated his description. For the purpose of this research, we are interested in two different attention functions: 1) how information is processed in order to perform a task, and 2) how cognitive effort is passively allocated to certain stimuli in any given environment.

15 "For information that is stored externally (ie, not in our heads), we are more likely to remember where the information is kept than to remember the information itself, even when the information (eg, "an ostrich's eye is bigger than its brain") is more memorable than the location (eg, a folder named "Items")": Curtis A. Olson, "Focused Search and Retrieval: The Impact of Technology on Our Brains." *Journal of Continuing Education in the Health Professions* 32, no. 1 (2012): 1-3, https://journals.lww.com/jcehp/Citation/2012/32010/Focused_Search_and_Retrieval__The_Impact_of.1.aspx.

16 William James et al., *The Principles of Psychology* Vol. 1, no. 2 (London: Macmillan, 1890): 403-404.

Examples of digital technologies' influence on attention include:

» **Distraction from critical tasks**: The presence of a phone or the sound of a phone ringing can distract attention enough to impact performance while driving a car.[17] Immersive digital experiences coupled with expanding connectivity and computational power, surround users psychologically.[18]

» **Information foraging:** Historically, the human dopaminergic system evolved around the desire-and-reward cycle of food-foraging and eating.[19] The impulse to seek information or to skim through digital content more passively, is rooted in the dopaminergic feedback system, which motivates neurological and behavioral patterns that evolved around food-foraging activity.[20,21]

» **Division of attention:** Digital technologies seem to encourage and facilitate multitasking and rapid task switching behaviors, which may influence attentional resource allocation and abilities or reduce the ability to focus on a single task.[22] Brasel and Gips found that subjects switched their attention between television and smartphone use at a rate of 4 times per minute.[23]

» **Neurological consequences:** Extensive screen time among adolescents can correlate with atrophy of gray matter areas of the brain attributed to information processing; atrophying white matter areas attributed to communication between different parts of the brain; reduced cortical thickness contributing to impaired cognitive performance; and, in the case of gaming, brain changes similar to those caused by drug addiction.[24]

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17 Radoslaw Zajdel et al., "The Sound of A Mobile Phone Ringing Affects the Complex Reaction Time of its Owner," *Archives of Medical Science* 8, no. 5 (2012): 892-898.

18 Susanne E. Baumgartner et al., "The Relationship Between Media Multitasking and Executive Function in Early Adolescents," *The Journal of Early Adolescence* 34, no. 8 (2014): 1120-1144; Roy Pea et al., "Media Use, Face-to-Face Communication, Media Multitasking, and Social Well-Being Among 8-to 12-Year-Old Girls," *Developmental Psychology* 48, no. 2 (2012): 327.

19 Thomas T. Hills, "Animal Foraging and the Evolution of Goal-Directed Cognition," *Cognitive Science* 30, no. 1 (2006): 3-41, https://doi.org/10.1207/s15516709cog0000_50.

20 Ibid.

21 Adam Gazzaley and Larry D. Rosen, *The Distracted Mind: Ancient Brains in a High-Tech World* (Cambridge: MIT Press, 2016); Peter Pirolli and Stuart Card, "Information Foraging," *Psychological Review* 106, no. 4 (1999): 643, https://psycnet.apa.org/doi/10.1037/0033-295X.106.4.643.

22 Adam Gazzaley and Larry D. Rosen, *The Distracted Mind: Ancient Brains in a High-Tech World* (Cambridge: MIT Press, 2016); Natasha Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Princeton: Princeton University Press, 2012).

23 S. Adam Brasel and James Gips, "Media Multitasking Behavior: Concurrent Television and Computer Usage," *Cyberpsychology, Behavior, and Social Networking* 14, no. 9 (2011): 527-534, https://doi.org/10.1089/cyber.2010.0350.

24 Victoria L. Dunckley, "Gray Matters: Too Much Screen Time Damages the Brain," *Psychology Today* 27 (2014). See also: Yan Zhou et al., "Gray Matter Abnormalities in Internet Addiction: A Voxel-Based Morphometry Study," *European Journal of Radiology* 79, no. 1 (2011): 92-95, https://doi.org/10.1016/j.ejrad.2009.10.025; Kai Yuan et al., "Microstructure Abnormalities in Adolescents with Internet Addiction Disorder," *PloS One* 6, no. 6 (2011): e20708, https://doi.org/10.1371/journal.pone.0020708; C. B. Weng et al., "A Voxel-Based Morphometric

» **Disordered attention:** Correlations have been found between higher frequency in checking social media and a higher likelihood of developing ADHD-like symptoms.[25]

CLICK TO VIEW "ATTENTION: HOW DIGITAL TECHNOLOGIES INFLUENCE WHAT WE NOTICE, WHAT WE FOCUS ON, AND HOW WE LEARN"

> "It all started with the graphical user interface that took us from the flat, two-dimensional text-based environment that operated on a line-by-line basis similar to a typewriter, to a small picture depicting an operation or program. From there it was a short hop to a completely multisensory world appealing to all of our visual, auditory, and tactile or kinesthetic senses. We now see videos in high definition, often in simulated 3D. We hear high-definition stereo sounds that feel as crisp as sounds in the real world. Our devices vibrate, shake, rattle, and roll, and our attention is captured." — *Adam Gazzaley and Larry D. Rosen, "The Distracted Mind: Ancient Brains in a High-Tech World"*[26]

Analysis of Brain Gray Matter in Online Game Addicts," *Zhonghua yi xue za zhi* 92, no. 45 (2012): 3221-3223; C. B. Weng et al., "Grijze Stof en Witte Stofafwijkingen bij Online Game-Verslaving," *Eur J Radiol* 82, no. 8 (2013): 1308-1312; Fuchun Lin et al., "Abnormal White Matter Integrity in Adolescents with Internet Addiction Disorder: A Tract-Based Spatial Statistics Study," *PloS One* 7, no. 1 (2012): e30253, https://doi.org/10.1371/journal.pone.0030253; Soon-Beom Hong et al., "Decreased Functional Brain Connectivity in Adolescents with Internet Addiction," *PloS One* 8, no. 2 (2013): e57831, https://doi.org/10.1371/journal.pone.0057831; Anyi Yang et al., "Longer Screen Time Utilization is Associated with the Polygenic Risk for Attention-Deficit/Hyperactivity Disorder with Mediation by Brain White Matter Microstructure," *EBioMedicine* 80 (2022): 104039, https://doi.org/10.1016/j.ebiom.2022.104039; John S. Hutton et al., "Associations Between Screen-Based Media Use and Brain White Matter Integrity in Preschool-Aged Children," *JAMA Pediatrics* 174, no. 1 (2020): e193869-e193869.; Yunqi Zhu et al., "Molecular and Functional Imaging of Internet Addiction," *BioMed Research International* 2015 (2015); Chih-Hung Ko et al., "Brain Activities Associated with Gaming Urge of Online Gaming Addiction," *Journal of Psychiatric Research* 43, no. 7 (2009): 739-747; Doug Hyun Han et al., "Brain Activity and Desire for Internet Video Game Play," *Comprehensive Psychiatry* 52, no. 1 (2011): 88-95; and Aviv Weinstein et al., "New Developments in Brain Research of Internet and Gaming Disorder," *Neuroscience & Biobehavioral Reviews* 75 (2017): 314-330.

25 Chaelin K. Ra et al., "Association of Digital Media Use with Subsequent Symptoms of Attention-Deficit/Hyperactivity Disorder Among Adolescents," *Jama* 320, no. 3 (2018): 255-263, https://doi.org/10.1001/jama.2018.8931.

26 Adam Gazzaley and Larry D. Rosen. *The Distracted Mind: Ancient Brains in a High-Tech World* (Cambridge: MIT Press, 2016).

REASONING

Cognitive psychologists frame reasoning as the act of constructing or assessing a logical statement, including the ability to apply counterfactuals to test an argument.[27] Within this broad definition, reasoning can be understood in a variety of ways and includes many components. Acknowledging the complex research on reasoning, DCDI refers to it as the ability to engage one's repertoire of cognitive tools to support goal attainment or higher order information processing. Of most relevance to the relationships between cognition, individuals, and democratic society are the judgment and decision making forms of reasoning.

Examples of digital technologies' influence on reasoning include:

- The mere presence of one's phone can have adverse effects on cognitive performance on reasoning tasks.[28]
- Digital tools provide short-cuts that affect judgment: Images are often used as heuristics to process information and even infer truthfulness.[29]
- Digital tools provide short-cuts that affect analysis: We rely on heuristics in order to process large volumes of information. That is, the digital media environment is designed for cognitive efficiency, thus engaging the use of prior mental models and schemas (through the use of heuristics) to enable quick judgment formation and, often, rushed or impulsive decision making.[30]

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27 Peter C. Wason, "Reasoning About A Rule," *Quarterly Journal of Experimental Psychology* 20, no. 3 (1968): 273-281; Richard A. Griggs et al., "The Elusive Thematic-Materials Effect in Wason's Selection Task," *British Journal of Psychology* 73, no. 3 (1982): 407-420; Patricia W. Cheng and Keith J. Holyoak, "Pragmatic Reasoning Schemas," *Cognitive Psychology* 17, no. 4 (1985): 391-416.; E. Bruce Goldstein, *Cognitive Psychology: Connecting Mind, Research and Everyday Experience,* 4th ed. (Boston: Cengage Learning, 2014).

28 Adrian F. Ward et al., "Brain Drain: The Mere Presence of One's Own Smartphone Reduces Available Cognitive Capacity," *Journal of the Association for Consumer Research* 2, no. 2 (2017): 140-154, https://www.journals.uchicago.edu/doi/full/10.1086/691462.

29 Eryn J. Newman et al., "Nonprobative Photographs (Or Words) Inflate Truthiness," *Psychonomic Bulletin & Review* 19, no. 5 (2012): 969-974, https://doi.org/10.3758/s13423-012-0292-0; Elise Fenn et al., "The Effect of Nonprobative Photographs on Truthiness Persists Over Time," *Acta psychologica* 144, no. 1 (2013): 207-211, https://doi.org/10.1016/j.actpsy.2013.06.004; Eryn J. Newman et al., "Truthiness and Falsiness of Trivia Claims Depend on Judgmental Contexts," *Journal of Experimental Psychology: Learning, Memory, and Cognition* 41, no. 5 (2015): 1337, https://psycnet.apa.org/buy/2015-13956-001; Eryn J. Newman et al., "Evidence That Photos Promote Rosiness for Claims About the Future," *Memory & Cognition* 46, no. 8 (2018): 1223-1233, https://doi.org/10.3758/s13421-016-0652-5.

30 See also: Amos Tversky and Daniel Kahneman, "Judgment Under Uncertainty: Heuristics and Biases: Biases in Judgments Reveal Some Heuristics of Thinking Under Uncertainty," *Science* 185, no. 4157 (1974): 1124-1131, https://do.org/10.1126/science.185.4157.1124.

» Digital tools atrophy reasoning functions: By rewiring dopaminergic pathways, aggressive "gamification" tactics can encourage addiction and weaken judgment and decision making, thus inhibiting the ability to engage in higher order decision making.[31,32]

» The significant ease with which one can acquire information has disincentivized the commitment of information to memory, and reliance on external digital information sources leads to a misattribution of the Internet's knowledge as one's own.[33] Reasoning may be adversely affected if knowledge that informs mental models resides externally and is never committed to retrievable memories.[34,35]

» Researchers have found that a user's degree of "comfort" navigating the digital environment is associated with their ability to handle the high "cognitive load" of digital spaces: the more comfortable in digital environments they are, the better they handle that overload.[36] Such findings suggest that human brains can preserve reasoning by adapting to digital formats.

CLICK TO VIEW "REASONING: HOW DIGITAL TECHNOLOGIES INFLUENCE DECISION MAKING AND JUDGMENT"

31 Mattias Brand et al., "Prefrontal Control and Internet Addiction: A Theoretical Model and Review of Neuropsychological and Neuroimaging Findings," *Frontiers in Human Neuroscience* (2014): 375, https://doi.org/10.3389/fnhum.2014.00375.

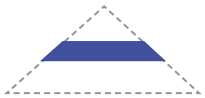
32 An example of this includes the cash management feature Robinhood planned to launch in 2019. Robinhood created a waitlist for interested users to see and change their position on the waitlist by tapping a fake debit card graphic up to 1,000 times per day. Not doing so everyday meant seeing one's position on the waitlist fall. Maxing out on the 1,000 taps per day meant users received the following message: "Out of taps today! Come back tomorrow if you're feeling tappy." See: "Administrative Complaint: Docket No. E-2020-0047," *Commonwealth of Massachusetts Office of the Secretary of the Commonwealth Securities Division* (Boston: 2020) accessed August 2022, https://business.cch.com/srd/MSD-Robinhood-Financial-LLC-Complaint-E-2020-0047.pdf.

33 Adrian F. Ward, "People Mistake the Internet's Knowledge for Their Own," *Proceedings of the National Academy of Sciences* 118, no. 43 (2021): e2105061118, https://doi.org/10.1073/pnas.2105061118.

34 Curtis A. Olson, "Focused Search and Retrieval: The Impact of Technology on Our Brains," *Journal of Continuing Education in the Health Professions* 32, no. 1 (2012): 1-3, https://doi.org/10.1002/chp.21117; Daniel M. Wegner and Adrian F. Ward, "How Google Is Changing Your Brain," *Scientific American* 309, no. 6 (2013): 58-61, https://www.jstor.org/stable/26018230.

35 Alan Baddeley, "Working Memory," *Current Biology* 20, no. 4 (2010): R136–R140, https://doi.org/10.1016/j.cub.2009.12.014.

36 Yoram Eshet-Alkalai and Nitza Geri, "Does the Medium Affect the Message? The Influence of Text Representation Format on Critical Thinking," *Human Systems Management* 26, no. 4 (2007): 269-279.



Tier 2: Individuals

Individuals combine cognitive processes to derive meaning from information, form arguments, and make decisions. The individual level of analysis is where cognitive processes socialize, coalescing and then interacting with the world by communicating thoughts and receiving feedback. Digital tools affect this level of analysis in three major areas: critical thinking, trust, and emotions.

CRITICAL THINKING

Critical thinking provides the avenue for deliberation and decision making. Thinking critically allows us to overcome biases, solve problems, and stay informed—all functions that feed into how citizens engage in democracy. By now, there is plenty of qualitative and growing amounts of quantitative research on how digital technologies have rapidly exacerbated certain issues that affect our critical thinking skills, including information overload/fatigue,[37] bias reinforcement,[38] how we learn and retain information,[39] and attention hijacking,[40] to name a few. We already knew that people don't always make decisions that are in their own best interest. Certain emotions, like fear, anger, and shame, can cloud people's judgment, undermining their ability to make informed, deeply considered decisions. These emotions can of course be stirred up without digital technologies, as evidenced by instances of effective human propaganda over thousands of years. Yet it is increasingly apparent that digital technologies are posing novel challenges—through scale, reach, and sophistication—to critical thinking.

37 David A. Ziegler et al., "The Acute and Chronic Impact of Technology on our Brain," *The Wiley Handbook of Psychology, Technology, and Society* (Hoboken: Wiley-Blackwell, 2015): 3-19.

38 Eryn J. Newman et al., "Evidence That Photos Promote Rosiness for Claims About the Future," *Memory & Cognition* 46, no. 8 (2018): 1223-1233.

39 Daniel L. Schacter, "Media, Technology, and the Sins of Memory," *Memory, Mind & Media* 1 (2022): e1, https://doi.org/10.1017/mem.2021.3.

40 Alexa Wehsener, "Pay Attention," *Institute for Security and Technology*, July 2020, https://securityandtechnology.org/virtual-library/reports/pay-attention/.

» The scale, accuracy, and speed of digital technologies make them particularly effective in stirring up the very emotions that undermine critical thinking. Not only do digital technologies have the ability to inflame those emotions, they also often have the incentive to do so as those very emotions drive engagement, use, and impulsive purchases.[41]

» Digital technologies make it easier for people to hew closely to their existing beliefs, with little incentive to go through the often arduous processes of thinking critically and updating them. The most prolific online spaces are designed to validate beliefs, rather than question them. This, in turn, causes people to be more confident and vocal in their beliefs, as they are surrounded by many who believe in similar things.[42]

» Overconfidence in beliefs makes people more vulnerable to disinformation targeted at the group/demographic and less likely to take in contrary arguments.[43]

» Compounding the problem, there's little financial incentive for tech companies to design products that encourage people to question their beliefs, especially if that involves helping people slow down, building friction into systems optimized for speed.

» Digital technologies are affecting the cognitive processes that make up critical thinking, including memory, attention, reasoning, and problem solving (see above section).

CLICK TO VIEW "SHORTCUTTING CRITICAL THINKING"

EMOTIONS

It is not an unreasonable assumption that digital systems are in many ways purposefully designed to affect emotion. In fact, with digital systems, emotions are the pathway to usage, a way to ensure engagement, advertising profits, and continued use. Some emotions, such as anger, defensiveness, and righteous indignation, can serve as an impetus for action, thus heightening this feeling of viability, legitimacy, and belonging, and providing a feedback loop between the digital system and the user's emotions, sense of self, and

41 Dag Wollebæk et al., "Anger, Fear, and Echo Chambers: The Emotional Basis for Online Behavior," *Social Media + Society* 5, no. 2 (2019): 2056305119829859, https://doi.org/10.1177/2056305119829859.

42 Daniel M. Wegner and Adrian Ward, "How Google Is Changing Your Brain," *Scientific American* 309(6), 58-61, https://www.jstor.org/stable/26018230.

43 Ullrich KH Ecker et al., "The Psychological Drivers of Misinformation Belief and Its Resistance to Correction," *Nature Reviews Psychology* 1, no. 1 (2022): 13-29, https://www.nature.com/articles/s44159-021-00006-y.pdf.

place. Digital systems thus work alongside the visual nature of the present digital environment to heighten user's emotions. The ready availability of these factors contributes, in turn, to creating an addictive cycle.

While emotion in itself is not a cognitive function, it affects how we process, engage with, and often act upon information and thus has played a central role in this research. How digital technologies exploit and/or manipulate our emotions is key to understanding how our cognitive functions are being impacted. Disinformation tends to appeal to emotions (mainly fear and outrage), and often looks to create apathy through anger, polarization, and the exploitation of inequities.[44]

Examples of digital technologies' influence on emotions include:

- Cognitive openings created as a result of difficult life events create a moment of vulnerability. When presented with a live option—something that feels viable enough that it could solve your emotional problem and give you a purpose—it becomes easy to become entrenched and isolated.
- 'Affective turn' plays a large role in political communication—the growing reliance of political actors on emotional reactions—due in part to populist communicative styles, and the nature of digital media (online platforms enable expression and articulation of emotions via new digital formats).[45]
- In social networks, the processes of recognition and status negotiation are intertwined with emotions; the more someone likes/links to your posts, the higher you will be ranked and listed in news feeds. "Since sharing emotions is essential for creating and maintaining social ties, somehow the status of social networks revolves around the emotions and feelings that users express about themselves, but at the same time find resonance among their circle of contacts."[46]

CLICK TO VIEW "EXPLOITING EMOTIONS"

44 Fabiana Zollo et al., "Emotional Dynamics in the Age of Misinformation," *PloS One* 10, no. 9 (2015): e0138740.

45 Mykola Makhortykh and Juan Manuel González Aguilar, "Memory, Politics and Emotions: Internet Memes and Protests in Venezuela and Ukraine," *Continuum* 34, no. 3 (2020): 342-362.

46 Javier Serrano-Puche, "Internet and Emotions: New Trends in an Emerging Field of Research," *Comunicar. Media Education Research Journal* 24, no. 1 (2016), https://www.scipedia.com/public/Serrano-Puche_2016a

TRUST

There is a rich scholarly literature on the various kinds of democracy, including debates about the essential elements of democratic governance. We assume that democratic systems rely on a society with access to critical information and the capacity and freedom to interpret that information to make collective choices. For a democracy to function appropriately, citizens also have to trust in the social contract, mainly that those collective choices result in legitimate authority of the state to govern all citizens. As such, trust in others is critical to the DCDI problem set.

Trust in technology is also a critical piece of the DCDI problem set. Consumers tend to prefer to use technologies that they trust, and sellers and developers of technology find more success when there is more trust in their systems. As such, relationships of trust determine our relationships to each other in a democracy, to the government of that democracy itself, and to the everyday technologies that we use. As a DCDI participant put it: "when trust is degraded or eroded it's like a social tax, it makes everything harder [and causes] a drag on democratic processes."[47]

Examples of digital technologies' influence on trust include:

- People are increasingly dependent on, and distrustful of, digital technology—however, they don't behave as though they mistrust technology; they use technology intensively in all aspects of daily life.[48]
- The democratization of truth, the idea that everyone can have their own truth, rather than the truth coming from reputable sources, can lead to a lowering of standards, where people choose their beliefs based on group identity and rationalize false beliefs to avoid cognitive dissonance.[49]

47 Expert DCDI Workshop participant, "DCDI Working Group Meeting Notes," Internal IST Meeting Documentation.

48 Bhaskar Chakravorti, "Trust in Digital Technology Will Be the Internet's Next Frontier, for 2018 and beyond," *The Conversation*, January 3, 2018, https://theconversation.com/trust-in-diBital-technology-will-be-the-Internets-next-frontier-for-2018-and-beyond-87566.

49 Andrew Hutchinson, "New Report Shows Universal Distrust in Social Media as a News Source," *Social Media Today*, February 1, 2020, https://www.socialmediatoday.com/news/new-report-shows-universal-distrust-in-social-media-as-a-news-source/571512/.

» Humans are programmed to trust those closest to them the most. This can also mean trusting those who they identify with the most. This phenomenon can extend to influencers,[50] with nano influencers in particular exploiting the human inclination to trust that which is near and dear, thereby building up devoted followings of like-minded individuals. The role that someone plays within an ingroup perpetuates certain behavior, and thought leaders get bigger rewards (followers, money through Patreon, merchandise sales) for promoting more extreme or more polarizing content.

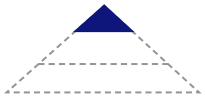
Digital Trust Transfer

One area of interest in DCDI research has been the phenomenon of 'trust transfer,' the idea that trust in one entity can be transferred to another. This transfer happens when an unknown entity is perceived as being related or adjacent to a trusted entity. Studies of trust transfer in online commerce have shown that users transfer trust they have in a platform itself to sellers on the platform, even if they have never interacted with them.[51] In the context of social media, this effect can be expanded to users transferring trust in the platform to other users on the platform. In this version of trust transfer, the users putting out content could be seen as sellers.

CLICK TO VIEW "MODULATING TRUST"

50 "DCDI Working Group Meeting Notes," Internal IST Meeting Documentation.

51 Katherine J. Stewart, "Trust Transfer on the World Wide Web," *Organization Science* 14, no. 1 (2003): 5-17, https://doi.org/10.1287/orsc.14.1.5.12810; Daniel Belanche et al., "Trust Transfer in the Continued Usage of Public E-Services," *Information & Management* 51, no. 6 (2014): 627-640.



Tier 3: Society

In a society the actions of individuals influence the lives of others. Some cases of cognitive distortions (for example, those caused by misinformation campaigns online) can lead individuals to make choices that directly and routinely impact many other people, a whole community, and their society more broadly. Once individuals engage with each other in groups, their singular goal-seeking routinely aggregates into collective goal-seeking. Attention, memory, and reasoning become social rather than just individual activities. For example, transactive–or group–memory is a mechanism in which a group collectively encodes, stores, and retrieves information.[52] Ideas and decisions go from being, "What should *I* think or do about this?" to, "What should *we* think or do about it?"

Following this intuition, the DCDI research observed that by altering cognitive processes and by mediating social interactions, digital technologies have effects not just on individuals, but on society as well. We noticed three major such effects: fracturing of collective memory; in group/out group dynamics; and radicalism and extremism.

FRACTURING COLLECTIVE MEMORY

Collective memories, including at the national level, turn shared experiences into stories, allowing even those who did not fully experience a major national event to understand what happened and the impact it had. Collective memories may be positive or negative. Collective memories that generate trust and pro-social behaviors are keys to healthy democracies. But negative memories may have some benefits if they help bolster a sense of commonality or unity of purpose. Traumatic examples of collective memories include natural disasters, terrorist attacks, wars, and genocide.

Constructing, revising, and passing on collective memory is always complex and typically contested. Yet digital technologies have added a dangerous new layer to these processes of historicizing and sense-making. Digital

52 Betsy Sparrow et al., "Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips," *Science* 333, no. 6043 (2011): 776-778.

media systems can splinter collective memory by weakening society's ability to agree on validated information while facilitating belief in conspiracy theories. Competing meanings of events and ideas find reinforcement without resolution, and sub-groups of wider society increasingly identify with groups who share digitally-sourced narratives that confirm their pre-existing beliefs, regardless of those narratives' veracity.

IN GROUP/OUT GROUP DYNAMICS

The fracturing of memory coincides with atomizing in-group and out-group identification. Findings about in-group behavior are well-established: People associate with those who are similar to them, be it by belief, ethnic or racial kinship, geographical proximity, religion, or age.[53] Those deemed part of the "in group" and similar to the individual less scrutinized, more easily believed, and more trusted. At its core, in-group feelings provide a heuristic (that those within our group are more trustworthy for example) that provides a shortcut around critical thinking and reasoning. Rather than thinking critically about what an in-group peer has said, our brains are evolutionarily wired to instinctively and instantaneously believe and trust them, without much thought.

Digital technologies, both those that foster social ties and those in the business of recommending content, take advantage of this evolutionary in-group cognitive process. Micro-targeting allows for disinformation to target specific communities and recommender engines recommend the most appealing content by using data to place us in similar groups, serving us similar content.

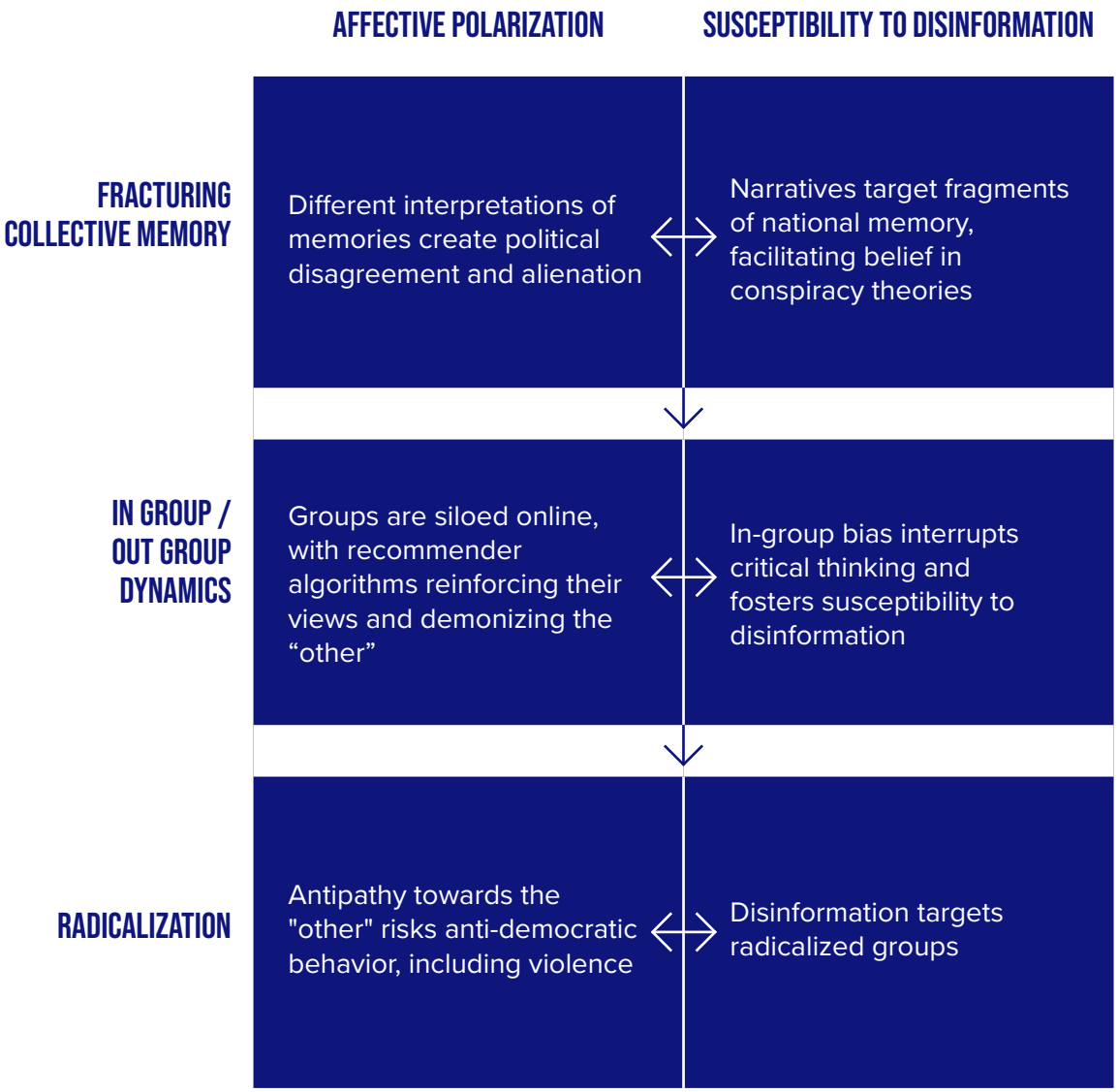
RADICALIZATION

Fractured narratives and in-group/out-group dynamics often have a radicalizing effect online. These bypass critical thinking and trigger emotion. Anger and resentment, alongside feelings of relief and comfort from finding a purpose, a like-minded group, or a universal truth, drive radicalism. Search engines and other digital sites that monetize user engagement exploit those emotions and serve content that may further radicalize.

53 Howard Giles and Jane Giles, "Ingroups and Outgroups," in *Inter/Cultural Communication: Representation and Construction of Culture*, ed. Anastacia Kurylo (Thousand Oaks: Sage Publications, 2012): 141-161, https://www.sagepub.com/sites/default/files/upm-binaries/48648_ch_7.pdf.

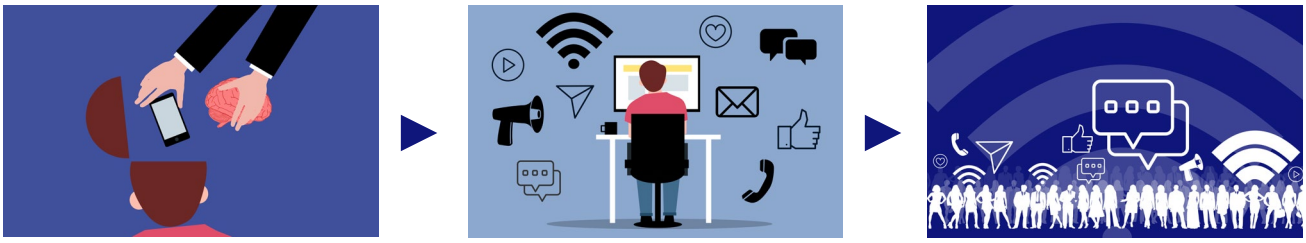
CONSEQUENCES: AFFECTIVE POLARIZATION AND SUSCEPTIBILITY TO DISINFORMATION

Each of these societal effects encourage affective polarization and increase susceptibility to disinformation. Affective polarization is a specific expression of the in-group/out-group phenomenon, where partisans of a political party distrust and are even hostile to members of the other political party or parties. Even those who do not identify strongly with a political party may be susceptible to disinformation–information intended to mislead audiences. The below chart depicts some of the ways that digital technologies' effects on society can generate affective polarization and susceptibility to disinformation.



The Microfoundations of Macro-effects: Digital Domains and Techno-Cognitive Risks

Digital Domains



Thus far, we have addressed the impacts of digital technologies generally. But are there meaningful differences between types of technologies? Under the guidance of and through the insights provided by the DCDI coalition, our research suggests that digital technologies fall under two broad categories of the type of effects they have on cognition, which in turn influence the drown-stream effects on individuals and society:

1. **Digital technologies that lead us to outsource cognition**

2. **Digital technologies that manipulate cognitive operations**

These two categories are not meant to represent a dichotomy; rather, they illustrate the two core areas of interest that explore technology's intersection with human cognition. Besides co-existing, outsourcing and cognitive manipulation are mutually reinforcing, each one accelerating the other.

OUTSOURCED COGNITION

Some digital technologies enable us to outsource cognitive operations, potentially freeing up cognitive faculties for other mental work. This follows the pattern of technological evolution: humanity develops a new way to do things faster and more efficiently, and that new approach allows us to focus energy and attention elsewhere. The calculator freed us from basic math, cell phones from memorizing phone numbers, and Google Maps from memorizing routes and directions.

But along with cognitive outsourcing come changes in our brain structure and cognitive processes. Not only is basic math outsourced to technology, but also memory storage, elements of critical thinking, information sourcing, and sometimes even reasoning skills, routinely without us realizing it.

This cognitive outsourcing, while inarguably more efficient, could potentially weaken the depth of our learning, understanding, and ability not only to process information but to be prepared for critical thinking and decision making tasks. These effects compound over time and reinforce our dependence on digital technologies, as they are no longer simple communication systems but an external cognitive resource—for example a bank of knowledge and memories—without which we would struggle to function.[54]

MANIPULATION OF COGNITIVE OPERATIONS

In many cases, digital technologies affect how individuals engage with and process information. Engagement-based social media is the most obvious example today of digital technologies that influence how we view and engage with the world, both by design and, worse yet, when intentionally exploited by bad actors.

54 On September 8, 2010, Google Co-Founder Sergey Brin suggested: “We want Google to be the third half of your brain.” Business Insider interpret that comment to suggesting that “Google will know what you want in a search, perhaps even before you know.” See: Jay Yarrow, "Sergey Brin: 'We Want Google To Be The Third Half Of Your Brain,'" *Business Insider*, September 8, 2010, https://www.businessinsider.com/sergey-brin-we-want-google-to-be-the-third-half-of-your-brain-2010-9.

Like cognitive outsourcing, these effects and manipulations can be hard to resist in part because they are efficient, like recommendation algorithms that push us to content that we like. They also appeal to our paleolithic brains and reward systems, whether through feeling a sense of community, seeing content that keeps us engaged, providing a worldview that mirrors our own, or stirring up emotions that can crowd out critical thinking.[55]

Examples of Cognitive Outsourcing

- The use of the Internet as an external memory bank, with people remembering less information, as they feel confident that they can look it up online whenever necessary.[56]
- Outsourcing our conscious decisions about the content we intake to algorithms.
- Instructions and directions exist online and are always accessible, lessening the need for us to learn processes and procedures.
- We are increasingly confident in how much we know, confusing what we actually know with what we know we can Google.

Examples of Cognitive Manipulation

- Algorithms that reinforce our biases by sending us confirming information, learning our biases and reflecting those back in information feeds, and creating information silos.[57]
- Encouraging outrage and anger to boost engagement on digital platforms.[58]
- Encouraging multitasking across one or multiple platforms, reducing our attention span and discouraging deep focus.[59]

55 Edward O. Wilson, "What Is Human Nature? Paleolithic Emotions, Medieval Institutions, God-Like Technology," *Big Think* (blog), accessed October 5, 2022, interview, https://bigthink.com/hard-science/eo-wilson-what-makes-us-human-paleolithic-emotions-medieval-institutions-god-like-technology/.

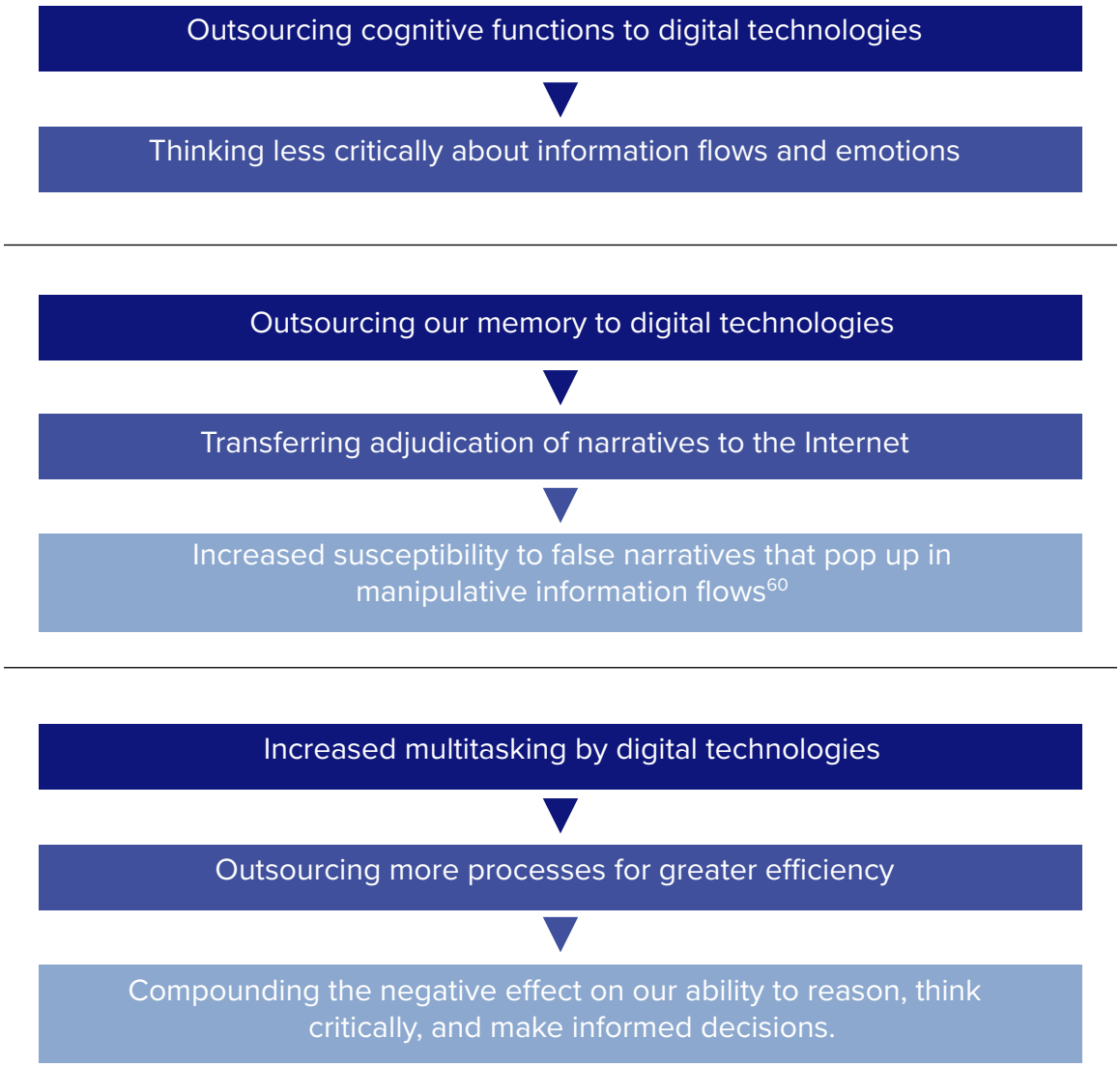
56 Josh A. Firth et al., "Exploring the Impact of Internet Use on Memory and Attention Processes," *International Journal of Environmental Research and Public Health* 17, no. 24 (2020): 9481, https://doi.org/10.3390/ijerph17249481.

57 Giovanni Luca Ciampaglia and Filippo Menczer, "Biases Make People Vulnerable to Misinformation Spread by Social Media," *Scientific American*, June 21, 2018, https://www.scientificamerican.com/article/biases-make-people-vulnerable-to-misinformation-spread-by-social-media/.

58 William J. Brady et al., "How Social Learning Amplifies Moral Outrage Expression in Online Social Networks," *Science Advances* 7, no. 33 (2021): eabe5641, https://doi.org/10.1126/sciadv.abe5641.

59 Kaitlyn E. May and Anastasia D. Elder, "Efficient, Helpful, or Distracting? A Literature Review of Media Multitasking in Relation to Academic Performance," *International Journal of Educational Technology in Higher Education* 15, no. 1 (2018): 1-17, https://doi.org/10.1186/s41239-018-0096-z.

REINFORCEMENT PATTERNS OF OUTSOURCED VS. CHANGED (AFFECTED AND MANIPULATED) FRAMEWORK:



60 Daniel Susser et al., "Technology, Autonomy, and Manipulation," *Internet Policy Review* 8, no. 2 (2019), https://doi.org/10.14763/2019.2.1410.

Techno-Cognitive Risks

The DCDI coalition and research team observed that certain features of digital technologies had the greatest effects on cognition, individuals, and society. We highlight these features as twelve techno-cognitive risks that fall into four areas of concern: gamification and addictive design; information overload; unnaturally immersive and easy experience; and lack of friction.

Gamification and Addictive Design

Information Overload

Unnaturally Immersive and Easy Experience

Lack of Friction

Gamification and Addictive Design

Gamification is when programs designed for purposes other than entertainment can be played like a game. Designers often gamify their products to retain users' attention. Such products are designed to be addictive and engaging – made to prolong interest and keep the user fixated. Spatial designs, colors, animations, and popups maintain attention and are why users find these technologies hard to resist.[61] These gamified features can include login streaks, follower and like counts resembling a score in a game, positive reinforcement with visual cues when an action is taken, and other approaches.[62]

61 Ananth Indrakanti et al., "Gadget Addiction," *Sutardja Center for Entrepreneurship & Technology*, accessed October 2022, https://scet.berkeley.edu/reports/gadget-addiction/.

62 "6 Examples of Gamification in Software Technology," *Spinify*, February 14, 2019, https://spinify.com/blog/examples-of-gamification-in-software-technology/.

Gamification can be a useful educational tool, as in language learning. But because of its ability to keep people engaged and interacting with the gamified technology, it is most often exploited for financial gain or influence.

Information Overload

The past twenty years of technological evolution have greatly expanded the amount of information flooding our cognitive capacity. Our research suggests that, as a result, human cognition is increasingly overwhelmed, constrained, and possibly even physiologically undermined by our growing reliance on digital technologies.[63]

Humans can only process a sliver of the information available to us, and even more concerning, that tiny amount is likely to be biased, whether due to algorithmic biases, cognitive biases, media landscapes, or information silos.[64] Making matters worse, small portions of the information environment are generally presented as representative of the entire information ecosystem. As a result, to fully understand the information we do see, we would have to do a prohibitively difficult amount of research to fact check, provide context, and understand alternative opinions.

Unnaturally Immersive and Easy Experience

One of the biggest obstacles to mitigating the potentially harmful effects of digital technologies on humans is the lure of convenience. Convenience can allow people to perform tasks more efficiently, freeing time for more sophisticated activities. Humans, and the human brain, like to take the path of least resistance, but that inclination can undermine reasoning, decision making, and our ability to think critically.

63 This graphic shows the enormous amount of data generated in one day in 2019: "A Day in Data," *Visual Capitalist,* accessed September 23, 2022, https://www.visualcapitalist.com/wp-content/uploads/2019/04/data-generated-each-day-full.html.

64 A expanded literature review including all the literature involved in this project can be found at: https://securityandtechnology.org/virtual-library//digital-tools-cognition-and-democracy-a-review-of-the-literature/

Technology is marketed to us on the basis of convenience: social media is a convenient way to keep in contact with people, fintech is a convenient way to bank, and edtech is a convenient way to learn. Many people find targeted ads convenient. Recommendation algorithms exist to make our lives easier, and personal data allows technologies to cater to us. Humans tend to seek information that reinforces what they already believe, or that challenges their ideas the least.

In the era of information bubbles, this tendency keeps people from challenging their inaccurate or harmful beliefs, and from straying from their algorithmically developed silos. Technology is also a convenient way to get a dopamine hit,[65] to get attention, to be distracted from life, to be entertained, and to get things done. As one expert put it:

> *"[Technology] satisfies a basic human need to be noticed, to get feedback, and it's bright and engaging and painless, unlike the real world."*[66]

It's a sensational stimulant and a wonderful distraction. As DCDI coalition Member and neuroscientist Don Vaughan put it, a seeming trend in apps is "don't make me think, just entertain me."[67] Another expert voiced concern that people were becoming addicted to constant stimulation and the ability to create a story for themselves. In many ways, the digital world is an easier place to craft your own narrative and your own story. You can avoid psychological discomfort, find research that supports everything you believe in, find individuals who think just like you, and craft a narrative where you matter in ways you may not offline. On social media, you can go into your bubble and block out the world.

65 Matthias Brand et al., "Prefrontal Control and Internet Addiction: A Theoretical Model and Review of Neuropsychological and Neuroimaging Findings," *Frontiers in Human Neuroscience* 8 (2014): 375, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4034340/.

66 Anonymous DCDI Coalition Expert, "Coalition Interview Notes," Internal IST Meeting Documentation.

67 Don Vaughan, "DCDI Working Group Meeting Note 5/17/21," Internal IST Meeting Documentation.

Lack of Friction

A final key facet of digital technology's impact on cognition is what is called "friction," or the notion of introducing "breathing space" into our experiences with digital technology and thus our processing of information. Friction can be introduced or minimized at the levels of visual design, user interface, algorithms, functionality, software, and hardware. Lack of friction has been shown to be particularly problematic for critical thinking. As our DCDI co-chair, Yaël Eisenstat explained in her 2020 TED talk when describing what she called "a world optimized for frictionless virality," a key issue with the current construction of many of our online spaces is:

> *"There is no incentive to help people slow down, to build in enough friction that people have to stop, recognize their emotional reaction to something, and question their own assumptions, before engaging."* [68]

A key question we will explore, and propose solutions for, is: Where and how can we add friction into the design of digital technologies in a way that, at the very least, doesn't shortcut the cognitive processes needed to think critically?

68 Yaël Eisenstat, "Dear Facebook, This is How You're Breaking Democracy." *TED Talk*, September 20, 2020, https://www.ted.com/talks/yael_eisenstat_dear_facebook_this_is_how_you_re_breaking_democracy?language=en.

Targeted Business Models

While economics were not a central focus of this project, the business incentives behind technological development play an undeniable role by driving many of the key risks identified by our coalition. Digital technologies are targeting human cognitive processes—and vulnerabilities in many cases—because in the end it is profitable to do so. Monetization of digital technologies, specifically the monetization of attention, is a core challenge that must be addressed when mitigating any harmful effects of digitally influenced cognition.[69] For example, to remain profitable, companies that do not sell an actual product to customers must continue to captivate people's attention to keep them engaged with their product, in order to harvest as much data as possible to sell personalized targeting tools to advertisers. This results in the need to intentionally target those cognitive vulnerabilities we've been discussing.

There is a tendency to think of many of these services as free, when they are very much not, as highlighted in the saying "if you're not paying for the product, then you are the product." We cannot examine the challenges of how digital technologies affect our cognition without considering that a business model that optimizes for free, frictionless virality is driving many of these threats to our cognitive resilience.

TECHNO-COGNITIVE RISKS MATRIX

The areas of risk described above allow us to identify specific cognitive, individual, and societal-level effects. The techno-cognitive risks we have highlighted in the below are not an exhaustive list, but focus on the phenomena most consequential to democracy that we have encountered thus far as part of this project.

These risks do not exist in isolation; they interact. Some of those interactions may not be known at present and will only emerge through further examination or even further evolution of technology and the increasing digitization of daily life. We offer one way of perceiving the risks and their major consequences in the matrix below.

69 Alexa Wehsener, "Digital Threats to Democracy: Pay Attention," *Institute for Security and Technology*, July 2020; "Future Digital Threats to Democracy," *Institute for Security and Technology*, accessed September 15, 2022, https://securityandtechnology.org/ist-policy-lab/in-the-works/future-digital-threats-to-democracy/.

Gamification and addictive design

Cognitive	*Individual*	*Societal*
1.1 Gamification of critical services such as banking, investing, and information curators (social media)		
More attention is paid to game elements while less attention is paid to the critical services themselves. Human desire to "win the game" takes over cognitive functions such as reasoning.	Unhealthy or risky use (e.g. addiction; bad or high risk financial choices.)	
1.2 Addictive design in technology, specifically notifications, colors, pop-ups, and other attention-grabbing features		
Attention is drawn to the enticing design, at the cost of other processes, like reasoning and judgment	Individuals keep being brought back to their devices, apps, and social media, reinforcing the influence over the individual and the time that the individual spends on those apps. Engagement leads to more data being collected, sharpened microtargeting, and even more engagement, and silos.	Increased time on those apps means more exposure to targeted disinformation, polarizing content, and silos.
1.3 Ludic Loops: "the repeating cycles of action created by digital interactive media such as video games, slot machines, apps, and websites, owing to certain design characteristics."[70]		
Attention is absorbed in ludic loop	Individuals keep being brought back to their devices, apps, and social media, fortifying the influence over the individual and the time that the individual spends on those apps	Increased time on those apps means more exposure to targeted disinformation, polarizing content, and silos.

70 Natasha Dow Schüll, "Ludic Loops," Skeptech Lecture Event, WFMU, New Jersey, May 24, 2016. See also: Natasha Dow Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Princeton: Princeton University Press, 2012); Natasha Dow Schüll, "Stuck In The Machine Zone: Your Sweet Tooth For 'Candy Crush,'' *NPR*, June 7, 2014, https://www.npr.org/sections/alltechconsidered/2014/06/07/319560646/stuck-in-the-machine-zone-your-sweet-tooth-for-candy-crush.

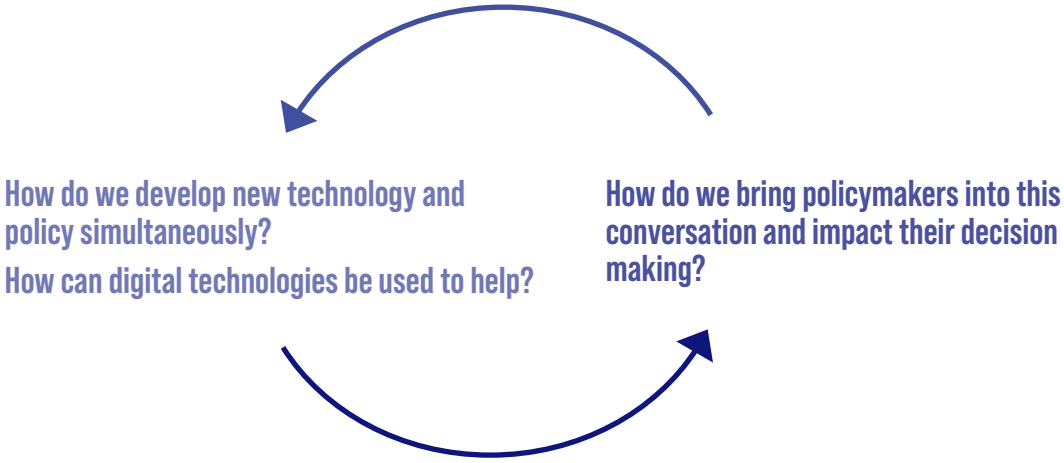
	Cognitive	Individual	Societal
Information overload	**2.1** Access to mass amounts of information via search engines and biased information through social media silos		
	Attention is diluted, and information is consumed based on algorithms instead of processed through critical thinking	Illusion of explanatory depth	Increasingly polarized discourse as everyone believes they are an expert
	2.2 Encouraging multiple tabs, things going, etc		
	Attention split among several focuses	Multitasking online and in person	Lack of in depth learning and memory encoding increases vulnerability to easily follow malign narratives
	2.2 Information overload and the production of more information than anyone could ever process		
	Heuristics to process a large volume of information	Biased information processing	Overconfidence in beliefs makes people more vulnerable to disinformation targeted at the group/ demographic
Unnaturally immersive and easy experience	*Cognitive*	*Individual*	*Societal*
	3.1 Rich sensory experience		
	Attention focused on digital experience rather than non-digital life experience	Reality apathy and lack of engagement with real world	Reduced participation and/ or understanding of democratic societal efforts
	3.2 Technology creating convenience		
	Cognitive preference for convenience reduces capacity for critical thinking and motivation to seek out alternative content, views, or non-technological means to achieve an end.	Avoiding cognitively demanding tasks	Aversion to inconvenient cognitive activity, such as democratic participation (civic debate, voting, etc.)
	3.2 Technology creating convenience		
	Information foraging (Triggers the dopamine system that evolved around the desire-and-reward cycle of food-foraging and eating.)	Lack of in depth information processing	Increases the potential of information fatigue, which can result in societal apathy.

Lack of Friction

Cognitive	*Individual*	*Societal*
4.1 Seamless online knowledge transfer		
Memory mis-encodes information found online as having been already known by the individual	Misattribution of knowledge/metacognitive overconfidence → overconfidence in beliefs; illusion of explanatory depth	Overconfidence in beliefs makes people more vulnerable to disinformation targeted at the group/demographic and less likely to take in arguments to the contrary.
4.2 Frictionless UX/UI in commercial technology products		
Attention is drawn to the enticing design, at the cost of other processes, like reasoning and judgment	The lack of friction makes multitasking and heavy use of technology intuitive and appealing. Leads to choices based on quick emotional responses.	Increased time on those apps means more exposure to disinformation, and polarizing content
4.3 Readily available external memory storage		
Cost to the core memory functions: encoding, storing, and retrieving	Diminished ability to recall information accurately	Reliance on external memory storage reduces the societal need to maintain oral history and increases the likelihood of false and potentially damaging societal narratives.
4.4 Lack of friction in social media technologies and recommender algorithms		
Individuals react emotionally to curated content, rather than with reasoning.	Emotional reactions impair critical thinking.	Emotionality makes people more vulnerable to disinformation targeted at the group/demographic and less likely to take in arguments to the contrary.

Areas for Future Solutions

DCDI focused on problem identification, research, building hypotheses, and developing a core set of indicators. To understand the difference between affective/manipulative and outsourcing/offloading technologies, individuals and society need mitigation strategies to counter the negative cognitive effects that can lead to greater susceptibility to disinformation, affective polarization, and in the most extreme cases, anti-democratic behavior. Policymakers and technologists should integrate their concerns and interests to ensure that solutions are comprehensive.



There also is more fundamental research to be done on the links between cognition, individuals, and society. Since the DCDI coalition began this work, our society and our world have changed how we interact with technology as a result of the COVID-19 pandemic. It is unclear how digitally influenced cognition will evolve over the next five years, much less over the next twenty. The following section examines a few of the most persistent and evolving questions for solution design, a list that will continue to grow as more work is done in this space.

COGNITIVE AND INDIVIDUAL ADAPTATION

How will our cognition evolve and adjust, parallel to that of technology?

The brain's inherent neuroplasticity[71] means that it evolves and adjusts to its environment, but the question remains whether our cognitive capabilities are evolving at the speed of technology, or at least at a speed that keeps us from harm overall. Will humans lose or enhance aspects of our cognition through this transition (for example, will people become less empathetic)? How humans adapt to the digital era will surely have repercussions on democracy, as we are already witnessing all around us. The extent of repercussions remain unclear—as do the tools available to us to more intentionally speed up our cognitive adjustment.

MISMATCHED RIVALS?

Can the human brain stay competitive vis-à-vis technology?

Can the human brain take on technology or is it losing the proverbial battle? Some believe that technology has already surpassed human capacity while others believe human brains are still intellectually superior. Technology knows humans well, and in many ways it is a reflection of us. This would suggest that we are still capable of remolding technology to better suit us. Or it could be that technology knows us better than ourselves because of the vast amount of personal data that filters through it.

71 "Neuroplasticity is a continuous processing allowing short-term, medium-term, and long-term remodeling of the neuronosynaptic organization, with the aim of optimizing the functioning of neural networks during phylogenesis, ontogeny, and physiologic learning, and following brain injury." See: Hugues Duffau, "Brain Plasticity and Reorganization Before, During, and After Glioma Resection," *Glioblastoma* (2016): 225-236, https://www.sciencedirect.com/science/article/pii/B9780323476607000185.

Conclusion

Neither policymakers nor the public have adequately understood the scope of the problem—that digital technologies are affecting not only our cognition, but also society and democracy. Understanding the effects of our ongoing digital transformation on human cognition is critical to our ability to evolve alongside technology, rather than watch the gap between technical capabilities and human understanding continue to grow. We need to better prepare our minds and our democratic institutions for the current and future information environments and digital landscapes, improving human resilience to new technologies and addressing core human vulnerabilities. We must engage in this effort to help people grapple with and understand just how much daily life is being impacted by these trends, if we stand a chance at keeping pace.

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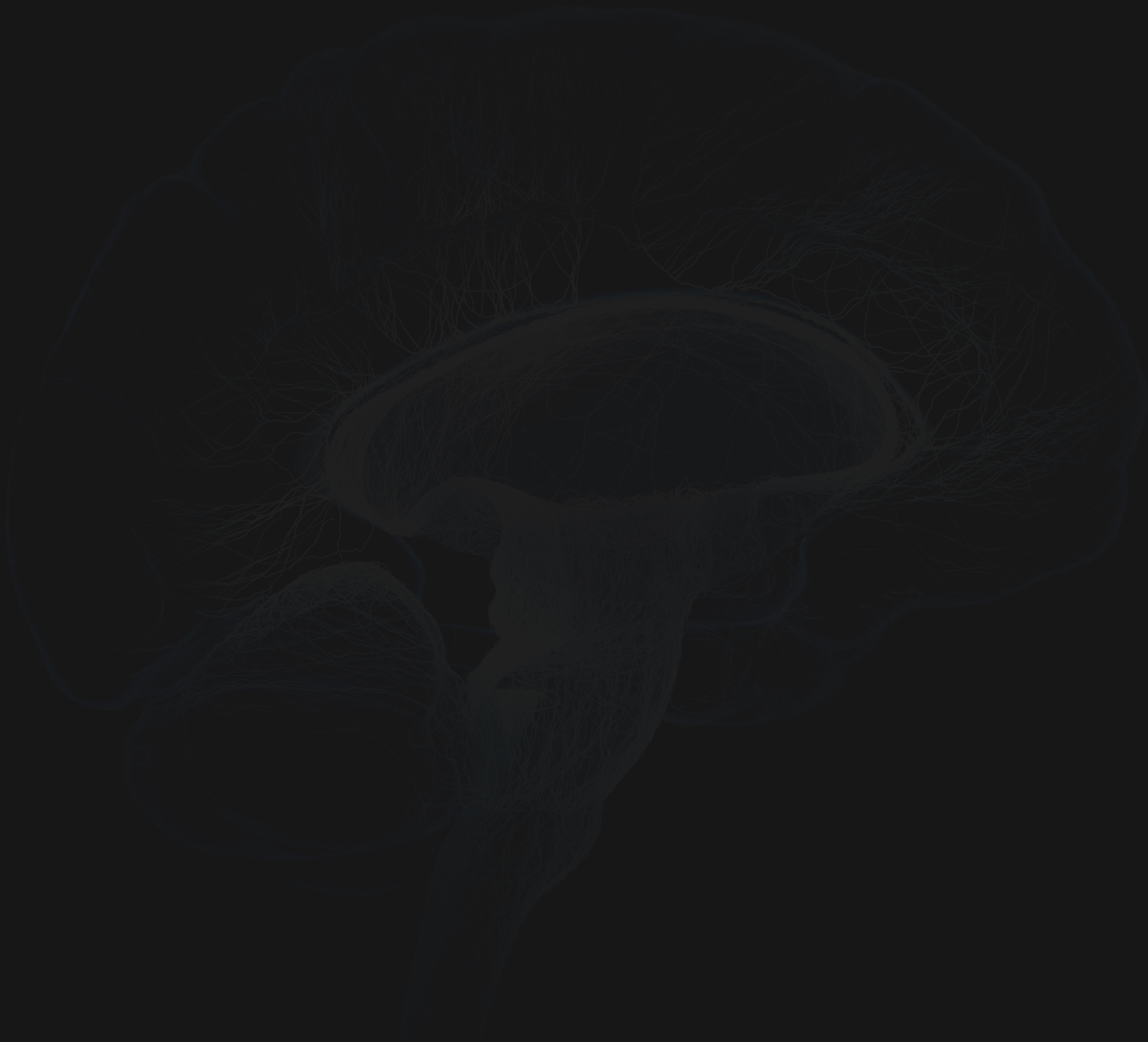

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