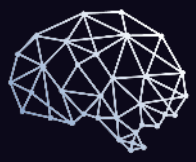

DIGITAL COGNITION AND DEMOCRACY INITIATIVE

REASONING

HOW DIGITAL TECHNOLOGIES INFLUENCE DECISION MAKING AND JUDGMENT

THE DIGITAL COGNITION AND DEMOCRACY INITIATIVE

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OCTOBER 2022

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About the Digital Cognition and Democracy Initiative

Digital technology has become a fixture in everyday life. The digital technology landscape has dramatically shifted, catering to individualized neurochemical reinforcement. Information mediation is now fast-paced, high-volume, low-friction, and extra-sensorial, garnering increasing concern about the impacts digital ubiquity is having on democracy.

Documented risks to the individual include impacts on mental health, particularly among young people; the proliferation of false information; and an overreliance on outsourced information. Impacts at the individual level cumulatively manifest in societal level concerns, such as affective polarization–defined as the tendency to distrust people from the opposite end of the political spectrum–and risks to public health as a consequence of disinformation campaigns. While digital technologies are not the sole cause of these concerns, the role they play is significant. A sound ability to update one's beliefs and to engage in constructive discourse are key elements of civic engagement and therefore healthy democracy. These skills rely on a concert of cognitive processes that are now influenced by rapid and extensive technology proliferation. The urgency of exploring this problem has grown as the risks to individual and societal well-being have become more evident.

This report is part of a series examining the effects digital technologies have on the following cognitive processes: "Memory," "Attention," and "Reasoning." The broader report series includes three additional papers looking at some of the society-level cognitive and democratic impacts of technology, titled: "Modulating Trust," "Shortcutting Critical Thinking," and "Exploiting Emotions." We have also compiled a capstone report, "Rewired: How Digital Technologies Shape Cognition," and a review of the literature on technology and cognition detailing the sources used for our analyses.

A note on methods

This report is informed by guidance from IST coalition members, but it is primarily derived from past and current cognitive science research findings relevant to the human relationship with digital technologies. It is not a synthesis of all available cognitive science research on technology. 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.

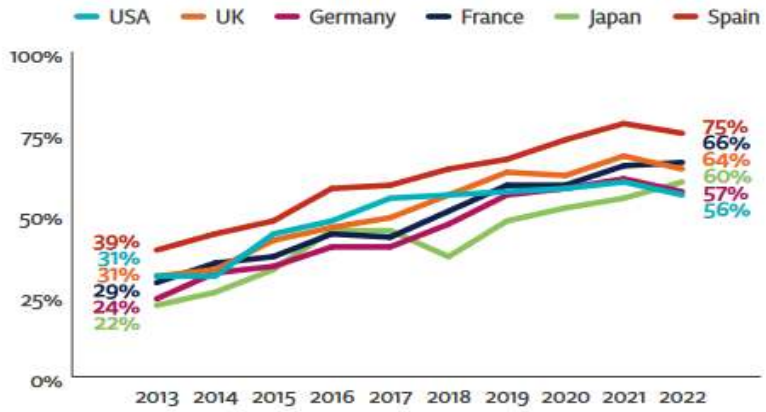
The relationship between digital technologies and cognitive processes

Why reasoning?

Reasoning is the cornerstone of deliberative discourse, an essential component of democracy. How members of a society engage with and debate issues of public concern to ensure their views are represented in higher decision making processes is a pillar of democratic practice.[1] Digital technologies that compromise individual engagement risk undermining these democratic practices.

Advances in computational power, shifts in user experience design paradigms, increased connectivity, and portable technologies have all made digital media a fixture in our lives. According to a study by Reuters Institute, smartphones are now the prevailing way people first access news in their day.[2] The ease in accessibility and shareability of information, and the richness of information-gathering experiences, are novel features of today's media ecosystem, with important consequences for how we make judgments and decisions.

Figure 1: Proportion who used a smartphone for news in the last week (2013-22) – Selected Markets



Smartphone use for news in the last week by year. Total 2013-22 sample in each market (most n = 2000).[3]

[1] Nico Carpentier, *Media and Participation: A Site of Ideological-Democratic Struggle* (Chicago: Intellect, 2011).
[2] Nic Newman et al., "Digital News Report 2022," *Reuters Institute*, accessed August 14, 2022, https://reutersinstitute.politics.ox.ac.uk/digital-news-report/2022.
[3] Nic Newman, "Overview and Key Findings of the 2022 Digital News Report," *Reuters Institute,* June 15, 2022, https://reutersinstitute.politics.ox.ac.uk/digital-news-report/2022/dnr-executive-summary.

This report provides a working definition of reasoning, narrowing the scope of the discussion to judgment and decision making. We identify three aspects of digital technology that exert significant impacts on reasoning: user experience design, gamification, and search engines. Examples include social media platforms, gamified platforms like Robinhood, and search engines like Google and Wikipedia. Key findings include:

- The mere presence of one's phone can have adverse effects on cognitive performance in reasoning tasks.[4]

- Digital tools provide short-cuts that affect judgment: Images are often used as heuristics to process information and even infer truthfulness.[5]

- 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 more impulsive decision making.[6]

- Digital tools atrophy reasoning functions: By rewiring dopaminergic pathways, aggressive "gamification" tactics can encourage addiction and weaken judgment and decision making, thus inhibiting higher order decision making.[7, 8]

- 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.[9] Reasoning

[4] 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.
[5] 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.
[6] 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.
[7] 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.
[8] 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.
[9] 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.

may be adversely affected if knowledge that informs mental models resides externally and is never committed to retrievable memories.[10, 11]

The effects listed above risk harming sound reasoning across diverse domains of activity and communication. Impacts could adversely affect the information ecosystem, public discourse, and civic engagement.

Judgment and decision making

In the context of digital technologies, reasoning has been framed in a variety of ways. Neuroscientist and DCDI coalition member Andrea Stocco and his co-authors have taken Earl Hunt's notion of fluid reasoning, "the capacity to reason through complex, novel scenarios for which there is no specific prior knowledge," and explored the underlying cognitive faculties that enable it.[12] They found that fluid reasoning rests on an ability to direct attention away from stimuli that do not serve one's immediate goals, also known as working memory. In addition to attention, they find that reinforcement learning is a key mechanism that enables one to commit to memory the mental models which are most rewarding in pursuit of an aim. Thus, Stocco and his colleagues were able to point to the cognitive faculties most crucial for reasoning in novel environments, while illustrating key neurological activation.[13]

The most popular framework as it pertains to digital technologies and reasoning is "dual process theories of reasoning," which proposes two distinct cognitive systems.[14] In System One, reasoning is characterized by automaticity. In System Two, reasoning is analytical, controlled, and considered.[15] Recent research has focused more on analytical, System Two reasoning. Psychologists Pennycook, Fugelsang, and Koehler put forward that analytical reasoning is defined by either rationalization or decoupling.[16] Rationalization is the process of substantiating or bolstering an intuitive response, whereas decoupling is the process of overriding the impulse to defer to the stereotypical or intuitive logic. The ability to rationalize aligns with the traditional

[10] 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.
[11] Alan Baddeley, "Working Memory," *Current Biology* 20(4) (2010): R136–R140, https://doi.org/10.1016/j.cub.2009.12.014.
[12] Andrea Stocco et al., "Individual Differences in Reward-Based Learning Predict Fluid Reasoning Abilities," *Cognitive Science* 45, no. 2 (2021): e12941, https://doi.org/10.1111/cogs.12941; Earl Hunt, *Human Intelligence* (Cambridge: Cambridge University Press, 2010).
[13] Andrea Stocco et al., "Individual Differences in Reward-Based Learning Predict Fluid Reasoning Abilities," *Cognitive Science* 45, no. 2 (2021): e12941, https://doi.org/10.1111/cogs.12941.
[14] Jonathan St. B.T. Evans, "In Two Minds: Dual-Process Accounts of Reasoning," *Trends in Cognitive Sciences* 7, no. 10 (2003): 454-459, https://doi.org/10.1016/j.tics.2003.08.012.
[15] Keith E. Stanovich and Richard F. West, "Individual Differences in Reasoning: Implications for the Rationality Debate?" *Behavioral and Brain Sciences* 23, no. 5 (2000): 645-665, https://doi.org/10.1017/S0140525X00003435.
[16] Gordon Pennycook et al., "What Makes Us Think? A Three-Stage Dual-Process Model of Analytic Engagement," *Cognitive Psychology* 80 (2015): 34-72, https://doi.org/10.1016/j.cogpsych.2015.05.001.

understanding of reasoning as the ability to verify the logical merits of an argument.[17] Decoupling has theoretical similarities to Stocco and colleagues' 2021 finding that the ability to disengage attention alongside reward-based reinforcement learning mechanisms is core to adopting successful reasoning strategies in novel situations.[18]

The variety of ways in which reasoning can be defined makes it a highly dynamic concept. Rather than adopting an overly rigid articulation of reasoning, the analysis in this report accepts its fluid nature. **Reasoning is loosely understood here as the ability to engage one's repertoire of cognitive tools to support goal attainment or higher order information processing.** For theoretical simplicity, this report will view judgment and decision making as forms of reasoning.

Judgment[19]

The primary mechanism behind judgment is inductive reasoning: the process of using past experiences and observations to make inferences about something's character, qualities, or a future event.[20] When engaging in inductive reasoning for the purposes of judgment formation, people often rely on two key rules of thumb, or heuristics: the availability heuristic and the representative heuristic. The availability heuristic refers to the assumption that events that are more easily recalled are more likely to reoccur than events that are more difficult to recall. Thus, the availability heuristic relies on frequency to inform judgment making. The representative heuristic states that the "probability that A is a member of class B can be determined by how well the properties of A resemble the properties we usually associate with class B."[21] More succinctly, this heuristic relies on resemblances shared between an object's or event's qualities and similar past observed objects or events to inform judgments.

The human brain's natural tendency to develop cognitive shortcuts through pattern identification, though efficient, can have biased and inaccurate results. The use of heuristics that rely on past experiences and prior knowledge introduces an opportunity for one's opinions and perceptions to play a part in judgment formation. This form of a confirmation bias is termed "myside bias."[22] Myside bias refers to the generation and evaluation of evidence in a way that

[17] Peter C. Wason, "Reasoning About a Rule," *Quarterly Journal of Experimental Psychology* 20, no. 3 (1968): 273-281, https://doi.org/10.1080/14640746808400161.
[18] Andrea Stocco et al., "Individual Differences in Reward-Based Learning Predict Fluid Reasoning Abilities," *Cognitive Science* 45, no. 2 (2021): e12941, https://doi.org/10.1111/cogs.12941.
[19] For the purposes of this paper, *judgment* and *inductive reasoning* are used interchangeably.
[20] E. Bruce Goldstein, *Cognitive Psychology: Connecting Mind, Research and Everyday Experience*, 4th ed. (Boston: Cengage Learning, 2014).
[21] Ibid, 373.
[22] Craig R.M. McKenzie, "Hypothesis Testing and Evaluation," in *Blackwell Handbook of Judgment and Decision Making,* eds. D. J. Koehler & N. Harvey (Hoboken: Blackwell Publishing Ltd., 2004): 200–219; Keith E. Stanovich et al., "Myside Bias, Rational Thinking, and Intelligence," *Current Directions in Psychological Science* 22, no. 4 (2013): 259-264, https://doi.org/10.1177/0963721413480174; Charles S. Taber and Milton Lodge, "Motivated Skepticism in the Evaluation of Political Beliefs," *American Journal of Political Science* 50, no. 3 (2006): 755-769, https://doi.org/10.1111/j.1540-5907.2006.00214.x.

aligns with one's own opinions and attitudes.[23] The subjectivity of perception and the challenge of contending with bias in cognitive processes is a recurring theme throughout this paper.

Decision Making

Decision making processes are influenced by the conclusions drawn from one's judgment. There are several models explaining how decisions are made, two of which are the expected utility theory and the neuroeconomics approach. The expected utility theory operates with the key assumption that humans are rational actors. This theory argues that if people have all of the relevant information, they will make decisions which maximize "utility," or goal attainment.[24] Though this theory presupposes an unrealistic expectation that people are purely rational actors, it introduces an important central argument that people will make choices that allow them to control outcomes that are ultimately beneficial to them or their goals.

Research into human behavior and psychology, however, finds that humans are "feeling" animals.[25] Our constant state of "feeling," a primal function of homeostatic preservation, allows us to be receptive to not only our body's physical well-being but also emotive states. This ability to sense and feel is not always conscious–we are not always aware of our emotions as we experience them, or might not be aware of what has triggered them.[26] In some contexts, our inaccurate prediction of our own emotions is correlated with poor decision making.[27] Other such tendencies that challenge the straightforward logics of utilitarian decision making include risk avoidance behaviors and optimism.[28]

Alan Sanfey and his co-authors employ a neuroeconomic approach combining economic and psychological models with neuroimaging techniques.[29] They find that when participants are confronted with an unfair choice, there is activation in two regions of the brain: the anterior insula, correlated with emotional processing, and the dorsolateral prefrontal cortex, often attributed to deliberative processing. Participants who rejected an offer on the basis of

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[23] E. Bruce Goldstein, *Cognitive Psychology: Connecting Mind, Research and Everyday Experience*, 4th ed. (Boston: Cengage Learning, 2014)
[24] Kenneth Ian Manktelow, *Reasoning and Thinking* (London: Psychology Press, 1999); Arthur S. Reber, *The Penguin Dictionary of Psychology* (New York: Penguin Press, 1995).
[25] Antonio Damasio, *The Strange Order of Things: Life, Feeling, and the Making of Cultures* (New York: Vintage, 2019).
[26] Ibid.
[27] Ellen Peters et al., "Affect and Decision Making: A "Hot" Topic," *Journal of Behavioral Decision Making* 19, no. 2 (2006): 79-85, https://doi.org/10.1002/bdm.528; Timothy D. Wilson and Daniel T. Gilbert, "Affective Forecasting," in *Advances in Experimental Social Psychology,* Vol. 35, ed. M. P. Zanna (Cambridge: Elsevier Academic Press, 2003): 345–411, https://doi.org/10.1016/S0065-2601(03)01006-2.
[28] Jon K. Maner and Norman B. Schmidt, "The Role of Risk Avoidance in Anxiety," *Behavior Therapy* 37, no. 2 (2006): 181-189, https://doi.org/10.1016/j.beth.2005.11.003; Martin P. Paulus and J. Yu Angela, "Emotion and Decision-Making: Affect-Driven Belief Systems in Anxiety and Depression," *Trends in Cognitive Sciences* 16, no. 9 (2012): 476-483, https://doi.org/10.1016/j.tics.2012.07.009; Keise Izuma and Ralph Adolphs, "The Brain's Rose-Colored Glasses," *Nature Neuroscience* 14, no. 11 (2011): 1355-1356, https://doi.org/10.1038/nn.2960; Tali Sharot et al., "How Unrealistic Optimism is Maintained in the Face of Reality," *Nature Neuroscience* 14, no. 11 (2011): 1475-1479, https://www.nature.com/articles/nn.2949.
[29] Alan G. Sanfey et al., "The Neural Basis of Economic Decision-Making in the Ultimatum Game," *Science* 300, no. 5626 (2003): 1755-1758, https://doi.org/10.1126/science.1082976.

unfairness exhibited greater activation of the anterior insula than the prefrontal cortex. Those who accepted offers exhibited the opposite pattern of greater activation of the prefrontal cortex than that of the anterior insula. This decision task, known as the Ultimatum Game, is a renowned example of the neuroeconomic approach which showcases the physical manifestation of the dual nature of deliberation and emotionality in decision making.[30] This interdisciplinary approach to understanding how decisions are made sheds light on the neurological mechanisms at play while simultaneously pointing to evidence of the inextricable nature of emotionality in cognitive processing.

How digital technologies influence reasoning, the many forms reasoning takes, and the many cognitive processes that comprise it will be explored in the subsequent section.

The Effects of Digital Technologies on Reasoning

Studies have long found that digital technologies influence the ways we think. Cognition researchers Guangheng Dong and colleagues found that those who struggle with Internet addiction disorder (IAD) took longer to engage in the decision making process than those who did not suffer from IAD.[31] They also found that those with IAD had a stronger sensitivity towards winning than losing, thus triggering a greater reward for a win than punishment for a loss.[32] Other research reinforces this finding by showing that Internet addiction can rewire dopaminergic pathways responsible for motivation-based reasoning in a way that impedes higher order decision making processes.[33] Although Dong and colleagues' findings point to more extreme afflictions, other research shows that the mere presence of one's phone has adverse effects on one's cognitive performance and reasoning (as measured by an OSpan task

[30] Alan G. Sanfey et al., "Neuroeconomics: Cross-Currents in Research on Decision-Making," *Trends in Cognitive Sciences* 10, no. 3 (2006): 108-116, https://doi.org/10.1016/j.tics.2006.01.009; Antonio Damasio, *The Strange Order of Things: Life, Feeling, and the Making of Cultures* (New York: Vintage, 2019). See also: Kevin N. Ochsner and James J. Gross, "The Cognitive Control of Emotion," *Trends in Cognitive Sciences* 9, no. 5 (2005): 242-249, https://doi.org/10.1016/j.tics.2005.03.010.

[31] Guangheng Dong et al., "What Makes Internet Addicts Continue Playing Online Even When Faced by Severe Negative Consequences? Possible Explanations from an FMRI Study," *Biological Psychology* 94, no. 2 (2013a): 282-289, https://doi.org/10.1016/j.biopsycho.2013.07.009.

[32] Guangheng Dong et al., "Reward/Punishment Sensitivities Among Internet Addicts: Implications for Their Addictive Behaviors," *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 46 (2013b): 139-145, https://doi.org/10.1016/j.pnpbp.2013.07.007.

[33] 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.

set and RSPM test).[34] While there are many discussions about the negative impacts the Internet and smartphones have on reasoning, this report reviews how specific digital technologies have been found to impact reasoning.

Digital media and user experience design

Social media platforms serve as a public forum for everyday discourse. Being active on social media means experiencing society across several different dimensions: auditory, visual, temporal, and haptic. The development of design features that play on each of these sensorial dimensions is a critically important facet of engaging with today's digital technologies, particularly digital media. Online dynamics have been found to enage System One (automatic) rather than System Two (deliberative) reasoning. Communications researchers Natalie Stroud and colleagues argue that "the social media environment itself (with huge quantities of bite-sized information, constantly updated in real time) promotes peripheral/heuristic processing by placing constraints on both users' ability and motivation to think carefully about the information presented."[35] The user experience on social media plays on the behavioral proclivity to rely on the heuristics described above. "Humans are cognitive misers," as psychologists Gordon Pennycook and David Rand put it, and thus find ways of avoiding cognitively demanding tasks.[36] Confirming these findings, Didem Pehlivanoglu et al. found evidence that digital media encourages the use of heuristics such as "news-related cues" to play on default cognitive laziness.[37]

The high volume of information online encourages users to adopt coping strategies that shortcut the analytical reasoning processes described above, and the way information is displayed and formatted (e.g., full screen viewing, ephemerality, layering text on images) plays a role in encouraging such cognitive shortcuts. Experience and comfort in navigating the digital environment shapes one's ability to be critical of digital information.[38] Researchers have found

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[34] Guangheng Dong et al., "What Makes Internet Addicts Continue Playing Online Even When Faced by Severe Negative Consequences? Possible Explanations from an FMRI Study," *Biological Psychology* 94, no. 2 (2013a): 282-289, https://doi.org/10.1016/j.biopsycho.2013.07.009; Guangheng Dong et al., "Reward/Punishment Sensitivities Among Internet Addicts: Implications for Their Addictive Behaviors," *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 46 (2013b): 139-145, https://doi.org/10.1016/j.pnpbp.2013.07.007; 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.

[35] Natalie-Jomini Stroud et al., "Making Sense of Information and Judging its Credibility," *Understanding and Addressing the Disinformation Ecosystem. First draft* (2017): 47.

[36] Gordon Pennycook and David G. Rand, "Lazy, Not Biased: Susceptibility to Partisan Fake News is Better Explained by Lack of Reasoning Than By Motivated Reasoning," *Cognition* 188 (2019): 39-50, https://doi.org/10.1016/j.cognition.2018.06.011; Keith E. Stanovich and Richard F. West, "Individual Differences in Reasoning: Implications for the Rationality Debate?" *Behavioral and Brain Sciences* 23, no. 5 (2000): 645-665, https://doi.org/10.1017/S0140525X00003435.

[37] Didem Pehlivanoglu et al., "The Role of Analytical Reasoning and Source Credibility on the Evaluation of Real and Fake Full-Length News Articles," *Cognitive Research: Principles and Implications* 6, no. 1 (2021): 1-12, https://doi.org/10.1186/s41235-021-00292-3.

[38] 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.

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.[39] Such findings suggest that human brains can preserve reasoning by adapting to digital formats. However, shifts in the digital media landscape tend to favor rich imagery and short format video. Research finds that images are often used as heuristics to process information and even infer truthfulness.[40] The unifying theme in these findings is the reliance on heuristics 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), which enables quick judgment formation, and therefore, often rushed decision making.[41]

Many have sought to identify the barriers preventing people from engaging in deeper reasoning, and have often attributed it to a propensity for bias or motivated reasoning.[42] Why one might be prone to bias or motivated reasoning is outside the scope of this report, but the literature indicates that digital technologies are designed to trigger and play on users' "cognitive miserliness" by triggering the engagement of preexisting mental models and schemas—explained by the default to heuristics above. Essentially, it seems that digital tools exploit, and at times exacerbate, the natural mental tendency to avoid more rigorous reasoning processes. Certain cues are baked into the design of both digital experience and content in order to encourage quick judgment and consequently poor decision making.[43]

Product designers enlist a medley of visual, audio, temporal, and haptic design elements with an aim of nudging user behaviors towards a specific behavior whether it be increased content sharing, screen time, or online purchases.[44] It is necessary to explore how the adoption of psychology-informed design practices across the digital media industry influences the ability to

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[39] Ibid.
[40] 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, 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; 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; Eryn J. Newman et al., "Evidence that Photos Promote Rosiness for Claims About the Future," *Memory & Cognition* 46, no. 8 (2018): 1223-1233, https://link.springer.com/article/10.3758/s13421-016-0652-5.
[41] 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://doi.org/10.1126/science.185.4157.1124.
[42] Dan M. Kahan, "The Politically Motivated Reasoning Paradigm," *Emerging Trends in Social & Behavioral Sciences, Forthcoming* (2015), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2703011; Michael Bang Petersen et al., "Motivated Reasoning and Political Parties: Evidence for Increased Processing in the Face of Party Cues," *Political Behavior* 35, no. 4 (2013): 831-854, https://doi.org/10.1007/s11109-012-9213-1; Jay J. Van Bavel and Andrea Pereira, "The Partisan Brain: An Identity-Based Model of Political Belief," *Trends in Cognitive Sciences* 22, no. 3 (2018): 213-224, https://doi.org/10.1016/j.tics.2018.01.004. See also: Gordon Pennycook and David G. Rand, "The Psychology of Fake News," *Trends in Cognitive Sciences* 25, no. 5 (2021): 388-402, https://doi.org/10.1016/j.tics.2021.02.007.
[43] Natasha Dow Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Princeton: Princeton University Press, 2012).
[44] Joe Leech, *Psychology for Designers* (Bristol: mrjoe press, 2013) https://mrjoe.uk/psychology-for-designers/; Natasha Dow Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Princeton: Princeton University Press, 2012).

attend to the right stimuli and to engage in sound judgment, decision making, and other such forms of reasoning.[45]

Gamification

A common extension of user experience design involves the employment of design principles layered with game-play elements. The platform Robinhood is an exemplar of design tactics also used in gig-economy applications such as Uber and Deliveroo. Robinhood is a commission-free digital brokerage platform. Core to its design is a seamless user experience, including, as *The New York Times* explained, "one-click trading, easy access to complex investment products, and features like falling confetti and emoji-filled phone notifications that made it feel like a game."[46] Attracting young and inexperienced traders, the application has recently been under scrutiny for encouraging reckless trading behavior.[47] The award-winning seamless design has garnered attention from regulatory bodies for employing aggressive "gamification" tactics that not only encourage addiction but poor judgment and decision making as well. [48]

The addictive nature of the application encourages what digital culture anthropologist and DCDI coalition member Natasha Dow Schüll terms ludic loops, or "the repeating cycles of action created by digital interactive media such as video games, slot machines, apps, and websites, owing to certain design characteristics."[49] Employing game play design features and incorporating simplicity into the core of the user experience have been fundamental to both its success and the risks it has introduced. The attractive and exciting gamified facets of engaging with digital applications can even alter dopaminergic pathways, inhibiting one's ability to engage in higher order decision making.[50] These design practices exploit the natural aversion people

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[45] Ibid.
[46] Nathaniel Popper, "Robinhood Has Lured Young Traders, Sometimes With Devastating Results," *The New York Times,* July 8, 2020, https://www.nytimes.com/2020/07/08/technology/robinhood-risky-trading.html.
[47] Annie Massa and Tracy Alloway, "Robinhood's Role in the 'Gamification' of Investing," *Bloomberg*, December 19, 2020, https://www.bloomberg.com/news/articles/2020-12-19/robinhood-s-role-in-the-gamification-of-investing-quicktake; Annie Massa et al., "Robinhood Is Accused of 'Gamification' by Massachusetts," *Bloomberg*, December 16, 2020, https://www.bloomberg.com/news/articles/2020-12-16/robinhood-accused-of-gamification-by-massachusetts-regulator; Misyrlena Egkolfopoulou et al., "How Robinhood Made Trading Easy—And Maybe Even Too Hard to Resist," *Bloomberg*, April 21, 2021, https://www.bloomberg.com/features/2021-robinhood-stock-trading-design/; Nathaniel Popper, "Robinhood Has Lured Young Traders, Sometimes With Devastating Results," *The New York Times,* July 8, 2020, https://www.nytimes.com/2020/07/08/technology/robinhood-risky-trading.html.
[48] Annie Massa et al., "Robinhood Is Accused of 'Gamification' by Massachusetts," *Bloomberg*, December 16, 2020, https://www.bloomberg.com/news/articles/2020-12-16/robinhood-accused-of-gamification-by-massachusetts-regulator; Brad M. Barber et al., "Attention Induced Trading and Returns: Evidence from Robinhood Users," *Journal of Finance*, forthcoming (2021).
[49] Natasha Dow Schüll, "Stuck In The Machine Zone: Your Sweet Tooth For 'Candy Crush'. In "All Things Considered," *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.
[50] 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.

have to cognitive complexity, thus bypassing the fundamental role reflective judgment and decision making play in important life decisions, such as handling one's finances.[51]

Judgment rests on the ability to make observations and to apply prior knowledge to form conclusions. In the case of a new investor, if their information is over-simplified or their experience is limited, their ability to make sound judgment is immediately compromised. Without a mental model or schema to frame how one should judge a good or bad choice, one is left in a poor position for sound decision making. A testament to this is the unusually high volume of trading occuring on Robinhood.[52] This behavior is ultimately counterproductive to achieving financial gains (assuming that is the goal), since research has found that the more active one is in trading, the worse their returns.[53] Treating financial investment as a speculative game, much like gambling, has resulted in negative consequences for many inexperienced traders.[54] Robinhood is but one of many case studies which demonstrates how the gamification of professional services is influencing reasoning and decision making.[55]

Memory and Search Engines

The final example of reasoning being impacted by digital tools demonstrates that the ease of acquiring new information has encouraged dependence on these external digital sources. The information stored in memory informs the mental models and schemas used to form in-the-moment judgments, make decisions, and solve problems.[56] As is discussed in the separate "Memory" report in this series, search engines have lowered the barriers to accessing information. The significant ease by which one can acquire information has disincentivized the

[51] Tarik Umar, "Complexity Aversion when Seeking Alpha," *Journal of Accounting and Economics* 73, no. 2-3 (2022): 101477, https://doi.org/10.1016/j.jacceco.2021.101477; Ryan Oprea, "What Makes a Rule Complex?" *American Economic Review* 110, no. 12 (2020): 3913-51.
[52] A study found that in one quarter in 2020, Robinhood traders made 40 times as many trades as Charles Schwab traders, and nine times as many as E-trade traders. See: Nathaniel Popper, "Robinhood Has Lured Young Traders, Sometimes With Devastating Results," *The New York Times,* July 8, 2020, https://www.nytimes.com/2020/07/08/technology/robinhood-risky-trading.html.
[53] Bloomberg Quicktake: Originals, "How Robinhood Gets Casual Traders Hooked," *YouTube*, 2021, https://www.youtube.com/watch?v=lxzMNomgOS8.
[54] Nathaniel Popper, "Robinhood Has Lured Young Traders, Sometimes With Devastating Results," *The New York Times,* July 8, 2020, https://www.nytimes.com/2020/07/08/technology/robinhood-risky-trading.html; Sergei Klebnikov and Antoine Gara, "20-Year-Old Robinhood Customer Dies By Suicide After Seeing A $730,000 Negative Balance," *Forbes*, June 17, 2020, https://www.forbes.com/sites/sergeiklebnikov/2020/06/17/20-year-old-robinhood-customer-dies-by-suicide-after-seeing-a-730000-negative-balance/.
[55] For more on this see: Noam Scheiber, "How Uber Uses Psychological Tricks to Push Its Drivers' Buttons," *The New York Times*, April 2, 2017, https://www.nytimes.com/interactive/2017/04/02/technology/uber-drivers-psychological-tricks.html; Sarah Mason, "High score, low pay: Why the gig economy loves gamification," *The Guardian*, November 20, 2018, https://www.theguardian.com/business/2018/nov/20/high-score-low-pay-gamification-lyft-uber-drivers-ride-hailing-gig-economy; Michael Safi et al., "The Uber Files: The drivers (part 3) - Podcast," *The Guardian*, 2022, https://www.theguardian.com/news/audio/2022/jul/13/the-uber-files-the-drivers-part-3-podcast.
[56] E. Bruce Goldstein, *Cognitive Psychology: Connecting Mind, Research and Everyday Experience,* 4th ed. (Boston: Cengage Learning, 2014).

commitment of information to memory.[57] Moreover, researcher and DCDI coalition member Adrian Ward found that this reliance on external digital information sources leads to a misattribution of the Internet's knowledge as one's own.[58] A habitual reliance on external digital information sources, such as Google and Wikipedia, can affect one's ability to reason. As discussed in prior sections, the digital environment is designed to elicit quick responses that rely on heuristics. This process is necessarily reliant on having mental models and schemas at hand to inform judgment and decision making. These findings imply potentially problematic downstream effects on sound reasoning if the foundational knowledge that informs mental models used for everyday decision making resides externally and is never actually committed to retrievable memories.[59] It is also potentially problematic for public discourse, and for comprehending current political stakes and positions, if one is less able to revise their mental heuristics by incorporating new ideas, information, and developments via new long term memories.

Conclusion

This report has reviewed several ways digital technologies influence reasoning. Psychologically-informed digital design practices, along with a large volume of information, jointly encourage the use of cognitive shortcuts. These digital design strategies are most effective at achieving their intended aims (e.g., product purchases) if users engage in the quick thinking often associated with System One reasoning (automatic). In addition to the use of digital design strategies, the integration of game-play logic into financial management, entertainment, and gig-economy platforms also interferes with more deliberative reasoning. Many of these platforms engage in design practices that contribute to decision making against the best financial interest of its users, or even at a cost to user well-being.[60] Across these examples, considering System One versus System Two framework has proven useful for assessing how the design of digital technologies take advantage of the proclivity for "cognitive miserliness."[61] The propensity to enlist one's prior knowledge in order to make assertions or

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[57] 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; Daniel M. Wegner and Adrian F. Ward, "How Google is Changing Your Brain," *Scientific American* 309, no. 6 (2013): 58-61.

[58] Adrian F. Ward, "People Mistake the Internet's Knowledge for Their Own," *Proceedings of the National Academy of Sciences* 118, no. 43 (2021): e2105061118.

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

[60] Noam Scheiber, "How Uber Uses Psychological Tricks to Push Its Drivers' Buttons," *The New York Times*, April 2, 2017, https://www.nytimes.com/interactive/2017/04/02/technology/uber-drivers-psychological-tricks.html; Michael Safi et al., "The Uber Files: The drivers (part 3) - podcast," *The Guardian*, 2022, https://www.theguardian.com/news/audio/2022/jul/13/the-uber-files-the-drivers-part-3-podcast; Sergei Klebnikov and Antoine Gara, "20-Year-Old Robinhood Customer Dies By Suicide After Seeing A $730,000 Negative Balance," *Forbes*, June 17, 2020, https://www.forbes.com/sites/sergeiklebnikov/2020/06/17/20-year-old-robinhood-customer-dies-by-suicide-after-seeing-a-730000-negative-balance/.

[61] Gordon Pennycook and David G. Rand, "Lazy, Not Biased: Susceptibility to Partisan Fake News is Better Explained by Lack of Reasoning Than by Motivated Reasoning," *Cognition* 188 (2019), https://doi.org/10.1016/j.cognition.2018.06.011.

predictions is at the core of reasoning and reinforces the importance memory plays in setting the stage for sound reasoning. One's judgment, a form of inductive reasoning that is heavily reliant on prior knowledge, is only as good as that prior knowledge. It is important to further explore how reliance on external information stores might influence the ability to be rationally responsive. How we exist in digital spaces and engage with digital technologies directly influences how we reason, and thus how we behave. The act of reasoning is critical for the ability to vet the logical merits of information, and to update one's beliefs accordingly—and is a key aspect of healthy democracy.

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