ROUTLEDGE HANDBOOK OF BOUNDED RATIONALITY

Edited by Riccardo Viale

First published 2021

ISBN: 978-1-138-99938-1 (hbk)
ISBN: 978-0-367-56394-3 (pbk)
ISBN: 978-1-315-65835-3 (ebk)

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THE WINDS OF CHANGE

The Sioux, Silicon Valley, society, and simple heuristics

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DOI: 10.4324/9781315658353-21

The funder of this chapter is Université de Lausanne.

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

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Introduction

Imagine the following: Born in 1860, Leaning-Bear, a Sioux (Lakota), grows up in the West of North America. His life unfolds amidst traditional and season-dependent tribal activities, such as hunting and gathering or moving from one camp site to another. There is regular contact with other tribes, and occasional ones with 'white' settlers. Then, suddenly, Leaning-Bear's world begins to change: More 'white' intruders enter the prairies and the Black Hills, and occasional skirmishes turn into an increasingly fierce struggle for survival (see e.g., Brown, 1971, 1974; Brown & Schmitt, 1976). In 1876, aged 16, Leaning-Bear fights in the legendary battle of the Little Big Horn; he sees George Armstrong Custer and his soldiers of the 7th U.S. Cavalry Regiment die. But shortly afterwards, the U.S. army gains control. At the age of 30, Leaning-Bear and his family live, on 'reservation land', under surveillance by government agents, no longer moving on horseback freely across the seemingly endless space of the Great Plains. Famine and government rations replace buffalo meat; and the memories of the massacre of Wounded Knee replace those of the victory of Little Big Horn. Violence, chaos, death, and misery surround him, and as time passes, alcohol enters his life. That is the end of Leaning-Bear's old world. But it is not the end of changes in his new world: Only a few years later, he finds himself surrounded by the impenetrable walls of a 'white' man's prison cell; and after release, he lives on to hear about cars and even airplanes; he sees factories and learns about a great war raging on the other side of the ocean between 1914–1918. Leaning-Bear, a man who was born in a teepee and who grew up in a world of buffalo hunting with bows and arrows, dies in 1933, at the age of 73 and in the same year Adolf Hitler seizes power in Germany.[1,2]

The story of Leaning-Bear's life is one about drastic changes in a person's environment. It is actually not only a story of change in one individual's environment, but also of change in the environment of a social collective: the Sioux nation. Changes in collective environments are common throughout human history: Genocides, wars, economic conflicts between groups, climatic catastrophes, epidemics, and technological revolutions can all lead to change.

What, then, characterizes the change in the story of Leaning-Bear more precisely? (1) The change is profoundly *disruptive*; it has terribly negative consequences for an individual's—here, Leaning-Bear's—well-being. (2) The change is *abrupt*; it is sudden, taking place within only a few years of an individual's life-time. (3) The change is *thorough;* it cuts across many, if not all, dimensions

 DOI: 10.4324/9781315658353-21

of life. It affects, for instance, what Leaning-Bear and his fellow tribe members eat, which tools and artifacts they use, how they dress, who is part of their social network, and whose laws are enforced. (4) Finally, from the perspective of the individual, at the moment of such sudden, profoundly negative, and all-encompassing change, the environment becomes deeply *uncertain*: Known regularities seem to break down and the environment continues to evolve at rapid pace. In short, Leaning-Bear's story is that of a revolution breaking out upon individuals. The violent winds of change that were blowing over the prairies in the 1870s seem fundamentally different to all those storms the Sioux and other Native American tribes had encountered throughout their entire history.

Today, one might argue, we are also living through a period of rapid, extensive change. A different type of change—not produced by war, invasion, genocide, or migration, but by technology. The contemporary winds of change we are referring to are not blowing over the prairies, but across the entire planet. One of their epicenters—to the extent that is possible to locate its roots geographically—is Silicon Valley with its many technology giants (for the philosophical and historical roots of digital technologies, see Emberson, 2009; Hoffrage, 2019). Digital technology has had and will continue to have a powerful impact across many dimensions of our lives: It affects what many of us do on a daily basis to make a living, what is considered to be wrong and what is considered to be right, how we search for and how we find information, and how we organize our social lives—or, more precisely, how digital technologies affect this organization. These technologies determine, and will increasingly continue to determine, what tools we use and have access to, and it is uncertain what other aspects of our lives they will change. The digital winds of change might shape some individual's or collectives' lives later, with remnants or pockets of old, non-digital environments being at least partially conserved within and by more-or-less isolated groups. Older generations who might have scant contact with digital technology offer one example. In that pockets subsist for some time, the digital winds of change are no different from other changes in human history, including those that impacted on the Native American nations over the last centuries. A stunning historical example is the existence of the last free Apaches, bearing their own tragic history by hiding in the Sierra Madre in the North of Mexico until at least as late as the 1930s (see Goodwin & Goodwin, 2018).

Importantly, while the digital winds of change will blow into different individuals' faces sooner or later, the ongoing digital revolution has great potential to do much harm to individuals and societies as a whole. In our view, those potential negative side-effects of the digital winds of change need to be understood scientifically, such that we, to the extent that we are still in control, might be able to counteract them. That is, reflection about how sudden, profoundly negative, and all-encompassing changes affect the ways in which individuals think, decide, and act seems warranted, alongside reflection about how individuals and societies can manage such changes.

By focusing on the possible negative aspects of digitalization, this chapter considers how humans understand and manage abrupt, disruptive, and thorough changes through the theoretical lens of a psychological framework: the *fast-and-frugal heuristics approach* to decision making, developed by the ABC (Adaptive Behavior and Cognition) Research Group around Gerd Gigerenzer and colleagues (e.g., Gigerenzer, Todd, & the ABC Research Group, 1999; Gigerenzer, Hertwig, & Pachur, 2011). This theoretical lens, also known as the *simple heuristics approach*, lends itself particularly well to trying to understand how boundedly rational humans––individuals who are neither "omniscient" nor endowed with computational "omnipotence" (e.g., Gigerenzer, 2008a, p. 5 and p. 4, respectively)—behave and decide in an uncertain world. In addition to this, the framework aids reflecting about normative, prescriptive aspects of adapting to and shaping a fundamentally uncertain world.

We proceed as follows: Upon offering an overview of the fast-and-frugal heuristics research program, we sketch out what future aversive digital environments might look like, and speculate

what strategies individuals and societies might rely upon in order to manage those aversive changes in their environments. We close by (1) pointing to a series of research questions about how digital environments might differ from other environments we humans have encountered both in our more recent history and over the course of our evolution as well as (2) turning to questions about children and education.

Before we start, a commentary is warranted. We acknowledge and believe that digital technologies can do, do do, and will do much good (and we are both, by no means, technology-aversive and/or change-resistant, reactionary scientists). Yet, we have decided to play devil's advocate and to focus, in this chapter, exclusively on digitalization's potential negative aspects, because we believe it is important for more people to adopt a healthily skeptical view in a time when 'going digital' has become a mantra for businessmen, politicians, administrators, and others. In so doing, we are intellectually indebted to and join others who have underlined the negative aspects of digitalization (e.g., Helbing, 2015, 2019; O'Neil, 2016; Helbing et al., 2017; SVRV, 2018).

The fast-and-frugal heuristics framework

The fast-and-frugal heuristics framework asks how the structure of environments shapes behavior and cognition. The assumption is that people can select inferential and other decision-making mechanisms from a repertoire, commonly referred to as the *adaptive toolbox* (Gigerenzer et al., 1999; for an overview, see e.g., Gigerenzer & Gaissmaier, 2011). By using different mechanisms (i.e., tools) from that toolbox as a function of the environment, people can make accurate inferences about unknown elements of their world, prevent being excluded from important social groups, find mates, or otherwise behave adaptively. Relying on tools that do not fit the environment through which people are navigating can produce maladaptive behavior and potentially catastrophic outcomes.

The idea that performance and behavior depend on an organism's environment is common to a number of research programs on human cognition. For instance, Gibson's (1986) theory of visual perception stresses that neither the perceptual system nor that system's environment can be understood in isolation; instead what matters is their interplay. According to Gibson, the environment comes with functional properties—dubbed *affordances*—that organisms can perceive and act upon. The *ACT-R theory of cognition* (e.g., Anderson et al., 2004) and the *rational analysis* (e.g., Anderson, 1991) on which parts of ACT-R are based, place emphasis on how human memory, by being adapted to the statistical structure of the environment, achieves its processing goals (see Anderson & Schooler, 1991). To give a final example, Brunswik's approach to studying human perception assumes that *achievement* (i.e., performance) depends on how individuals integrate cues available to them in the environment. According to Brunswik (e.g., 1955), it is the statistical structure of information in an environment (i) that needs to be studied in order to understand behavior and cognition, and (ii) that needs to be maintained in experiments and in observational studies aimed at assessing performance.

The fast-and-frugal heuristics research program has been influenced, to a large extent, by Brunswik's conceptual framework of *probabilistic functionalism*, and by Simon's seminal work on *bounded rationality* (e.g., Gigerenzer, Hoffrage, & Kleinbölting, 1991, and Gigerenzer & Goldstein, 1996, respectively). According to Simon (1990), "[h]uman rational behavior ... is shaped by a scissors whose two blades are the structure of task environments and the computational capabilities of the actor" (p. 7). In emerging from the interplay between mind and environment, human rationality does not correspond to that prescribed by classic, content-blind norms (e.g., Bayes rule, expected utility maximization, logic). Instead, rationality is ecological: Rational behavior

 DOI: 10.4324/9781315658353-21

is that kind of behavior that allows an individual to achieve its goals in a given task environment (for a volume on the fast-and-frugal heuristics framework that focuses on ecological rationality, see, e.g., Todd, Gigerenzer, & the ABC Research Group, 2012).

The fast-and-frugal heuristics framework's emphasis on the environment (i.e., the first blade of Simon's scissors) contrasts with the focus on traits as explanations of behavior, as it is typical for personality psychology. For instance, imagine that Leaning-Bear, at 13 had 'celebrated as victory' the slaughter of Pawnee families in Massacre Canyon, and as a 14- or 15-year old, he had joined war parties attacking 'white' intruders, and participated in raids against other tribes. Later, he had stolen horses on the reservation and then beaten up, with several other Sioux, a former army scout. Rather than attributing what some today might call 'anti-social' behavior to stable traits, deeply entrenched in Leaning-Bear's 'pathological' personality, the fast-and-frugal heuristics framework would ask how the interplay between his decision-making strategies and his environment may have led Leaning-Bear to commit those acts. Candidate mechanisms in the repertoire may be imitation strategies: Raids against others and the stealing of horses may represent behaviors that were common in Leaning-Bear's old world, so one hypothesis may read. In committing these acts, one could speculate, Leaning-Bear might have simply been imitating the behavior of respected peers. Even in our contemporary world, *not* participating in certain acts can signal distancing from social groups, with the risk of social isolation. Belongingness to a group, in turn, can be key to an individual's well-being and, ultimately, survival—especially in societies that depend on cooperative hunter-gatherer activities in harsh environments.[3]

Another assumption of the fast-and-frugal heuristics framework, adapted from Simon's work (i.e., the second blade of his scissors), is that human information-processing capacities are bounded: We do not have unlimited computational power, infinite knowledge, or endless time. In trying to achieve their goals, humans do not try to optimize or maximize, which are descriptive and/or normative building blocks in both classic and contemporary theories of human and animal behavior (e.g., Becker, 1976; Stephens & Krebs, 1986). Instead humans need to strive for solutions that are *sufficient* to achieve those goals in a given environment—they *satisfice*, as Simon (e.g., 1990) put it.

To illustrate the point, a utility-maximization approach assumes that, when deciding whether or not to steal a horse, Leaning-Bear would take into account *all* the numerous possible consequences of both stealing and not stealing (e.g., relating to the former: being arrested, getting killed; having a vision after being injured by a soldier's gunshot; gaining prestige among his tribe members, and even counting a coup; see Hassrick, 1992, on the role of coups in Sioux warfare). Moreover, he would have had to assess not only the probabilities that each of these consequences would occur, but also the utility of each one. These utilities would then have to be brought into the same currency or scale (e.g., being killed, gaining a horse, and so on would all need to be assigned a numeric value). Finally, with all that in mind, Leaning-Bear would have had to calculate which option would yield the largest expected utility and decide for that course of action. While it is certainly possible to assume that Leaning-Bear made these calculations (perhaps unconsciously), there might be a simpler way of explaining his decision which involves only one goal: to increase social prestige, thereby ignoring anything else: As far back as Leaning-Bear could remember, one way for warriors to gain recognition had been to participate in raids on other tribes, and, notably, to steal their horses (see Hassrick, 1992, on how the successful theft of horses mattered for a Sioux's social prestige and economic well-being). Indeed, prestige played and plays a role as a motor for action in other communities as well, including the Comanche of the Southern Plains (Hämäläinen, 2012), the Tiwi people of northern Australia (Hicks, Burgman, Marewski, Fidler, & Gigerenzer, 2012), or modern-day scientists, as an own particular tribe. Such a hypothesis about a driving motive could then be

combined with others, focusing on the behavioral strategies relied upon to achieve a goal (e.g., imitation of others' behavior as a route to prestige; see above).

In taking up Simon's notion of bounded rationality, the fast-and-frugal heuristics framework assumes that behavioral strategies do not need to depend on massive amounts of information and complex information integration (see e.g., Marewski, Gaissmaier, & Gigerenzer, 2010). Instead, the fast-and-frugal heuristics research program stresses that people can make smart decisions by relying on particularly simple mechanisms, dubbed *heuristics*. Heuristics are strategies that ignore information (hence frugal), and that can, in so doing, enable efficient behavior, such as making decisions quickly (hence fast; see e.g., Gigerenzer & Gaissmaier, 2011). For instance, the simple *take-the-best heuristic* (Gigerenzer & Goldstein, 1996) bases inferences on just one predictor variable. In computer simulations, this heuristic has yielded, on average, more accurate inferences than multiple regression when tested, out-of-sample, in 20 different real-world environments (e.g., Czerlinski, Gigerenzer, & Goldstein, 1999; see also Brighton, 2006; Gigerenzer & Brighton, 2009; Katsikopoulos, Schooler, & Hertwig, 2010). Surprising performance has been reported for other heuristics, too—be it in marketing, criminal profiling, or forecasting of political election results, and such like (Gaissmaier & Marewski, 2011; Goldstein & Gigerenzer, 2009; Hafenbrädl, Waeger, Marewski, & Gigerenzer, 2016). Note that this is not to say that simple heuristics will always and necessarily yield smart decisions with favorable outcomes. Such a guarantee does not exist, because the relative efficacy of a heuristic depends on the environment. For example, Leaning-Bear's environment changed in many dimensions and continuing to use the same heuristics, such as imitation, despite environmental change, can lead to disaster, including punishment for horse theft, or alcoholism when imitating the alcohol consumption of others.

The research questions of the science of simple heuristics

The fast-and-frugal heuristics framework asks a series of research questions that can be grouped into four categories: descriptive, ecological, applied, and methodological (e.g., Gigerenzer, 2008b; Gigerenzer, Hoffrage, & Goldstein, 2008).

(1) *Descriptive*: What are the heuristics people have in their adaptive toolbox that they are able to rely upon—be it when it comes to making simple decisions or when navigating through a complex social world? What elements of our cognitive architecture (e.g., memory and perception) do these heuristics exploit? When and how do people choose to use which heuristic?
(2) *Ecological*: To which aspects of environmental texture is each heuristic from the toolbox adapted? How can those environments be described (e.g., in terms of statistical regularities or affordances)? Answering this question aids understanding of how selecting a heuristic in a fitting environment can aid people to make clever decisions; or, conversely, how failure can result if a heuristic is mismatched to an environment. This is a question of ecological rationality.
(3) *Applied*: How can human performance be improved by better matching heuristics to environments? Two ways of boosting performance are possible. One would be to lead people (e.g., through education) to change the heuristics they rely upon in a given environment; another would be to change (e.g., through policy-making) the environment in which people rely on given heuristics.
(4) *Methodological*: How can people's use of heuristics (the descriptive question) and the fit of the heuristics to different environments (the ecological question) be studied, and how can the effectiveness of interventions (the applied question) be tested?

 DOI: 10.4324/9781315658353-21

Instructive answers to these four types of questions have been formulated in numerous fields and disciplines to which the fast-and-frugal heuristics program has been applied (e.g., Gigerenzer et al., 1999, 2011). How can these four questions aid our understanding of drastic environmental change, notably, the ways in which individuals think, decide, and act?

Descriptive questions would ask which heuristics people rely upon when they sense such massive changes: Are there heuristics for managing environmental change? For instance, when an individual does not know what a right or clever course of action is, relying on others and imitating their behavior are typically viable strategies: Groups can furnish resources in situations of scarcity and unpredictable access (e.g., through the pooling of food), and observing what others do can facilitate learning of what works well and what does not, thereby avoiding repetition of costly errors. But how are people's willingness, propensity, or readiness to imitate others affected by the stability of the environment?

Ecological questions would ask: Which characteristics of massively changing environments would likely increase the performance of different strategies—be they heuristics or other tools—and which characteristics of changing environments would limit those strategies' performance? For example, when it comes to making accurate inferences about unknown or future events, imitating others is likely helpful when these others can be expected to make at least minimally accurate judgments. If the future is fully unpredictable or if all individuals in a group are likely to be led astray, then relying on others will not aid making accurate inferences (but could still help inclusion in the social group; on the ecological rationality of imitating the majority of others, see Gigerenzer, 2008a). If environments differ with respect to which strategy performs best—and they may vary over time, or space, or both—then an ecological analysis becomes quite complex and its conclusions cannot be summarized in one sentence (for a review and a simulation study that compared the performance of various individual and social learning strategies depending on the stability of the environment, see McElreath, Wallin, & Fasolo, 2013).

Applied questions might prescribe asking, for instance, how imitation strategies could be turned into clever ones in a new environment; for example, by endowing at least certain individuals from a collective with training and insights (e.g., through schooling), this way creating leaders or role-models others might benefit from by imitating. Applied questions might also ask how heuristics could be used as tools (Hafenbrädl et al., 2016), and how they could be taught to foster insights and boost people's decision-making competencies (see also Grüne-Yanoff & Hertwig, 2016, on boosting; Kozyreva, Lewandowsky, & Hertwig, in press, on nudging versus boosting with a focus on internet users; and Gigerenzer, 2014, on heuristic principles for teaching).

Finally, the methodological perspective would prescribe tackling those descriptive, ecological, and applied questions by means of observational studies, laboratory experiments or, as is often done in studies of fast-and-frugal heuristics, through mathematical analysis (e.g., Martignon & Hoffrage, 2002) and computer simulation (e.g., Gigerenzer & Goldstein, 1996; Schooler & Hertwig, 2005). General guiding principles for asking methodological questions can be found in Marewski, Schooler, and Gigerenzer (2010).

The ecological focus of its research questions allows differentiating the fast-and-frugal heuristics research program further from other frameworks. Take applied questions on policy making and approaches that locate explanations for performance largely *inside* individuals, such as in psychopathic personality structures, lack of intelligence, or other traits. Corresponding to those inside-explanations, those frameworks' prescriptions might look very different than those of the fast-and-frugal heuristics program. For instance, a trait-approach to eradicate horse-stealing and other anti-social behavior might start from the basis that traits are difficult to change; hence corresponding individuals need to be 'managed,' not their environment or the changes that occurred therein. A simple way of managing individuals with undesirable traits is to eliminate

them, say, by locking them away. To give another, more modern example, consider individuals involved in a scandal, such as *Dieselgate* or a case of industry bribery. Rather than seeking simplistic "one-word explanations" (Gigerenzer, 1998, p. 196) for wrong-doing (e.g., greed, recklessness, or egoism), which in the worst case can border re-description or tautology (e.g., a person behaves egoistically because she is an egoist), one could ask what behavioral strategies lead such individuals to do what they do, and what the ecological rationality of adopting those strategies is. To turn to the latter, ecological question: Could it be, for instance, that an unexpected change in their environment (e.g., how pollution should be assessed) in the past casts them and their behavior in a bad light (e.g., being reckless, behaving not particularly smart), but only today, that is, with the benefit of hindsight? This example also illustrates that, when answering the ecological question, no universal (here: time-invariant) norm for assessing rationality exists. While the fast-and-frugal heuristics framework is by no means the only program that shifts the focus from people to their interaction with their context (for an example from ethics, see e.g., Palazzo, Krings, & Hoffrage, 2012), this shift is not about sides in debates on meaningless dichotomies (e.g., inside versus outside explanations, genes versus culture and such like; on dichotomies in psychology more generally, see e.g., Newell, 1973), but rather about describing the interplay between environments and decision making mechanisms with precision.

On environments and heuristics

The functioning of heuristics cannot be assessed independently of the environment (Todd et al., 2012). Likewise, answering the four research questions set out above hinges on building adequate models of heuristics *and* environments. Environments can be characterized in multiple ways (e.g., Bullock & Todd, 1999; Czerlinski et al., 1999). For instance, they may change over time in systematic and hence predictable manners. The environment of the Plains tribes looked very different depending on the season, but the seasons were periodic. The Sioux (Lakota) of the nineteenth century were nomads and they could exploit such regularities: They knew when to be where in order to harvest ripe wild berries or to hunt (see Hassrick, 1992). More generally, environments can be described in terms of their regularities, with past research on fast-and-frugal heuristics having focused on, for instance, the statistical regularities found in modern-day informational environments (e.g., the news media, Goldstein & Gigerenzer, 2002; Schooler & Hertwig, 2005).

Moreover, environments differ between and within people. 'White' contemporaries of Leaning-Bear, living in the same area, did not live in his environment. And Leaning-Bear's biography offers an example of a difference within a person: there is a before and after the breakdown of Sioux (Lakota) military power.[4]

Furthermore, not only the objective, but also the perceived environment determines behavior and performance and such perceptions may change over time. Hence, a description of the environment in terms of its objective properties (e.g., cue inter-correlations) can be complemented by the environment's inner (e.g., mnemonic, emotional) representation (e.g., Marewski & Schooler, 2011).

Finally, an environment offers opportunities but also imposes challenges and confronts one with different tasks, such as finding a mate, maintaining friendships, or securing food and shelter. Consequently, environments can be described alongside different task-relevant dimensions. Gibson's (1986) notion of affordances, which highlights environments' functional properties (e.g., what actions does the property X afford?), offers a complement to this level of description.

Still another dimension by which an environment can be described is how much uncertainty it entails. Since the notion of uncertainty is particularly important in the context of

 DOI: 10.4324/9781315658353-21

this chapter—with its focus on uncertainty-generating changes and our digital future—let us discuss that notion in a bit more detail. In the literature on fast-and-frugal heuristics, uncertainty typically implies a world in which the full range of behavioral options is unknown, or in which the consequences of acting in a certain way are unknown, or the probabilities of these consequences occurring are inaccessible (see e.g., Mousavi & Gigerenzer, 2014, 2017, for discussions). In such a world, unforeseeable and/or surprising, fully unexpected events can ruin plans, for better or worse.[5] Savage (1972 [1954]) referred to such situations as *large(r) worlds* and contrasted them with *small(er) worlds*, a dichotomy that corresponds, roughly, to Knight's (1921) distinction between *uncertainty* and *risk* (see Binmore, 2007). Small worlds, characterized by risk, are roulette and card games: Here all options, their consequences, and probabilities of occurring are known or can be estimated with sufficient accuracy—assuming nobody cheats. From the perspective of the fast-and-frugal heuristics framework, it is only in small, risky worlds that Bayesian, subjective expected utility-maximizing, and other classic rational approaches to modeling human behavior, and performance might work well and represent adequate benchmarks for gauging human rationality (e.g., Gigerenzer, 2014; Hafenbrädl et al., 2016). In contrast, in large worlds, characterized by uncertainty, optimization is not feasible. If the decision maker does not know (1) what the consequences of behavioral options might be, or (2) what the probabilities of these consequences are (e.g., because the probabilities of relevant future events are not known, and eventually not even the events themselves are known—events that will, jointly with the chosen behavioral option, determine these consequences), or (3) eventually does not even know how any of these consequences should be evaluated, then optimization is pointless.

As a side note, optimization, as a mindset, is hence also not useful when reflecting about policies for shaping digitalization. For example, chains of unforeseen, distant future consequences, including changes in values letting current evaluations of foreseeable consequences diverge from future evaluations of the same consequences, might all be brought about by digitalization, resulting in massive uncertainty.

Importantly, the construction of models of heuristics hinges on the type and amount of uncertainty in the environment, an insight that is, actually, not always stressed in the literature on fast-and-frugal heuristics. Historically, the fast-and-frugal heuristics program started with inferential heuristics (for a brief history of this program, see Hoffrage, Hafenbrädl, & Marewski, 2018). The first heuristic formulated by members of the ABC Research Group dates back to before the group came into existence: the *PMM-algorithm* (which was a central component of a Brunswikian model on overconfidence; Gigerenzer et al., 1991). Gigerenzer and Goldstein (1996) renamed it take-the-best, referred to it as a heuristic, and determined its performance in a complete-paired comparison between all German cities with more than 100,000 inhabitants. Like other heuristics for inference, take-the-best can be described in terms of three algorithmic rules: A *search rule* and a *stopping rule*, which describe how specific cues are searched for and when information searching stops, respectively, and *a decision rule* formalizing how the cues identified are relied upon to arrive at a decision. Such heuristics are sufficiently precise in order to be implemented in computer simulations testing the accuracy of the heuristics in predicting the criterion against that of other models (e.g., other heuristics or more information-greedy statistical models, including regressions). A well-defined reference class with a finite set of objects (cities), one criterion (number of inhabitants), and nine dichotomous or dichotomized cues (e.g., a soccer team in the national league, an industrial belt)—this was, in fact, a relatively 'small' 'large world' and not a situation that would be characterized by the massive uncertainty that is typical of large (e.g., social) worlds in real life.

A first, albeit, small, step in the direction of a 'larger' world was taken by Czerlinski et al. (1999). These authors tested strategies, including heuristics, in cross-validation: Each strategy estimated its parameters in a given sample, but was then tested on another sample, taken from the same population. In this set-up, the world is still clearly defined, namely, in terms of a known criterion, and known cues, but there is noise when it comes to the assignment of objects to learning and test samples. Arguably, such variation through sampling does not entail a strong form of uncertainty.[6]

Stronger forms of uncertainty emerge, for example, when predictions have to be made out-of-population—situations where the learning sample might have little, if anything, in common with the world that one wishes to generalize. Even more uncertainty can arise when distant or quite general goals (e.g., survival, reproduction, well-being) can only be achieved if multiple intermediate goals are met and when it is far from clear how these intermediate goals should be prioritized and/or considered when deciding among options. Such complexity is likely to be found in social environments (Hertwig, Hoffrage, & the ABC Research Group, 2013).

Whereas some simple heuristics for navigating such very large, fuzzy worlds can still be cast into algorithmic search, stopping, and decision rules, others resemble guidelines, principles, or routines, tailored to specific situations or domains. An example is "*hire well and let them do their jobs*," a simple rule that the former president of Florida International University, Modesto Maidique (2012), gleaned from CEOs whom he interviewed (cited in Gigerenzer, 2014, p. 116). Other examples, from the domain of leadership, are: "*If a person is not honest and trustworthy, the rest does not matter*," "*First listen, then speak*," "*You can't play it safe and win. Analysis will not reduce uncertainty*," or "*When judging a plan, put as much stock in the people as in the plan*" (cited from Gigerenzer, 2014, p. 117, italics added). To return to the Sioux, Hassrick (1992) points out that a lemma of the Sioux was, "*It is better to die on the battlefield than to live to be old*" (p. 47, italics added), could this be thought of as a heuristic that would have eliminated, akin to a non-compensatory decision rule, any concerns about injury or death, such as when deciding whether to steal a horse?[7]

These heuristics for a large world characterized by massive uncertainty bear resemblance to the simple rules discussed by others (e.g., Manimala, 1992). Emphasizing their frugal nature, Sull and Eisenhardt (2015), for instance, describe such rules as "shortcut strategies that save time and effort by focusing our attention and simplifying the way we process information" (p. 5). They "allow people to act without having to stop and rethink every decision" (p. 5).

Such rules can be categorized in different ways. Sull and Eisenhardt (2015), for example, distinguish among *boundary rules* (which "define the boundaries of inclusion or exclusion, … like the 'thou shalt nots' of the Ten Commandments," p. 50), *prioritizing rules* (which "can help you rank a group of alternatives competing for scarce money, time, or attention," p. 57), *stopping rules* (e.g., "[s]top eating when I start feeling full," p. 67), *how-to rules* (that "address the basics of getting things done without prescribing every detail of what to do," p. 81), and *coordination rules* (which "guide interactions among members who intermingle in a complex system," p. 84).

Complementary ways to classify heuristics for massively uncertain worlds would be in terms of the functions they can serve (e.g., imitate-the-majority can allow for increasing accuracy of inferences, inclusion in a group, avoiding conflict, protecting oneself). Considering such functions may aid understanding of how people select between different heuristics. Conversely, the same function may be achieved by various heuristics, with such redundancies potentially enhancing the robustness of human decision-making capabilities (on Brunswik's related notion of vicarious functioning, see e.g., Wolf, 1999; on strategy selection and robustness, see e.g., Marewski & Schooler, 2011). Notwithstanding their name and classification (see also e.g., Guercini, 2019), a common feature of all such rules is that they constrain the space of possible

 DOI: 10.4324/9781315658353-21

behavioral options or decisions, and hence facilitate finding solutions to problems—and indeed, the term heuristic comes from ancient Greek and means "to discover" or "to find." This is why we conceive—and refer to—such rules or recommendations also as *heuristic principles*. In our view, when it comes to coping with the challenges offered by the winds of digitalization, these heuristic principles are more likely to be used (and be helpful) than the algorithms the fast-and-frugal heuristic program studied in its early days.

Modern-day dramatic change: from buffalo hunting on the Great Plains to the fruits of Silicon Valley

Jenny was born in 1983. When she grew up, cell phones were virtually non-existent in her world. The internet played no role in her youth and if she wanted to contact a friend she would have to call her either from home or from a public speaker phone. Calling someone in another country was expensive, the way to stay in touch with someone abroad would be to send a letter via postal mail. Twenty years later, in 2005, at the age of 22, Jenny uses the internet to find scientific articles during her university studies. She regularly looks up other information on the web, too, be it about political issues, medical conditions, or subject-matter related to her great passion: horses. She becomes excited about the prospect of a society where information is freely available to everyone, she engages in social networks, puts her CV and photos online, and writes her emails at work as if she were having a normal casual conversation with somebody, a mode of address and interaction that migrates to instant messaging services a few years later. That informal communication style is consistent with the *netiquette* of the time (a word used to refer to the rules of behavior in electronic communication). As a matter of fact, in becoming an internet actor, via email and other digital technologies, she behaves almost in the same way as she would if she were interacting with other people personally (be it face-to-face or on the phone). Jenny's life in the 2010s continues with her starting a job at a major car manufacturer, giving birth to two children, taking out the usual insurances, and buying the usual commodities. She has a customer discount card for her preferred supermarket chain, she updates the software on her computers on a regular basis, and she uses a smartphone like most of her peers. She pays for things electronically and is enthusiastic about getting paperless when it comes to managing all administrative aspects of her life, ranging from health insurance to writing a will. Cameras ensure the security of her mansion and that of most streets in the city she lives in. Jenny lives a happy life.

But then, in 2030, everything changes. Jenny's husband develops a disease, and his health insurance provider refuses to pay because the disease was allegedly present prior to him taking out the insurance policy. The insurance company 'discovered' this with the help of an algorithm which—when Jenny's husband asked for reimbursement of treatment costs—had searched through all accessible electronic records on him, pooled from multiple sources, including other companies, numerous individuals (e.g., private pictures of Jenny's husband floating around on the internet), and government databases. Jenny's husband is devastated—he does not remember having suffered from or even having been tested for that disease when he started his policy 30 years ago. Furthermore, he also has not saved any documents from that time that would allow him to prove the insurance company is wrong. But things get worse: Jenny gets arrested, charged for threatening national security. The accusation is based on emails Jenny had sent over the years, containing criticism of the government and on her having watched too many videos on the internet considered to be supportive of certain conspiracy theories. None of these activities alone would have been enough for such an accusation, but the evidence accumulated over the years such that, in 2030, the algorithms that scrutinized her electronic traces classified her as a threat. Suspicious gestures captured by cameras that filmed her when reading the email accusing

her of criminal activity, as well as recordings of phone conversations with her friends (automatically saved by her phone company) provide further butter for the prosecutor's bread: She suffers from a psychopathological personality, claims the prosecution based on the available digital evidence. Once the charges become public, Jenny's friends drop her on social networks, she is fired from her job, and even her family avoids talking to her. Nobody wants to be associated with somebody like Jenny. In 2032, she commits suicide after coming to the conclusion that there is no way to escape this vicious circle. The same year, in Jenny's hometown alone, hundreds of citizens receive similar treatment, suffering public shaming and stigmatization. Some were caught watching porn, for others there were clear indications that they supported a prohibited political movement fighting against digital surveillance, some were in favor of abortion, and at least ten were caught making derogative comments about a leading political party in private (captured by their smartphones). None of those behaviors are tolerated in Jenny's world of the 2030s. And it is virtually impossible to keep behavior, preferences, or interests as a secret—the citizen of that time is entirely transparent.[8]

Helbing (2015) offers a comprehensive overview of what kind of personal data can be collected in the digital age, and in Box 18.1 we let Google's privacy policy as it stands at the time of writing, alongside a recent statement from the European Commission on creating rules for so-called "E-evidence," speak for themselves. Can both documents be seen as signposts of small but decisive steps toward Jenny's world? After all, the technology is already operational. The more interesting question, however, is who will use it, when and for what purpose, and how will such use be legitimated, enforced, and controlled?

Box 18.1 Privacy: Quo vadis?

We collect information … from figuring out … which language you speak, to … which ads you'll find most useful, the people who matter most to you online, or which YouTube videos you might like …

… We also collect the content you create, upload, or receive from others when using our services. This includes … email you write and receive, photos and videos you save, docs and spreadsheets you create, and comments you make on YouTube videos …

… We collect information about the apps, browsers, and devices you use to access Google services … The information we collect includes unique identifiers, browser type and settings, device type and settings, operating system, mobile network information including carrier name and phone number, and application version number. We also collect information about the interaction of your apps, browsers, and devices with our services, including IP address, crash reports, system activity, and the date, time, and referrer URL of your request. …

…We collect information about your activity in our services, which … may include:

- Terms you search for
- Videos you watch
- Views and interactions with content and ads
- Voice and audio information when you use audio features
- Purchase activity
- People with whom you communicate or share content
- Activity on third-party sites and apps that use our services
- Chrome browsing history you've synced with your Google Account

 DOI: 10.4324/9781315658353-21

… we may collect telephony log information like your phone number, calling-party number, receiving-party number, forwarding numbers, time and date of calls and messages, duration of calls, routing information, and types of calls…

… We collect information about your location …

... In some circumstances, Google also collects information about you from publicly accessible sources ...

We may also collect information about you from trusted partners, including marketing … and security partners ….

Extracts from Google's Privacy policy[9]

⋆ ⋆ ⋆

To make it easier and faster for law enforcement and judicial authorities to obtain the electronic evidence they need to investigate and eventually prosecute criminals and terrorists, the Commission proposed on 17 April 2018 new rules in the form of a Regulation and a Directive, which will:

- create a European Production Order: this will allow a judicial authority in one Member State to obtain electronic evidence (such as emails, text or messages in apps, as well as information to identify a perpetrator as a first step) directly from a service provider or its legal representative in another Member State, which will be obliged to respond within 10 days, and within 6 hours in cases of emergency …

Extract from the European Commission's online statement on "E-evidence"[10]

Why did we include two fictional characters in this chapter? What do they have in common, Leaning-Bear, the Sioux born more than 150 years ago, and Jenny, born at the end of the last millennium? First, we believe that digital technology has the potential to lead to a change in our environment that might, in a certain way, end up being almost as dramatic as the change we proposed Leaning-Bear experienced 150 years ago. Note that Jenny, born in 1983, belongs to the last generation who has a few childhood memories of a world in which computers have not yet entered the daily life of the masses. Only a few decades later, today's born-digitals find it hard to imagine a time without smartphones and internet—and no one knows how technological advances will continue. So, second, as much as Leaning-Bear's and Jenny's stories are fictional ones, the following discussion about how digitalization may change our environment is, by necessity, a speculative narrative concerning an uncertain future. We deliberately chose these fictional characters to highlight this speculative nature. However, we also believe that there is sufficient basis for our speculation and know that some of the worries we formulate are shared by others (e.g., Helbing, 2015, 2019; Helbing et al., 2017; O'Neil, 2016).

In the remainder of this chapter, we discuss what insights the fast-and-frugal heuristic framework might offer when it comes to understanding and eventually managing changes related to the digital revolution. We speculate what future aversive environments might look like. We reflect on how such environments might consequently influence behavior by leading people to adopt different heuristics. We then ask how such heuristics might, in turn, shape environments, namely, the societies in which they are enacted. Subsequently, we explore how aversive environmental changes can be managed, first, by an individual navigating through a changing environment and, second, by societies as a whole undergoing environmental change. Finally, we turn from changes in evolutionary history to the children of evolution: the digital natives.

In writing these sections, we have followed common wisdom—a meta-heuristic of sorts—for dealing with potentially aversive future environments: In order to prepare for challenges, one has to try to identify them, knowing that the future is uncertain and that surprises may occur. But even when leaving these caveats aside, it is clear that future digitalized worlds might take many forms. The goal is not to speculate about every form; rather, we focus on three aspects of digitalized worlds that we take to be particularly disruptive of individual behavior and performance (see Helbing, 2015; Helbing et al., 2017; Kozyreva et al., in press; O'Neil, 2016; SVRV, 2018).

What might future aversive digital environments look like: interconnectedness, influenceability, and traceability

First, whereas Leaning-Bear's world was one of relatively small groups, our contemporary modern world is one in which small groups intermingle with larger groups and contexts. Thanks to email, social media, and so on, we can easily reach out to people who live far away. When reflecting on how digitalization might affect our social environment, one thesis that might be formulated is that those growing social worlds make individuals more reachable by other people, including those who live on the other side of the planet. In some ways, new 'tribes,' united via digital technology over potentially thousands of miles might emerge. Such 'tribes' might share common (e.g., political) beliefs and worldviews, indeed, technology itself might contribute to creating and cementing those 'tribes' (e.g., through the selective posting of information via algorithms, resulting in echo-chambers; see Helbing et al., 2017). Needless to say, any increased ability to reach out to others can also offer more opportunities for collaboration, the sharing of knowledge and insights into warranted political and societal reforms. However, like a two-faced Janus head, the accessibility of individuals can also offer increased opportunities for attack and social destruction (e.g., Helbing, 2015). Virtual bullying and cybercrime are cases in point. Twenty years ago, a child that was bullied at one school might have moved to another school (possibly in another town) in order to be placed out of reach of his aggressors. Nowadays, the bullying can continue online through social media. Likewise, in order to steal money, robbers 20 years ago had to physically enter houses or banks. Nowadays, online theft and other types of cybercrime are possible over thousands of kilometers. The new digital world is an interconnected one. But note that not all connections are visible, at least not for John Q. Public: Individuals may have a hard time figuring out where social attacks come from—one cannot see enemies' actions on social media and unless one is part of a chat, one does not know who said what—uncertainty reigns. Indeed, it is worth asking, who, actually, is the adversary in a vastly interconnected world full of digital 'tribes'? At best, one can only sense that something is going wrong, giving rise, potentially, to paranoia and even vicious cycles. A manager's authority at a company, for instance, may be undermined by anonymous electronic messages spread widely among employees. Such messages may transform a supportive or neutral work environment into an aversive one that the manager no longer understands and, hence, cannot adequately respond to, potentially resulting in behavior that further contributes to the decline of the manager's authority.

Second, increased potential for attack comes with increased potential for influence: Be it news about shark attacks in Australia or local government corruption in some remote country, in a digitalized world, information from all parts of the globe can easily spread, and hence influence individuals' beliefs, emotions, and behaviors. How would you feel if, after watching 20 videos of shark attacks somewhere on the other side of the planet, you snorkeled over deep blue water in the Mediterranean Sea? Would you experience some kind of anxious arousal, even if you knew that any fear is completely unwarranted? Or if you hear stories, repeated over

 DOI: 10.4324/9781315658353-21

and over again, thanks to social media, about waves of violent immigrants, stealing, beating, and raping: Would you call for stricter immigration laws or even applaud the building of walls at the border of your country? Over-informed, over-aroused, and over-reactive are three words that characterize our modern, interconnected world.

A third aspect of our world that is changing is the traceability of individuals' past behavior: Individuals are likely now to leave behind far more traces of their past actions and intentions than ever before in human history. If an individual coughs on the street, laughs out loud or farts, gives a polemical speech, wears crocodile skin trousers, drives through a red traffic light, visits a brothel, does not pay her taxes, commits fraud, or hacks the bank account of his neighbor, chances are there is a trace of those actions somewhere. When we interact with a digital device, it is presumably even more likely that records of this interaction remain, and this holds true not only for our own devices but also for those beyond our own control; for instance, the devices of those to whom we sent an email, the owners of websites we visit, or the owner of a camera installed on the street or in a car. This, in turn, might create additional affordances for social destruction (see Helbing, 2015). Obviously, not all traces are visible to everyone; and, indeed, those who can access them are also those who have power—and so everything hinges on what their interests and intentions are. Moreover, the individual is not necessarily in control of the recorded traces; she does not 'own' the data and cannot destroy them. The individual might not even know what data were recorded or when. And the amount of data that can be traced back in time exceeds what the individual would be able to remember about her own actions. All of this generates uncertainty.

In short, in digitalized societies, individuals lose control of what is knowable about their own past and present behavior. At the same time, individuals can be aggressed over any distance and by any other individual on the planet, and similarly they can also be influenced over any distance (see Helbing, 2015).

What heuristics might people rely on to navigate through aversive digital environments?

Individuals who realize, ahead of time, how traceable and attackable behavior will become, might react in various ways. One might be defensive.

> Heuristic principle: *If you have to have to make a decision, act in a way that allows you to defend your decision*.

Defensive decision-making has been described in managerial and medical environments (e.g., Artinger, Artinger, & Gigerenzer, 2019; Marewski & Gigerenzer, 2012)—that is, in situations where decision makers fear punishment for their actions, such as a physician who might be afraid of being sued for a wrong diagnosis or unsuccessful treatment. Indeed, what is commonly subsumed under the label paranoia can possibly be conceived of as the end of the spectrum of cognitive and behavioral outcomes of such defensive approaches to decision making.

Increased social conformity might be another behavioral outcome displayed by individuals who think defensively about their future (see Helbing, 2015). Conformity might be produced by genuine defensive decision-making principles ("*If you act like everybody else acts, then your action can likely not be wrong*") or by mere (not necessarily intentionally defensive) imitation heuristics. Those social decision strategies can allow dealing with situations where the 'correct' or desirable course of action will never or only later reveal itself (Gigerenzer, 2008a; Hertwig et al., 2013). More generally, they may also aid an actor who has little or no knowledge about the situation at hand (Gigerenzer & Gaissmaier, 2011).

DOI: 10.4324/9781315658353-21

Heuristic: "*Imitate the majority*" (Gigerenzer, 2008a, p. 31)—*behave as most others do*.

It takes two to tango, but three to make a list. A third example of how individuals might adapt their behavior once they become aware of the increased traceability of actions and the potential for destruction resulting from those traces is that those individuals resort to offense as the best defense. An example of this is dash cameras, nowadays being increasingly installed in cars. The rationale is that these cameras can record the potentially hazardous behavior of other drivers, offering important legal proof in case of an accident. The downside: If an accident occurs and only one party has a dash camera, then only that party will have access to the images, allowing them to potentially control which images enter the judicial stage and which do not. Hence, those who do not have a dash camera installed might find themselves in a less advantageous situation compared to those who have, thereby eventually leading to all drivers recording each other's behavior constantly.

Heuristic principle: *If your behavior can potentially be recorded, record the behavior of everybody else who you interact with*.

What might be thought of as a digital arms race can also take place when trust among different members of an institution erodes. For instance, the prevailing communication style might gradually shift from verbal commitments and promises to the sending out of emails that summarize the contents of conversations, to eventually all details being put in writing by each party, each one trying to be the one with the best documentation—just in case. Putting others' cc on emails in work contexts—ideally higher in the hierarchy—is a notorious escalation signal, too.

Such arms races do not depend on digital media for their existence, but digital media can fuel them. Digital media facilitate the storing, copying, and sharing of content, regardless of whether it comes to individuals, companies, public administrations, governments, or secret services. Some of these agents may fear that having less information than others may be disadvantageous in a complex, competitive, or potentially threatening social world. A world that comes, moreover, with seemingly little margin for error, because behavior that represents, either in foresight or in hindsight, a 'wrong-doing,' might have a greater chance of being detected or leading to negative consequences (see also Helbing, 2015). One does not need to understand much of game theory to anticipate that corresponding fears, whether justified or not, can spiral into a desire to collect data and to store information.

What might future aversive digital societies, shaped by defensive, social, and offensive heuristics, look like?

The heuristics people might rely upon to navigate through a digital environment might, in themselves, contribute to shaping those environments. What kinds of societies could a consistent enactment of those and other defensive and offensive heuristics create? Possibly, societies governed by fear. Perhaps societies governed by mistrust in social relations. And maybe societies characterized by less individualism and less individual freedom, with the masses defining, through social media, which behaviors are acceptable for certain collectives (digital 'tribes'), and which are not. Indeed, changes in value systems might be an additional consequence (Helbing, 2015). For example, it is likely to be no coincidence that in many European countries the word "transparency" has become frequently used in public discourses: Transparency is needed, so the public outcry goes, when yet another scandal is uncovered. But calls for transparency might also transform into beliefs and the spread of heuristic principles such as "*He who has nothing to hide has no problem with sharing all information about him*," a lack of transparency

 DOI: 10.4324/9781315658353-21

being equated with a lack of trustworthiness, or even worse, criminal intent. Still another consequence might be a lack of willingness for decision makers to take risks and potentially make mistakes (Helbing, 2015). Those decision makers might be politicians who opt for defending what they take to be 'safer' positions or entrepreneurs who opt not to promote a new technology because if things go awry, it might be easy to make a case against them thanks to the massive amounts of data collected in the brave new digital world. The lack of willingness to make mistakes, in turn, might translate into reduced opportunities for learning: after all, only those who make mistakes can learn. To avoid misunderstandings: In both analogous and digital worlds, mistakes can occur; but the difference is that they might be less likely to be detected in an analogous world and, if detected, they might be less likely to stay visible—people forget, but computers and big data do not. (For more detail, see Helbing, 2015, who discusses these and related observations, pointing, for instance, to the emergence of vicious cycles, herding effects, and the loss of independent judgment of others.)

If social relations, value systems, and the permissibility of mistakes change on a societal level, what else can happen to make things even worse? Totalitarianism, not 'just' dictated by new norms and controlled, bottom-up, by the masses through digital media, but totalitarianism put into place top-down by institutions. Institutional totalitarianism can start small, with individuals being assigned digital scores if their behavior conforms to a certain target, say, customers buying certain products in a supermarket being awarded a score that offers them a discount. This is already a reality today and might represent a slippery, habituating slope into "Super-scores" (SVRV, 2018, p. 7). Indeed, institutional totalitarianism can also start bigger, with citizen scoring systems being located, perhaps, still at the lower end of the spectrum (e.g., Helbing, 2015; Helbing et al., 2017; Hoffrage & Marewski, 2020). At the upper end of the spectrum, there might be room for total surveillance and control over all areas of life, including of life itself.

How can heuristics aid individuals to manage aversive change?

Above, we speculated about the heuristics that individuals might resort to in aversive digital environments. Are there other heuristics that could aid individuals to manage aversive change? A first move to managing aversive changes might be to recognize that they may occur—and in dramatic ways. A follow-on step may then be to reflect upon how those changes might look, much like we did above. For instance, the authors of this chapter tend to believe that some of the most dramatic changes brought about by the digital revolution might concern people's values: Behavior that is deemed acceptable or even desirable today might, within a few years, be thought of as being unacceptable (Helbing, 2015). Why? Digital technology allows actors to reach out to many individuals at once, offering tremendous potential to influence what people believe they know (Kozyreva et al., in press). Whether such inter-personal influence is steered, top-down, by individuals trying to impose their views (we firmly believe that Joseph Goebbels, Hitler's propaganda minister, would have been excited if he had had the internet at his disposal and, perhaps more importantly, under his control) or whether it emerges bottom-up through chats and social networks does not matter. If that hypothesis is correct, then it becomes potentially risky for individuals to be unable to quickly adapt their values and behavior to the new trends.

> Heuristic principle: *Avoid getting caught in a spider-web of old-world values and behavior as your world changes*.

The German expression "*Die Fahne nach dem Wind hängen*" (loosely translated: hanging the flag as the wind blows) seems to reflect this heuristic principle, or simple rule. Following this

principle could have helped Leaning-Bear to realize that stealing horses is not acceptable in a reservation environment.[11] Yet, such a strategy might not always be easy to enact in a digital world in which behavior is fully traceable, offering potential for destruction even 20 years later. This is akin to stating that it might be impossible to avoid failure. If failure is unavoidable, then another set of strategies might come into play: Strategies that allow dealing with failure once it has occurred. A classic representative of this is the simple heuristic of "*not putting all your eggs into one basket*" but rather to diversify.

Heuristic principle: *Split resources up across different, non-connected targets*.

For instance, this diversification heuristic might suggest that income should be earned not just through one job (which might be lost) but through at least two, and that those jobs should ideally come with unrelated failure modes (e.g., losing one job will not entail losing another). A simple way to decrease connectivity might be to distribute jobs, and hence income, across different individuals, that is, to pool them. Partnerships where both individuals work in largely unconnected domains (e.g., different sectors) are a case in point. If one partner loses her job, the income from the other might still offer enough resources to make for a living (e.g., until a new job is found).

Factoring in redundancy while avoiding common failure modes are simple engineering principles for creating robust systems, heuristics for resilient design. Modern passenger aircrafts are examples of this, as most important components typically exist in at least two versions that are unconnected and made in different ways. This way, a failure in one component is less likely to imply a failure in its disconnected counterpart (see e.g., Kitano, 2004).

How can heuristics aid societies to manage aversive change?

Just as there are heuristic principles for building robust machines, could there also be principles for creating societies that are potentially more robust to digital change? We believe that this might be possible (see also e.g., SVRV, 2018). For instance, Helbing et al. (2017) stress how important the encouragement of diversity might be at the societal level, the co-existence of different goals and opinions aids the creation of robust, resilient societies (see also Helbing, 2015, 2019, on robustness and digitalization). Here are four additional heuristic principles that, when implemented together, might further help to create what we would take to be more resilient digitalized societies.

Principle of disconnectedness: *Implement policies that disconnect people from each other* (see also Helbing, 2015).

There may be different forms—weak and strong—of disconnecting people. At the upper end, there would be legal prohibitions and digital censorship. The lower end comprises much less dramatic forms. For example, users of Skype cannot receive messages or calls from others unless they explicitly approve it, technically, by having accepted a contact request. Other communication services could follow this model, leaving it to the market, that is, ultimately, to users, whether they want to have such protection against an avalanche of incoming information. Such decisions require that users are aware of the problems, potentially inviting policy makers to design corresponding educational interventions to further boost John Q. Public's digital expertise (e.g., Kozyreva et al., in press). Equally important, not only receivers but also senders should be aware of problems generated by the high degree of connectedness in modern societies. For instance, the forwarding of emails, often even without the original sender's knowledge, can cause quite a

 DOI: 10.4324/9781315658353-21

lot of harm. We, personally, think legal prohibition of such practices is neither feasible nor desirable, but we posit that more mindfulness might be healthy (e.g., with regard to a higher threshold for forwarding emails and, eventually also, for sending them in the first place).

> Principle of deceleration: *Implement policies that slow down the spread of information among people*.

Rather than speeding up the flux of information via ever faster transmission speed, it might be worth slowing down the spread of information (see Helbing, 2015); for example, by setting the speed of transmission of electronically-represented information to the equivalent speed of regular long-distance travel: *Let trivial news about shark attacks in Australia travel at the same speed as it would take an individual to, physically, deliver such news!* Building time lags into a system can make the system less reactive (and e.g., foster forgetting or emotional tranquilization). Of course, there is uncertainty over what counts as trivial. For instance, information that may be trivial at t1, might turn out to be nontrivial at t2, or what is trivial for one person might not be for someone else. Another way to reduce the spread and, indirectly, the speed of information transmission may be to tax (e.g., Helbing, 2015) or otherwise charge for electronic communication, placing a burden on either the receivers or the senders of information. The challenge lies in mitigating the side-effects of such an economic approach to steering behavior, such as wealthy individuals or companies being allowed to increasingly dominate the information flux, simply because they have more resources.

While the first and second principles tackle the interconnectedness and influenceability of digital environments discussed above, the third principle tackles the traceability of individuals.

> Principle of information loss: *Implement policies that prevent the unlimited storage of behavioral data*.

There are different ways to implement information loss. One might be to prohibit storing behavioral data such as browsing on the internet or messages sent out publicly via social media. Another way might be to implement systematic data loss via decay over time: *Just as human memory forgets information, digital information should systematically fade away!* What information should, over time, be lost is an extremely difficult question, with the most radical approach prescribing the forgetting, over time, of all information, and others allowing for the selective forgetting of certain (e.g., private) contents (for a legal basis in the European Union, see Article 17 GDPR).

> Principle of non-sharing: *Records of individuals' behavior when interacting with digital devices cannot be shared beyond the original purpose of the recording*.

Of course, companies, non-profit organizations, governments, and other institutions do have to share data in order to function well in an interconnected, borderless world, at least that is a frequently made argument. The tricky question is to determine what kind of data ought *not* to be shareable. Why is this an issue? In digital environments, increased complexity is caused by the massive trading of information about individuals: By letting algorithms pool customer ratings with their credit score, health-related data, and other records, available in big data lakes, even minute details about an individual can become knowable and exploitable for commercial and political ends. That, in turn, can contribute to increasing traceability and influenceability. To diminish the traceability and influenceability of individuals, policies that prevent the trading and pooling of data could be put into place, including laws that

prohibit such actions (see also Helbing et al., 2017, on making punishable the unauthorized use of data).

Note that this principle of non-sharing would be undermined if individuals were given the possibility to voluntarily share their data. Such voluntary authorization can be instigated by offering opt-ins and opt-outs on websites (often not very user-friendly or transparent.)[12] An example of this is to alert internet users that continuing to surf on a website constitutes cookie consent; a parallel from outside the digital realm is to inform customers that walking into a shop implies agreement with being filmed. While there are different ways to induce individuals to authorize the recording and potential sharing of their behavior, from an ethical point of view it is highly problematic that, as of today, many individuals might not understand what can be done with their data (for Germany, see SVRV, 2018). And they might never have reflected upon the possibility that their world might change. The possibility that non-sharing could be something highly desirable for them might simply not be on many people's radars and so they do not care. Moreover, understanding how data from multiple sources can be used to classify individuals, for instance, in their role as patients, customers, or citizens, into different categories requires knowledge of statistics. Corresponding statistical knowledge might simply be insufficient in the general population or in certain collectives. Those, in turn, who are aware of the risks might be averse to buying into yet other risks associated with non-sharing: Even if social exclusion or limited access to information (triggered by, for instance, shunning digital networks, messaging tools and internet search engines) do *not* spell doom for individuals who want to avoid one's behavioral data being shared, life will certainly not get easier for them if they try to prevent this data-sharing, if only because personalized digital services (e.g., web search, shopping) permit people to save time and effort. Indeed, the recording and subsequent selling of digital behavior have become a business in the digital world. Clearly, policy makers might find it hard to simply prohibit the pooling, selling, and other forms of sharing of behavioral data given that there is a market with numerous individuals consenting to such activities.

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Changing tack. Above, we pointed to difficult questions arising when trying to implement each of the listed principles, such as the tricky question how to decide what information ought to be classified as trivial (or harmful), warranting its spread to be slowed down, what information to forget, or what information to share. Those questions boil down, in one way or the other, to classification problems. In any classification problem, two types of mistakes can occur: false positives (e.g., sharing information that should better not be shared) and false negatives (e.g., not sharing information that should be shared). Could such classification tasks be tackled with heuristics? An obvious candidate model for classification tasks, one might think, are *fast-and-frugal trees* (e.g., Woike, Hoffrage, & Martignon, 2017).

Yet, contrary to other (smaller-world) classification tasks where the criterion is certain and reveals itself (e.g., classifying a mushroom as poisonous or not, and then eating the mushroom), in these kind of large-world classification tasks, the criterion is fundamentally uncertain, and perhaps even unknowable. Counterfactuals, too, may be impossible to observe (e.g., what would have happened had I not sent this email to my boss or written that tweet about my neighbor?), making learning more difficult than in tasks where the counterfactual is accessible to the decider (e.g., inferring, in a TV show, which of two cities has more inhabitants, while being told after each decision what the correct answer would have been). Moreover, in those larger worlds, the criterion might be multi-dimensional and criterion values might vary over time. Hence, fast-and-frugal classification heuristics might actually not represent adequate tools to tackle those types of tasks. Instead, we believe that simple rules that foster a maximum of diversity of classification outcomes might be a better bet: If we do not know what classifications

 DOI: 10.4324/9781315658353-21

are desirable, the best option might be not to "put all your eggs into the same basket." Diversity can, too, foster robustness, to the extent, for instance, that issues arising from different classification outcomes are unconnected (see also Helbing et al., 2017).

What could these diversity-maintaining principles be? And can we entrust humans to enact them? A common belief is that we humans may suffer from systematic biases, causing not only reasoning fallacies, but also other undesirable behavioral outcomes, including discriminative behavior (e.g., against certain collectives) and/or self-serving actions. Classification algorithms are, nowadays, often seen as better alternatives to those 'biased,' 'egoistic' humans (Hoffrage & Marewski, 2015). Machines are seemingly stripped of all undesirable subjectivity; they are objective in that they can make decisions independently from humans who, in one way or the other, have to be mere objects of the decisions (e.g., what messages, written by a human, are to be deleted.)[13]

Yet, there is no bias-free classifier, whether human or algorithm-based. Any policy, explicitly or implicitly, enacts values, reflected, for instance, in how it trades off one mistake (false positives) against the other (false negatives). Moreover, human classifiers differ, not only between individuals (e.g., in values) but also over time (i.e., individuals change their views, they make mistakes in enacting their own worldviews, they forget). That is, humans do not only vary in terms of their biases, human behavior can also be conceived of as exhibiting a noise component. As a consequence, human classifiers, with all their idiosyncrasies and resulting variation in behavior, could, in principle, be their own solution to the problem they created, with the heuristic principle being, "*Put humans in full power*," that is, let humans make their own decisions about, for instance, what information to share massively, to quickly pass on, or to save on the public cloud! We write "could." Democracies can maintain diversity, but totalitarianism can synchronize human behavior. *Gleichschaltung* (i.e., making equal or uniform) is a word capturing how the Nazis reduced variation, trying to bring all elements of society in line with their ideology: a single horrific bias. The disturbing question is: Can a few digital technologies (e.g., email, social media, search engines) dramatically reduce the variation in behavior across human classifiers, a *digital Gleichschaltung*, not necessarily orchestrated top-down by authorities, but emerging bottom-up, as a vast assimilation or acculturation process, caused by the massive pooling of information?[14]

If so, a first step for policy makers may be to regulate the magnitude of those technologies' outreach. Anti-trust laws and other rules that might break up the market share of (dominating) companies might go in that direction, but such approaches fall short of solving the problem, because different companies, as well as different digital technologies that are nonetheless compatible with each other, can all support the massive spread of the same information and thereby continue reducing diversity. In short, the paradox is: Regulators should implement policies that reduce the speed, spread, and saving of information, and the resulting classification problem (e.g., what information to slow down, not share, or forget) might be best tackled by heuristic principles that foster diversity—diversity which may be destroyed by the forces unleashed (e.g., speed, spread of information) that make tackling the classification problem necessary in the first place. But that is not the end of it: a trade-off must be managed between fostering diversity and limiting it enough, such that, to put it bluntly, people can still talk to each other.

How to foster diversity? Help people construct a toolbox of heuristics for critical judgment, would be our recommendation (see Gigerenzer, 2014, who puts forward a toolbox of simple heuristics for health care, business, and other domains). This toolbox would include guiding principles such as push oneself to understand a subject matter at hand (e.g., a classification problem), even if one is not an expert in the topic (e.g., if one has no expertise in statistics) or to play devil's advocate on dominant views. Box 18.2 lists examples of heuristics for managing another important challenge, brought about by digitalization: scoring.

Box 18.2 Teaching scoring with heuristics

One of us teaches executives and other individuals, potentially affected by and/or interested in leading digitalization in companies, non-profit organizations, and other institutions. One basis of that teaching is the book, *Weapons of Math Destruction*, by O'Neil (2016), which invites us to extract, from context-rich stories, more general insights that can, in our view, be cast as heuristic principles. A few of these heuristic principles are, alongside related points (see also e.g., Helbing, 2015), listed below; they are meant to help people to reflect on scoring (e.g., of customers or citizens), such as when algorithms are used by companies (e.g., banks) or public institutions (e.g., administrations) to make decisions (e.g., which customers to offer credit to; which citizen is allowed to buy a high-speed train ticket):

1. *Convert probabilities into natural frequencies* when trying to comprehend classification problems (e.g., Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, & Woloshin, 2007; Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000). To understand what natural frequencies are, consider the following fictional example. Imagine an algorithm is used to grade convicts; if the score is positive, the person is not let out of prison. The overall recidivism rate in that population is 5 percent, the true positive and false positive rates are 80 percent and 30 percent, respectively. What is the probability of recidivism if the score happens to turn out positive for a given criminal? Many people might find answering that question difficult and, as a result, they may blindly trust the positive score. Now, take 1,000 criminals. Of those 1,000, 50 (5 percent) will commit another crime and of these, 40 (80 percent) will score positive. Of the 950 who do not commit another crime, 285 (30 percent) get a false positive score. Since the total number of positive scores is 40 + 285 = 325, the probability of recidivism if the score is positive is only 40/325 ≈ 12 percent!
2. *Recognize that no decision—be it made by a human or a scoring algorithm—is free of values* (e.g., how to trade off false positives and false negatives, such as when building scoring algorithms like the one described in point 1's fictional example). As O'Neil (2016, p. 21) herself puts it, "models, despite their reputation for impartiality, reflect goals and ideology".
3. *Recognize that even scoring algorithms you try to program to act in line with your values* (e.g., to not discriminate on the basis of race or gender) *might end up deciding against your values*. For instance, few people would want credit-worthiness scores to include race as a variable; however, let us assume that ZIP code is predictive of income and you decide to include that variable in the score. Voilà! To the extent that people of the same race are poor and live close to each other (e.g., in ghettos), the score may end up being racist. Another way to frame this heuristic principle is that one needs to realize that there is uncertainty with respect to hidden confounds.
4. *Realize that scoring systems can create vicious circles* (e.g., criminals get poorer and even more criminal). This can happen, especially if the systems upscale (see point 8 below). Such vicious cycles can be another constitutive element of uncertainty; they can create new unknown confounds, and, without you realizing it, can lead to decisions that do not align with your values.
5. *Transparency is not the solution; at worst it helps only a bit*. Even very simple, transparent scores (e.g., produced by equal-weighting heuristics, laid open to the general public) can generate dynamic, hard-to-foresee, and non-transparent outcomes; for instance, by creating the aforementioned vicious circles on a societal level.

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6. *Make sure that you constantly monitor the performance of your scoring algorithms*. Because environments can quickly and unexpectedly change, the performance (e.g., accuracy) of scoring algorithms can also change.
7. *Do not think of scoring in the singular. Never implement just one scoring algorithm*. Instead, approach scoring experimentally and implement several diverse algorithms. For instance, randomly assign different customers to different scoring algorithms and monitor and compare performance, such as the accuracy of the scores, across treatment groups. In so doing, if possible (e.g., ethically acceptable) also try to implement counterintuitive (out-of-the-box) algorithms (e.g., if need be, as merely hypothetical secondary scoring rules kept in the background, without consequences for people). Diversity can provide a buffer to sudden changes in environments; and diversity also aids learning about those changes (e.g., if counter-intuitive algorithms suddenly start to work well). The insight to test counter-intuitive algorithms in model comparisons (and, ideally, out-of-sample or population) reflects the development of the fast-and-frugal heuristics framework: many would not believe that less information and computation can be more (see e.g., Hertwig & Todd, 2003).
8. *Think about scale*. For example, an algorithm used to score 1,000,000 individuals which discriminates against a certain group with just a very low probability could turn out to be more devastating than another algorithm which discriminates with a high probability, but which is applied to only 1,000 individuals.
9. *Understand that you may have to make difficult decisions*. For instance, if one of your algorithms has scaled up and obtained a huge market share, then that's good for business (short term) but can be bad for society (long term). If you voluntarily give up on market share (short term), the competition may step in (and, in the worst case scenario, you may have to sacrifice your business or job).

In line with the environmental focus of the fast-and-frugal heuristics research program, perhaps law makers should also reflect in how far legal frameworks warrant adaptation, moving away from allocating agency and responsibility to individuals and more toward making the environment surrounding individuals the central unit of analysis (for other legal issues, see Helbing et al., 2017). In other words: When, why and to what extent is the individual to be held accountable (corresponding, roughly, to an inside-explanation for behavior and performance) as opposed to her/his digital environment (corresponding to an ecological explanation)?

What else could one do to aid societies to manage aversive digital change? Perhaps the best recommendation is to try to slow that change down: People need time to understand new environments in order to be able to shape them. The lemma of a "digital Enlightenment" (Helbing, 2019) might be: Let people learn about the changes (heuristic principle: *Boost John Q. Public's digital knowledge!*), and create opportunities for feedback that are forgiving of mistakes: digital error-cultures in times of uncertainty. That recommendation is in line with the notion of the adaptive toolbox of the fast-and-frugal heuristics research program. Decision makers need to be aware of the tools (i.e., decision strategies) in their repertoire; they need to be ready and able to create new ones and, equally importantly, they need to acquire expertise when it comes to selecting from among the different tools available to them. Strategy selection, calls for, at the end of the day, not a (seemingly unbiased) algorithm, but good human judgment (Hoffrage & Marewski, 2015). Of course, there may be other principles, too—principles referring to aspects of digitalized environments

we did not explicitly discuss above (for more aspects, concerns and recommendations, see e.g., Gigerenzer, 2014; Helbing, 2015, 2019; Helbing et al., 2017; Kozyreva et al., in press).

Digitalization: from evolution to the children of evolution

In this chapter, we have looked at environments mainly from a life-history perspective. Another perspective might be an evolutionary one. The resilience of our make-up allowed *homo sapiens* to survive and spread over millennia. Yet, the robustness of a system is always relative to the environment in which it acts; after all, the environment forms part of the system. Without wanting to evoke catastrophic scenarios borrowed from apocalyptic science-fiction, we feel that it is paramount to consider the degree to which digital technology is able to transform human environments. Is there a possibility that, after a rapid transformation process, environments will emerge that are very different from those that our cognitive architecture evolved to be adapted to over the course of evolutionary history? Does it make sense to speculate about the extent to which design features that can make information processing systems robust might be present in the cognitive make-up of the mind *and* in the structure of pre-digital environments, but *not* in the texture of digitalized worlds?

Arguably, features of human environments that played a role in human cognitive evolution, notably, our information-processing mechanisms, were constituted by humans themselves: It is the social world with its affordances for cooperation and mating that may have shaped not only imitation and other heuristics for a social world, but more generally the mechanisms that determine how we perceive, think, feel, and act, including the ways how we *can*, potentially, perceive, think, feel, and act. According to this view, cognition is shaped and constrained by our phylogenetic history. And it is this heritage from the *environment of evolutionary adaptedness* (e.g., Tooby & Cosmides, 1992) that now stands to meet our new environments. As discussed above, digital environments may have a number of characteristics that distinguish them from pre-digital environments. All of them concern the social world:

- In digital environments, social interactions over long distances (across the globe) are possible, and they are instantaneous, that is, without a time delay. Long-distance interactions, of course, have always been possible in non-digital environments, but never throughout human evolutionary history has it been as easy, and never has it been as instantaneous.
- Humans can interact with everyone who is connected to the digital network, potentially resulting in a very large number of interaction partners. Compared to non-digital worlds, the potential number of partners has thus tremendously increased.
- In a digital world, humans do not interact with each other face-to-face, but by means of technical mediators such as social media, instant messaging services, and email. Such mediated interactions were also possible in the pre-digital world (e.g., by means of letters or messengers transmitting oral messages), but the ease of access to such indirect forms of interaction, and hence their frequency have increased in digital worlds. Equally importantly, since social information is now maintained as digital records, it is no longer forgotten.
- In contrast to the pre-digital world, in digital environments, information can be pre-processed, modified, and even fully created by non-human agents, that is, by computer programs, without either human or artificial recipients (e.g., other computer programs) of the information necessarily being aware of these manipulations. This seems to be new in human evolutionary history.

 DOI: 10.4324/9781315658353-21

Easier, faster, longer-distance, and more frequent machine-mediated interactions might not at all represent significant changes in evolutionary terms. They might not pose, per se, any threats to the robustness of human-information processing mechanisms in social worlds. But do they create indirect potential for harm, for example, by fueling interpersonal conflict and aggression? In a digital world, there can be more connections between different elements (humans) in a social system (a group). As a consequence of this, false information (e.g., rumors about hostile agents, past or intended future aggressions) and other types of disturbance (e.g., fake news) might have a greater potential to spread (Kozyreva et al., in press). Do these disturbances also have more potential to endure, just as information is not simply sorted out by digitalized social systems over time through decay or other forms of information loss (see Helbing, 2015)? Is cooperation aided by forgiving, and is forgiving aided by forgetting, such as the forgetting of past aggressions (e.g., Stevens, Marewski, Schooler, & Gilby, 2016)? How would challenges likely to have been important to human cognitive evolution (e.g., cooperating, mating) in the past be transformed if, in the future, human information-processing systems only received information via digital technology? What are the implications for society and human interaction if all information transmitted becomes fully detached from the context in which the information was produced, including the smiles, smells, and sounds emitted by the sender (another human being) and the texture of the environment in which that sender is located (a group of anxious, angry, or happy humans)?

Rather than trying to reach back into our evolutionary history, one might adopt a more modest historical perspective; for example, by asking how different technological artifacts shaped behavior and cognition in different epochs. For instance, one might believe that digital communication comes with less trust than face-to-face communication; yet is there evidence that interpersonal trust decreased in collectives when individuals started to communicate by means of paper (e.g., writing letters)? What affordances does paper offer when it comes to deciding what and how to communicate? What affordances are special to digital media? Both allow for long-distance communication; yet only the latter allows for delivery within seconds. Paper might retain the exciting smell of the beloved one (even if it is only because perfume can be sprayed on paper); an email, in turn, affords attaching a picture and a video-conference even affords watching that lover in real time, making things like cybersex possible. Touching (or even actual sexual reproduction) is afforded by neither artifact.

To turn to another technological artifact, when the TV was invented and became available in households, these new machines afforded making many different decisions, including the decision to access information or to entertain one's children. Modern-day smartphones seem to come with these affordances, too; albeit watching a movie in front of a TV is possible for a group of up to a dozen people, watching a movie on a smartphone gets more difficult if there are more than three or four persons crowded in front of the small display. Moreover, carrying a TV around (a heavy item at the time and dependent on a mains electric power supply) was impossible, hence TVs did not pose affordances for entertaining, say, small children while waiting in line in the supermarket or in the waiting room of a doctor's practice. In contrast, smartphones afford children entertainment in any location and at any time. Moreover, TVs afforded receiving pre-selected information (e.g., a movie listed in a TV program in the analogue age) at certain points in time; smartphones, in turn, allow receiving self-selected information (e.g., any movie) at any point in time, and they also afford the sending of information. If these 'new' affordances are conceived of as decisional options that are systematically acted upon, what, then, might be the possible longer-term consequences? Could it be, for instance, that children are more likely to get used to being entertained, less used to active play, more easily bored (e.g., when there is nothing to play with), or more likely to participate in familial conflict (e.g., when boredom and impatience result in behavior that mummy and daddy are not willing

to tolerate)? Will those children's upbringing and education prepare the ground for yet more environmental changes, namely when those children, as adults, shape environments themselves?

Another gift of digitalization that is entering households these days is artificial intelligence and the internet of things. Like TV and smartphones, both are entirely new from an evolutionary point of view. In contrast to adults, children do not know that these are very recent gadgets, after all, for them, everything is, at one time, new anyway. But still: What happens psychologically if a child is exposed to an electronic assistant at home, a machine one can talk to and that responds? Imagine you give a child a toy, say, a car, a doll or a teddy, that has a microphone, a motion sensor, and other built-in devices. Nowadays such toys can transmit information, ranging from the toy's position to the child's utterances (down on earth), (up) to a central server on the cloud. That information, in turn, allows inferences to be made, such as when the child sleeps or what the child likes. How do children know that a doll is more than just a doll? How should parents teach them what they can tell their doll and what not (e.g., Mum and Dad fight? We go on vacation and the house will be empty? My uncle has debts? I will be alone at the bus station tomorrow after school?). In the analogue age, children could be taught principles such as "*Do not trust strangers! Do not talk to others about X, Y, and Z (e.g., your family) at school!*" But the doll is not a stranger—it is not even an "other." Likewise, what principles can we teach children for interacting with an electronic home assistant, a device that transmits information to the cloud and that is just a box; that is, something that does not even have the shape of a being (see Box 18.3)? Manches (2019) and Manches, Duncan, Plowman, and Sabeti (2015) raise and discuss such and related issues. In particular, Manches et al. (2015) ask three questions:

> *How do IoT [Internet of Things] devices influence children's interpretation of, and interaction with, everyday things? … How is the data that is captured by IoT devices being used? … How cognisant are children and their carers of IoT devices?*
>
> *p. 77, emphasis original*

As they point out,

> The nature of IoT is that everyday things become interfaces for digital technology. As technology becomes more seamless, children may become less aware of how their actions are being captured and used. Without explanation, children may be unaware that hugging a teddy is providing a range of adults with intimate knowledge of their biometric data. Clearly, parents need to be informed if they are to give consent on behalf of their children, but the public's awareness of the implications of the IoT for data protection is currently quite low.
>
> *Manches et al., 2015, p. 77*

Box 18.3 Teaching children with narratives

During a presentation at the workshop of the Herbert Simon Society in November 2019, Manches pointed to the misfit of the rule "*Don't talk to strangers!*" to a world of IoT devices, including teddies with microphones. This rule is insufficient to protect children against the dangers that come with the digitalization. What rules can we teach them that are adapted to these new technologies with their new affordances for others (e.g., who have access to the cloud)? Rules for behavior are taught, across cultures, with narratives including fairy tales and holy books. Fairy tales and the bible contain

 DOI: 10.4324/9781315658353-21

> mysteries and one should be careful not to destroy these with an intellectual mindset. However, one can ask what they reveal about human nature and how such an enriched understanding allows one to better understand elements of the *Zeitgeist* and technology coming with digitalization. Can the witch in *Hänsel und Gretel*, in her perfidy, reveal more about an Internet-of-Things-teddy than we think? Can we use the mirror in *Schneewittchen* to talk to our children about omniscience, self-reflection, and vanity by relating it to modern affordances such as spying, stalking, 'liking' or 'dis-liking' and cyberbullying? Who is the most beautiful, both here and at the other side of the world? What is the correspondence between a mirror, reflecting an image of oneself, and the echo in digital echo-chambers? "Smartphone, Smartphone in der Hand, wer hat die meisten 'Likes' im Land?" ["Smartphone, smartphone in my hand, who has the most 'likes' across the land?"] (Martignon & Hoffrage, 2019, p. 185).

These issues become even more disturbing when one takes into account that such devices do not need to be 'just' dolls or teddys collecting data on a toddler's movements or a young child's 'secrets'; the devices could also be digital learning games gathering inferred IQ. There could be computer games that gauge a teenager's sleeping habits or behavior in brutal virtual fights. Imagine that the collected data were indicative of (e.g., later) academic aptitude, job performance, or health and consider that such data might stay on the cloud for decades, and be shared with others (e.g., insurance companies, job application portals) for an unlimited time.[15]

We want to stress that while such issues are certainly important to consider, they may actually be miniscule compared to those related to building proper representations of the physical and social world. This is already hard enough (Hirschfield & Gelman, 1994) and it is an open question how children can and will acquire concepts, such as person, agency, intelligence, intention, or responsibility if they grow up in an environment in which the winds of change have eradicated the border between man and machine. Applying a precautionary principle suggests that we should withhold digital technology from younger children for as long as possible, and this is, in fact, what many managers working for digital poster child companies in Silicon Valley do (Dwyer, 2011), but this requires some understanding, awareness, discipline, and courage (for a more in-depth discussion of the risks of digitalization for children and adolescents, see Martignon & Hoffrage, 2019). On the other hand, learning about the dangers stemming from digital devices may require exposure, or even some direct experience of them, and, if so, through vicarious learning or storytelling. Perhaps we could create tales of almighty, all-knowing beings, who can, through a spider web composed of other people, know everything about us and our lives. Will angry, almighty gods and mythological figures (e.g., the Hydra) come back into our lives, albeit in new guises? Can we even learn from millennia-old stories, religious beliefs, and other forms of wisdom, how to teach our children how to interact with these new-old 'beings'? Will there be new-old heuristics, such as "*You cannot hide anything from the gods!*" or "*Don't make the gods angry!*" Perhaps the cloud is a strikingly accurate name for gods, who, in a material sense, are new and a human creation. We find it extremely thought-provoking that Dicke and Helbing (2017) entitled their science-fiction novel, which is centered around the interaction between the protagonist Alex and a world-encompassing artificial intelligence that uses Alex's smart-home assistant as an interface, *iGod*. And interestingly enough, perhaps also some of those old stories foreshadow the cataclysmic drama of the current attempt to build a digital version of a new God. After all, the Tower of Babel, which was meant to be tall enough to reach heaven, was stopped thanks to diversity (through language), which halted the flux of information among its builders. It remains to be seen what will happen to the modern towers (shall we say, server farms accessed by artificial intelligence?).

We want to remind readers that the "Wind of Change"—a song by the Scorpions—became a kind of hymn of the fall of the Berlin Wall. This fall closed a chapter in history (Fukuyama, 2006, even declared this event marked the "end of history"), and opened a new one. What will fall and what will rise through the winds of digitalization? These and many other issues might be worth reflecting upon, not only for scientific reasons, but also when it comes to actively shaping the brave new digital world—and thereby potentially paving the way for what might follow.

Conclusion: compassion in the winds of change

Leaning-Bear and Jenny experienced drastic aversive changes in their environments; changes that they did not foresee, but had to cope with by relying on the behavioral and cognitive mechanisms available to them. They lived through them, and they suffered through them. Their life histories, despite being fictitious, can help us to think about such changes. We close this chapter with the words of a non-fictional character, a person who experienced dramatic change in his environment for real. Changes that, with Gleichschaltung and an all-dominant ideology, brought horror and devastation to large collectives. A person who decided to act against those changes, and who, in stepping out of the line dictated by that ideology, lost his life. Dietrich Bonhoeffer was executed for acting against the Nazi regime just a few days before the regime collapsed in 1945. The following lines by Bonhoeffer could be taken as a general statement on drastic aversive change:

> One has to expect that most humans will only become savvy when they themselves experience suffering. This way one can explain, *firstly*, most human's stunning inability to execute any kind of preventive action – one simply tends to believe to still be able to avoid the danger, until it is finally too late; [and this way one can explain] *secondly* the insensibility with respect to others' suffering; compassion emerges proportional to the growing fear of the threatening proximity of doom … Deedless waiting and obtuse standing on the sidelines are not Christian postures. It is not, at first, his proper sufferings, but the sufferings of his brothers, for whose sake Christ suffered, which calls the Christian to action and to co-suffering.
>
> *Bonhoeffer, 1998 [1942], pp. 33–34, translated from German, additions in brackets*

As Bonhoeffer points out, the route to wisdom may be paved by first-hand experiences. Indeed, as we have discussed in this chapter, we humans are not "omniscient," we cannot boast of computational "omnipotence" (see e.g., Gigerenzer, 2008a, p. 5 and p. 4, respectively), rather, our rationality is bounded, as is our ability to foresee the digital future. Without adequate foresight, preventive action might seem pointless. Yet, as Bonhoeffer further remarks, we are capable of something else: Compassion, as well as action and co-suffering. Compassion can be produced by environmental cues signaling growing threats to oneself. But action and co-suffering can come without threats from values. It is beholden on us to reflect whether we want to follow the heuristic "*Act once you feel compassionate!*" or its counterpart, namely, "*Act prior to feeling compassionate!*" as we encounter the winds of change.

Epilogue

In his memoirs, likely written in 1939, Bruno Stange, the great-grandfather of one of the authors, describes the following encounter with Hitler, which presumably took place in 1933: "The 'Führer' wanted to speak to the workforce in the Dynamowerk of the Siemenswerke.

 DOI: 10.4324/9781315658353-21

What enthusiasm ... Special admission tickets were issued, multiple checks were carried out, then we were allowed to wait for three hours until the splendid Führer appeared in the presence of his paladins. For a short time, I had the opportunity to look into Hitler's eyes. A horror overcame me and back at home I said to ... my dear wife: 'I have looked into the eyes of a madman'." Today, with a benefit of hindsight and greater knowledge, we know what happened after this "madman" came to power in 1933. We wonder what our great-grandchildren will say when they read this essay after the winds of digital change have had another few decades to marry humans with machines.

Acknowledgments

We would like to thank Riccardo Viale, Benjamin Müller, and the GABE reading group at the Faculty of Business and Economics at the University of Lausanne for many helpful comments on earlier versions of this chapter. We also thank those attendees of the 2019 Workshop of the Herbert Simon Society ("The digital world, cognition and behavior") in Turin who shared their thoughts with us on digitalization. We especially owe Dirk Helbing a large debt: His warnings and notably his books *Thinking ahead: Essays on big data, digital revolution, and participatory market society* (Helbing, 2015) and *Towards digital enlightenment: Essays on the dark and light sides of the digital revolution* (Helbing, 2019) have been a major source of inspiration for us. We are also indebted to Gerd Gigerenzer, founder of the fast-and-frugal heuristics approach, and to several members of the former ABC Research Group with whom we have discussed the potential negative aspects of digitalization over the course of two working retreats. Finally, we would like to thank Barnaby Dicker and Susan Dunsmore for their careful copy-editing and Caroline Plumez and Jérémy Orsat for additional checks.

Notes

1 The character of Leaning-Bear is fully fictional; yet the story depicted here may have happened in one or the other form to individuals from Native American nations. They all experienced the dramatic breakdown of their world (see e.g., Brown, 1974 for an encompassing recent account of the history of the Lakota, see Hämäläinen, 2019; for first-hand accounts of Lakota ways of life, see Waggoner, 2013). In general, there have been numerous instances of dramatic changes during history that resulted from violence, war, or some sort of clash of civilizations. When discussing a previous version of this chapter with colleagues, some pointed to the possibility that our example of the Sioux might elicit negative emotions, in particular, among the descendants of Native Americans. However, when contemplating using another example, we realized that this concern is quite general and could be made, presumably, for all other historical examples of sudden, dramatically negative, and thorough changes in an individual's environment. These changes for the worse set the stage for the topic of this chapter. Our hope is that by looking at a grim picture of the past, we might aid reflection on new types of potentially grim future changes.

2 After having finished this chapter, we learned about Luther Standing Bear (Ota Kte, Plenty Kill), a Sioux born in the 1860s. His fascinating autobiography (Standing Bear, 2006 [1928]) tells the story of the life of a man who grew up when the world of the Sioux was changing dramatically—a man who had experienced traditional ways of life on the Great Plains, who then attended Carlisle Indian Industrial School in Pennsylvania, who later in his life traveled with Buffalo Bill to Europe where he "had the honor being introduced to King Edward the Seventh, the monarch of Great Britain" (Standing Bear, 2006 [1928], p. 256), who was injured in a train accident in 1903, and who came to write his own books. He died in 1939. The following lines, taken from his autobiography, speak for themselves about the change in his world:

> Our scouts, who had gone out to locate the buffalo, came back and reported that the plains were covered with dead bison. These had been shot by the white people. The Indians never were such wasteful, wanton killers of this noble game animal. We kept moving, fully expecting soon to run across plenty of live buffalo; but we were disappointed. I saw the bodies of hundreds of dead

> buffalo lying about, just wasting, and the odor was terrible ... Now we began to see white people living in dugouts, just like wild bears, but without the long snout. These people were dirty. They had hair all over their faces, heads, arms, and hands. This was the first time many of us had ever seen white people, and they were very repulsive to us. None of us had ever seen a gorilla, else we might have thought that Darwin was right concerning these people.
>
> *Standing Bear, 2006 [1928], p. 67*

3 Take the (real) story of Plenty Horses, a Lakota born in 1869, who was brought from the West to a boarding school (Carlisle Indian Industrial School) in the East (Pennsylvania), where he stayed from 1883–1888. When he went back to his tribe, a few days after the Wounded Knee Massacre (which happened on December 29, 1890), he killed an army Lieutenant by firing a bullet through the back of his head, a man with whom he had just previously "chatted" (Gitlin, 2011, p. 96). Plenty Horses was put on trial. He explained:

> Five years I attended Carlisle and was educated in the ways of the white man. When I returned to my people, I was an outcast among them. I was no longer an Indian. I was not a white man. I was lonely. I shot the lieutenant so I might make a place for myself among my people. I am now one of them. I shall be hung, and the Indians will bury me as a warrior.
>
> *cited in Fear-Segal & Rose, 2016, p. 3*

4 The Sioux documented events and experiences in pictorial form. These chronicles, painted on hides, are referred to as winter counts; they represent a valuable source for contemporary historians. As Hämäläinen (2019) points out, "[t]here is a tangible change in winter counts during and after the painful years between 1877 and 1890. Several counts stopped in the late 1870s, ending with Crazy Horse's death, with the U.S. Army confiscating horses, or with children sent to boarding schools. 'Big Foot killed,' reads one of the few winter counts that refers to the Wounded Knee Massacre, the silence capturing the enormity of the shock and trauma." (p. 380)

5 Also Plenty Horses' life took a surprising turn. At the end of his trial, he was not found guilty of murder and not hanged, but acquitted and released. The argument was that a state of war had existed; without a state of war also the soldiers who participated in the Wounded Knee massacre a few days beforehand could have been accused of murder, too. Assuming a state of war helped to exonerate them (Fear-Segal & Rose, 2016). Plenty Horses died in 1933, like our fictional character Leaning-Bear.

6 To the extent to which there are repeated learning opportunities (e.g., repeated model calibration and testing) *and* the compositions of the learning samples and the test samples only differ at random across repetitions *and* that average (rather than one-shot performance) matters to an organism, this kind of uncertainty might even invite attempts to 'optimize', that is, to identify the strategy in the repertoire that performs, on average, best across many test samples. While past research on fast-and-frugal heuristics has stressed assessing absolute accuracy when making inferences out-of-sample, one might, alternatively, want to identify the strategy that suffers the least when generalizing from the calibration to the test samples. Note that these two different goal functions may lead to the selection of different strategies, which, in turn, offers an interesting link to the psychology of happiness: A person's happiness, after a loss, might not depend only on the final state after the loss (e.g., health, prestige, fortune), but on comparisons with reference points in the past, that is, the magnitude of the loss. Do people make comparative evaluations when selecting their decision making strategies in environments hit by winds of change?

7 Interestingly, that lemma seems to have propelled Luther Standing Bear, as a young boy, directly into the 'white' man's world, eventually boosting his ability to navigate that new environment in later phases of his life. In his autobiography (Standing Bear, 2006 [1928]), he discusses his motivations to go East (to Pennsylvania to Carlisle Indian Industrial School) in 1879: "I was thinking of my father, and how he had many times said to me, 'Son, be brave! Die on the battle-field if necessary away from home. It is better to die young than to get old and sick and then die.' When I thought of my father, and how he had smoked the pipe of peace, and was not fighting any more, it occurred to me that this chance to go East would prove that I was brave if I were to accept it." (p. 124) He continues by pointing out: "I had come to this school merely to show my people that I was brave enough to leave the reservation and go East, not knowing what it meant and not caring." (p. 135) "It did not occur to me at that time that I was going away to learn the ways of the white man." (p. 128)

8 While our fictitious Jenny only appears in one section of this chapter, Dicke and Helbing's (2017) science fiction novel *iGod* is entirely centered around their protagonist Alex. The life of Alex is a projection of the authors' speculations, or, shall we say, informed guesses, given that both authors are scientists, and the

 DOI: 10.4324/9781315658353-21

reader, wondering whether he has a utopia or a dystopia in his hands, is invited to imagine how a world shaped by digitalization, big data, artificial intelligence, and social scoring might soon look.

9 Available at: https://policies.google.com/privacy?hl=en#infocollect (accessed January 21, 2020).

10 Available at: https://ec.europa.eu/info/policies/justice-and-fundamental-rights/criminal-justice/e-evidence-cross-border-access-electronic-evidence_en (accessed January 21, 2020).

11 Tragically, 'horse-stealing' seemed actually acceptable to American policy-makers: In an attempt to dismount the Sioux (Lakota), their horses were taken away in the aftermath of the battle of the Little Big Horn (Waggoner, 2013).

12 Whoever has read, in detail, the long privacy statements that come with digital services knows what we are talking about: Page-long, seemingly transparent disclosure statements alerting users that their data can be pooled, sold, or otherwise shared with other parties, including other companies or government agencies.

13 Traces of this view can be found in the decision sciences, bibliometrics, and statistics, with null-hypothesis significance testing or metric-based science evaluations representing examples of seemingly automatic, objectifying decision procedures (see Marewski & Bornmann, 2020; Gigerenzer, 2018).

14 Gleichschaltung brought about by digital technologies represents just one way of reducing diversity. Another way to reduce diversity is to set *nudges* (Thaler & Sunstein, 2009) that lead a large number of people to behave in the same way, namely, in line with the behavioral options championed by the policy maker. In that sense, nudges can be thought of as potentially inducing "behavioral biases" (see also Kozyreva et al., in press, and Helbing et al., 2017, on "big nudging").

15 If such devices collected data that, furthermore, would aid in making or justifying judgments about a child's descendants, then issues related to surveillance, privacy, security, and (e.g., heath-related) discrimination would become inter-generational. Note that such inter-generational judgments would not need to be justifiable, scientifically. What would matter would be that, for instance, people in power would be able to believe or pretend that attributes (e.g., inferred IQ or psychopathic personality traits) were informative across generations. Numeric scores may be particularly susceptible to such exploitation as they may be able to lend seeming objectivity to dubious claims and/or policies, as the history of IQ and other indicators, used to score individuals, illustrates (see e.g., Gigerenzer, Swijtink, Porter, Daston, Beatty, & Krüger, 1989; Gould, 1981; Severson, 2011; Young, 1922).

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