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# The Oxford Handbook of Psychological Situations

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CHAPTER

# 10 The Ecological Rationality of Situations

*Behavior = f(Adaptive Toolbox, Environment)*

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**Abstract**

The study of situations involves asking how people behave in particular environmental settings, often in terms of their individual personality differences. The ecological rationality research program explains people's behavior in terms of the specific decision-making tools they select and use from their mind's adaptive toolbox when faced with specific types of environment structure. These two approaches can be integrated to provide a more precise mapping from features of situation structure to decision heuristics used and behavioral outcomes. This chapter presents three examples illustrating research on ecological rationality and its foundations, along with initial directions for incorporating it into an integrated situation theory.

**Keywords:** ecological rationality, adaptive toolbox, heuristics, decision making, environment structure

Human rational behavior... is shaped by a scissors whose two blades are the structure of the task environments and the computational capabilities of the actor.

—*Herbert Simon, 1990, p. 7.*

## Introduction

In his field theory, Kurt Lewin (1936) argued that every behavior depends upon the person *and* the environment, and that their relative importance varies from task to task. He expressed this general insight in what became known as Lewin's equation:

$$B = f(P, E), \qquad (1)$$

where $B$ stands for behavior, $P$ and $E$ for person and environment, respectively, and $f$ for a function that maps person and environment onto behavior. By environment, Lewin meant the present environment or "life space" in which a behavior takes place, with past events being relevant only insofar as they led to the present situation. How to determine the function $f$ and how to measure $P$ and $E$, however, were all left open. Despite its supreme generality, the equation reminds us of an obvious fact that psychologists tend to forget, again and again: Explanations of behavior by inner ($P$) forces alone are incomplete, and so are explanations by external ($E$) forces alone. The majority of psychological theories try to explain behavior by focusing on inner forces, such as personality traits, risk preferences, and cognitive abilities. Most personality theories such as the Big Five, most Bayesian theories of cognition, and all dual-systems theories of reasoning are examples of this neglect of the environment. On the other hand, a few psychological theories have tried to explain behavior predominantly by external forces, such as Skinner's reinforcement schedules, Gibson's affordances, and Brunswik's ecological validities. Even after the overthrow of behaviorism by the cognitive revolution, this tendency for only-$P$ or only-$E$ theories continues to reign, just with fewer theories focusing on the environment.

In his satisficing theory, Herbert Simon argued that one cannot understand behavior without looking at cognition *and* environment and carefully considering how the two interact. Simon (see epigram) used the analogy of a pair of scissors: Without looking at both blades, here the cognitive and the environmental, one cannot understand how the scissors cut so well. An essential part of Simon's cognitive blade was heuristics, robust rules of thumb that help to make good decisions under uncertainty (as opposed to "risk")—that is, in situations where calculating the optimal future course of action is impossible. The research that we and others have been pursuing on the mind's "adaptive toolbox" builds on Simon's foundation, systematically analyzing the heuristics people use and how they select those heuristics depending on the environment (Gigerenzer, Hertwig, & Pachur, 2011; Todd, Gigerenzer, & the ABC Research Group, 2012). The adaptive toolbox of a decision maker contains the set of heuristics and other strategies that an individual (or institution) can draw on in different settings, built up via evolution or learning. From this perspective, we propose a reformulation of Lewin's equation:

$$B = f(AT, E), \qquad (2)$$

where $AT$ stands for *adaptive toolbox*. By rewriting Lewin's equation, we can now replace the earlier internal term $P$ with precise models of heuristics and define relevant structures of the environment $E$. This further enables us to use the study of ecological rationality to work out the match between specific heuristics and environment structures and predict the decisions and behaviors that emerge when a particular heuristic is applied in a particular environment.

We begin the next section of the chapter with three examples that illustrate the research program on ecological rationality and its conclusions. These illustrate that the adaptive toolbox program requires a radical rethinking of the types of questions asked in psychology (including social and personality psychology) and the types of answers one will find. Following this, we present a general introduction to the research on ecological rationality and how individual heuristics interact with environment structure to produce ecologically rational behavior. In the penultimate section, we present some ideas on how the study of ecological rationality can provide a framework for understanding the role of situations in human decision-making behavior.

## Three Illustrations of the Ecological Rationality Program

### *Trust Your Doctor*

A common decision situation plays out in the interaction between a physician and a patient when a choice about a medical procedure must be made. There are two important ways of thinking about this situation. One is the philosophy of *shared decision making*, where doctors take time to discuss the pros and cons of medical interventions with informed patients, and where the final decision is made by the patient or both patient and doctor together. The classical philosophy is different: Doctors take little time to inform their patients but instead request that patients trust them, and the patients who lack sufficient knowledge have no choice but to trust. For the patient, this second relationship amounts to relying on a simple heuristic: *If your doctor recommends a medical intervention, follow his or her advice.* Simply stated, the heuristic is:

Trust your doctor.

This rule is also known as the *white-coat heuristic* (Wegwarth & Gigerenzer, 2013). For instance, if your doctor advises you to undergo thyroid cancer screening, or have a CT scan, you do whatever your doctor recommends. This fast and frugal heuristic saves time and you do not need to search for information in medical sources or from other people—and you do not need to take responsibility if something goes wrong. In fact, with exceptions such as parts of Russia, the majority of patients in western countries appear to follow the white-coat heuristic most of the time. Even academics who are able to read medical studies tend to prefer to trust rather than read. For instance, two thirds of 133 male economists did not inform themselves about the pros and cons of prostate cancer (PSA) screening but simply trusted their doctors (Berg, Biele, & Gigerenzer, 2016). (Contrary to such behavior, most medical societies do not recommend PSA screening because of its documented harms such as incontinence and impotence after surgery, but rather counsel that men should inform themselves.)

Is trust a good idea? A heuristic is neither good nor bad per se; it all depends on the environment. The study of the situations in which a heuristic succeeds or fails is called the study of *ecological rationality*. As a first approximation, an ecologically rational decision is one that arises from the application of a heuristic in an environmental setting where it typically leads to a good outcome. To illustrate, if one or more of the following three environmental conditions holds, it is *not* ecologically rational, from the perspective of the patient, to rely on the white-coat heuristic:

1. *Defensive medicine.* Doctors practice defensive medicine if they recommend tests and treatments to patients primarily for legal rather than clinical reasons. In this situation the doctors fear that patients might sue them, and to avoid that, they typically over-medicate and over-treat patients.
2. *Conflicts of interest.* Doctors often work in settings where they have to choose between the best practice for the patient and the best income for themselves or the clinic. Conflicts of interest encourage performing expensive, unnecessary, and potentially dangerous tests and treatments.
3. *Statistical illiteracy.* If a doctor does not understand the relevant medical options, their likelihoods, benefits, and harms, and health statistics in general, this lack of statistical literacy can lead to uninformed recommendations.

The first two conditions relate to trust in motives, while the third relates to trust in competence (Siegrist et al., 2003). If none of these three features hold in a particular medical situation, then relying on the white-coat heuristic is a fast and frugal way to take good care of your health. However, if one or more of these features is in place, then the heuristic is not ecologically rational and will often lead to a poor outcome for your health. Let us have a closer look at these three classes of situations (Wegwarth & Gigerenzer, 2013).

#### DEFENSIVE MEDICINE

If a doctor recommends (or performs) a test or treatment that is not the best option for the patient, but one that protects the doctor from being sued by the patient, this behavior is called defensive medicine. Among 824 surgeons, obstetricians, and other U.S. specialists at high risk of litigation, 93% reported that they practiced defensive medicine. This behavior includes ordering unnecessary CT scans, MRIs, biopsies, and bypass surgery, and prescribing more antibiotics than medically indicated (Studdert et al., 2005). The spread of defensive medicine depends on the tort law in a country. Physicians in the United States face one of the highest risks worldwide of being sued by their patients, and thus they feel that they have no choice but to perform more unnecessary surgeries and other forms of defensive medicine on their patients than in most other countries.

#### CONFLICTS OF INTEREST

In market-driven health systems, doctors experience a conflict between best care for the patient and earning money (or reputation). In fee-for-services systems, doctors earn a fee for each service, which encourages unnecessary but expensive tests and treatments, even if these are likely to harm the patient. For instance, every year an estimated 1 million US children have unnecessary CT scans, which is a major source of income for doctors and clinics but puts children at risk of getting cancer later in their lives due to the radiation involved (Brenner & Hall, 2007).

#### STATISTICAL ILLITERACY

Surprisingly, medical schools across the world rarely teach medical students where to find evidence-based information and how to understand health statistics. For instance, only one out of 32 professional HIV counselors at German counseling centers was able to tell a low-risk client who tested positive the correct probability of actually being infected with HIV (Prinz et al., 2015). Tests of physicians in the United States and various other countries reveal that about 70 to 80% of physicians do not understand health statistics (e.g., Wegwarth et al., 2012). As a consequence, the average physician is not able to understand and critically evaluate a journal article in his or her own field but has to depend on "information" provided by the pharmaceutical industry and other unreliable sources.

The general point is that health outcomes are not simply due to the personality of patients driving trusting or independent decision making, but to the interaction between the specific heuristics patients rely on and the structure of the medical environment they face. Some of the three environmental features mentioned earlier may not even be apparent to the patient (if physicians do not understand health statistics, they rarely tell this their patients). Translated into Equation 2, the behavioral outcome $B$ (such as good or bad health, undergoing necessary or unnecessary surgery) is a function of the strategy a person selects from his or her adaptive toolbox and the current environmental setting in which the strategy is applied. For the case in which the white-coat heuristic is used in a medical treatment situation, the present analysis can be summarized as

$$B = f(\text{white-coat heuristic}, \{DM, CI, SI\}), \quad (3)$$

where the first comma marks the line between person (using a heuristic) and environment, which here is the line between the patient (using the white-coat heuristic), on the one hand, and the doctor and the medical system, on the other. With regard to the latter environment, *DM* stands for the presence or absence of doctor's defensive decision making, *CI* for conflicts of interest, and *SI* for statistical illiteracy. The simple Equation 3 has policy implications. To improve a health system, one can keep the "trust your doctor" heuristic and change the environment (e.g., reduce *DM, CI, SI*) so that trust is then ecologically rational. Or one can change the white-coat heuristic to shared-informed decision making, which could make up for some of the negative features of the environment. What will probably not work is to change one blade of the decision-making scissors without considering the other.

This example reveals three general principles:

1. *Different strategies cause individual differences.* Individual differences in the strategies patients rely on can lead to individual differences in health outcomes. For instance, parents who search for information in the Cochrane library (cochrane.org) or other evidence-based sources would not let their children undergo unnecessary CT scans and expose them to large doses of radiation.

2. *Individual differences can also be caused by one-and-the-same heuristic.* Two individuals who both rely on the white-coat heuristic may nevertheless show different health behaviors if their doctors and medical situations differ on the three environmental factors.

3. *The environment, along with the mind, determines the outcome.* Much of research on medical decision making considers only one blade of Simon's scissors, the mind, and attributes health behaviors to presence or absence of internal factors such as self-control, intelligence, or willpower. The situation in which the individual acts is too often not factored into the equation. (See Morse & Sweeny, this volume, for an overview of research on medical situations.)

### *Parental Investment: The Case of the Neglected Middle-Borns*

Another common class of decision situations involves family interactions. The belief that one's parents favor one's brother or sister is a frequent cause of sibling rivalry. It is told in the Bible, in Shakespeare' plays, and by many who are jealous about their more-favored siblings. In fact, a study in Syracuse, New York, found stark differences in the hours of child-care that children received from their parents up to age 18 (Figure 10.1). The black squares show that in families with two children, both get equal time. In families with three or more children, however, systematic inequality can be observed. On average, parents spend more time with their first-born and last-born children than with their middle-borns (resulting in the V-shaped distribution of hours of child-care). This inequality increases with the spacing of the children: The larger the interval between siblings (moving left to right in the graph), the larger the relative disadvantage for the middle-borns (the deeper the V). Parents appear to be fonder of their oldest and youngest children. How can we explain these parents' behavior? (See Hertwig, Davis, & Sulloway, 2002, for an in-depth discussion.)

One psychoanalytic explanation is that birth-order influences children's personality, which in turn may influence the time parents spend with each child. Specifically, Sulloway (1996) argued that first-borns tend to identify with the father and conform to authority, while second-borns and younger children tend to rebel (but later large studies failed to find evidence for these effects—see Rohrer, Egloff, & Schmukle, 2015). This hypothesis explains individual differences despite a shared environment, and it suggests parents may want to spend more time with the firstborns who conform. Yet this hypothesis does not explain why last-borns get about equal time from their parents, nor why the effect is not seen in two-child families.

A second potential explanation would be that in many cultures, parents have a preference for the first-born, especially if it is a boy, because he will inherit the estate. Yet this explanation runs into the same problems.

A third explanation can be derived from economist Gary Becker's (1981) book, *A Treatise on the Family*. According to Becker, parents behave as if they would try to maximize total child quality, defined as the sum of their children's adult wealth. To do so, parents would need to estimate each child's future skills in earning money, and put different time and effort into different children so that the expected parental payoff is maximized. This economic theory, however, does not explain why the first-born and last-born would be expected to end up with the largest adult wealth and so with the greatest parental input.

All these explanations are *internal* explanations in terms of personality, preferences, or expected payoff (utility) maximization. They do not take into account the environment in which parental investment decisions are made.

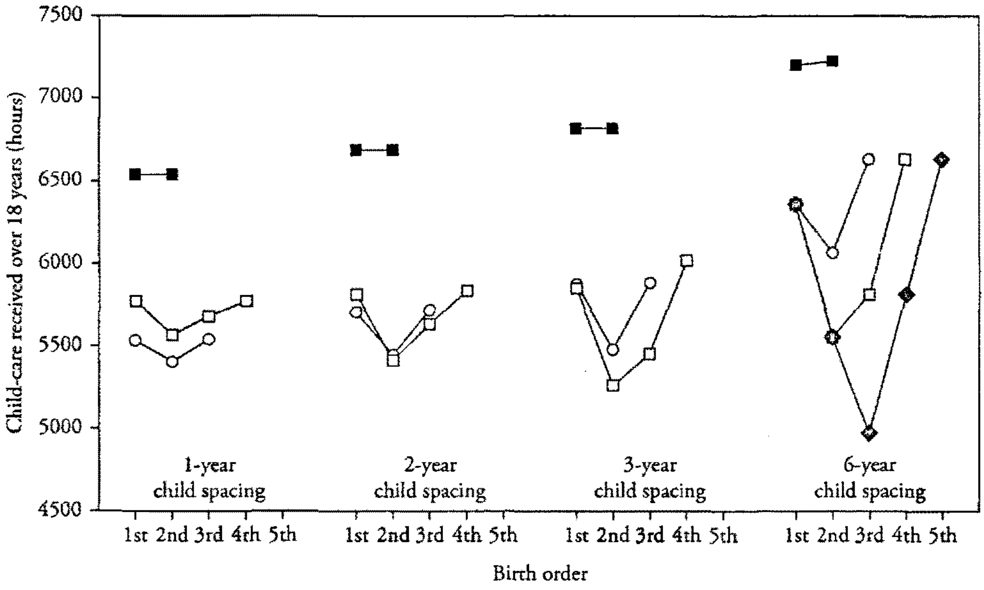


**Figure 10.1.** Parents spend more time with their first-borns and last-borns than with middle-borns. The inequality increases when parents have more children and when the spacing between children is longer. Why is this? A simple allocation heuristic and two environmental features can predict the complex pattern observed (see text).

*Source*: 1,296 families in Syracuse, New York. Analysis based on Lindert (1977) and Hertwig et al. (2002). Figure 1 reproduced from Gigerenzer (2014, p. 154), modified from original figure in Hertwig et al. (2002).

Now consider the adaptive toolbox approach to explain the complex pattern in Figure 10.1. In this research program, one investigates what parents actually do, that is, what heuristics they use to allocate their time in the environmental situations they actually face, rather than what personality traits or preferences might be in play. The two components in Equation 2 are the heuristics selected from the adaptive toolbox of parents and the relevant environment structures in their decision situations. The challenge is to show that these two components jointly predict the complex pattern of observed behavior.

Studies about parental time allocation report a number of heuristics (see Hertwig, Davis, & Sulloway, 2002) that vary between parents and cultures. We focus here on a single heuristic that has been frequently reported by parents in the United States as well as in other cultures with ideals of fair allocation and an equalitarian society:

Distribute your time equally over your children.

This heuristic is also known as $1/N$, with $N$ as the number of children. How can $1/N$, which is equal allocation, explain the unequal time the middle-borns end up with in Figure 10.1?

Consider first families with two children. If parents divide their care time between their children equally every day or week, the total care time received by each child will be the same after 18 years, consistent with the black squares in Figure 10.1. In families with three children, however, the same heuristic will (unintentionally) lead to inequality. The first-born has a period in which it gets all available care alone, that is, before the second child arrives. The last-born also gets a period of care alone, after all the others have left the family. The middle-born sibling, in contrast, has to share with the others without a period for himself or herself, thus resulting in overall less care time. Figure 10.1 shows that this prediction holds: Unlike in two-child families, middle-borns get on average less care time in three-child families (white circles) and in four-child families (gray squares). Thus, in terms of Equation 2, the behavioral pattern is a function of the heuristic ($1/N$) and an environmental feature, the number of siblings $N$.

Now consider a second environmental feature, the spacing of siblings $S$. If parents rely on the $1/N$ heuristic and the interbirth interval spacing is $S = 1$ year, then the first-born will have 1 year of care time for itself. With increasing length of $S$, this extra time increases, which amounts to relatively more time for the first- and last-borns compared to the middle-borns. That is, parents who rely on $1/N$ will increase the overall inequality among their children as the spacing between siblings increases. This implication of the interaction between heuristic and environmental feature (here, $S$) is again observed in Figure 10.1.

This analysis maps a heuristic, $1/N$, and two environmental features, number of siblings $N$, and spacing of siblings $S$, into the care time behavior $B$ allocated to each sibling:

$$B = f(1/N, \{N, S\}).$$

The shape of the function $f$ is shown in Figure 10.1, and all parameters can be measured from the data. Lewin's equation is put to very specific work.

To summarize, the complex pattern of parental investment in Figure 10.1 is logically implied by the use of a simple heuristic, $1/N$, which is widespread among American parents, and two environmental features, the number of siblings and the birth spacing between siblings. There are doubtless many other factors in play, but this single heuristic and the two environmental factors yield all the major patterns seen here: equal time in two-child families, disadvantage for the middle-borns in families with three or more children, and the increase of the disadvantage with larger spacing of siblings.

Once again we see these three general principles at work:

1. *Different heuristics cause individual differences.* Individual differences in the strategies that parents use can lead to differences in the care time that children receive. An example of another simple heuristic that would lead to quite different observed behavior is "spend more time with boys (or girls)."

2. *Individual differences can also be caused by one-and-the-same heuristic.* Here, the same heuristic, $1/N$, generates individual differences between parents' time allocation to first-borns compared to second-borns, depending on the number of children. These differences in time allocation can in turn result in individual differences among their children's behavior.

3. *The environment, along with the mind, determines the outcome.* Knowing someone's preference is not enough to know what behavior will emerge—here, an equality motive (implemented in the $1/N$ heuristic) can produce systematic inequality. One should not attribute observed behavior (such as inequality) to a corresponding motivation or trait without analyzing the underlying heuristic process and the environment in which it is used.

This example also illustrates a fourth principle of ecological rationality:

4. *Complex behavioral patterns do not always need complex explanations.* Here, a simple heuristic implies the entire observed behavioral pattern, while complex utility-maximization models such as Becker's would need multiple free parameters and assumptions to fit the pattern. Complex behavior can emerge from the interaction of simple strategies with particular environment structures.

### *How Do Burglars Choose Which Property to Break Into?*

Situations leading to criminal behavior may be less familiar to many readers, but they provide another telling example of the importance of considering both individual differences in strategies and how they interact with environmental settings. It is often assumed that experts make decisions in highly complex ways, while novices rely on simple heuristics. In many real-world situations, however, studies indicate the opposite: Experts appear to use less information and rely on simple heuristics, while novices do not know where to look and so search for more information (Shanteau, 1992). Consider a problem that a class of rarely studied experts on the dark side face on a regular basis: which property to break into?

Understanding how burglars choose properties to steal from can be useful for homeowners who want to reduce the likelihood of being burgled (i.e., by "thinking like a thief"), and for police who want to predict situations where burglary is likely to happen. Garcia-Retamero and Dhami (2009) studied 40 experienced burglars (recruited from a British prison), who reportedly committed burglary an average of 57 times, and 40 police officers with an average of 19 years of work experience investigating residential burglaries. As a control, they included 40 graduate students who (we hope) were novices with respect to burglary. Each participant was given 40 pairs of properties, described by eight cues. Table 10.1 shows one example pair. Participants first had to choose the property more likely to be burgled, then rank the cues according to how useful they were in predicting the burgled property, and finally assign a weight (importance) to each cue. Participants were asked:

*Based on the description of the two residential properties below, which one do you think would be more likely to be burgled?*

The main question of the study was, how do burglars think? The first part of the answer is to identify what cues burglars use in making their decisions about where to break in. For the burglars, the most important cue was security, that is, the presence versus absence of an alarm system, followed by location (middle versus corner of the street) and the

**Table 10.1. Illustration of the burglary choice task. Here the cues (first column) are ordered according to their average weight (importance) given by the professional burglars in the study. (In the experiment, in contrast, the order of cues was varied randomly across participants.) All cues have two possible values. "Positive" cue values that put the property at greater risk of being burgled are shown in bold. Adapted from Garcia-Retamero and Dhami (2009).**

| Cues | Property 1 | Property 2 |
|---|---|---|
| Security | **No burglar alarm system** | **No burglar alarm system** |
| Location | **Corner of the street** | Middle of the street |
| Letterbox | Empty | **Stuffed with post** |
| Light | On | **Off** |
| Access | **Doors/windows on ground floor** | Doors/windows on second floor |
| Garden | Short hedges/bushes | **Tall hedges/bushes** |
| Type | **Flat** | House |
| Care | **Not well-kept property** | **Not well-kept property** |

state of the letterbox (empty versus stuffed with post). One finding of the study was that even long-time police officers failed to track exactly how thieves think: Officers believed that access to the property was the most important cue, not security or location. Students believed that access and letterbox would be most important considerations.

Next, the researchers asked, how do burglars choose which property to break into given all these cues? Two hypotheses were tested. The first is the standard model in information processing theories: that people weight and add all available information. This hypothesis was tested by constructing a weighted-additive linear model with the weights each participant assigned to each cue, and then using that participant's model to predict their choices of properties to burgle for all property pairs they saw. The second hypothesis was based on a consistent finding from studies of expertise: Experts have mastered the art of ignoring information. This hypothesis was tested by predicting each participant's property choices using the *take-the-best* heuristic with his or her individual rankings of the cues (Gigerenzer & Goldstein, 1996). This heuristic is a type of "one-reason" decision mechanism, which only uses a single reason or cue to make its choice (with that one reason being found by considering the reasons in a specific search order). Take-the-best first compares the two properties on the highest-ranked cue, and if their cue values differ, it chooses the property with the positive cue value. If these two cue values do not differ, this process is then repeated with the next-highest cue until a cue is found where the values differ for the two properties. Consider the example in Table 10.1. A burglar would look at security first, and find that neither of the two properties has an alarm. That is good news for the burglar, but it does not help in making a choice between them. Next, location is evaluated, and here the properties differ; the burglar then ignores all other cues and goes for Property 1, which has the positive cue value for location.

The authors report that 34 of the 40 expert burglars (85%) and 31 of the 40 expert police officers (78%) could be best described as relying on take-the-best, compared to only 1 of the 40 novice students. The students' choices were best predicted by the complex weighted-additive strategy.

This result raises another question: Why would experts ignore part of the information they had? Note that in the judgment and decision-making literature, ignoring information has in the past been equated with reasoning fallacies and cognitive illusions—that is, irrationality (Ariely, 2008; Kahneman, 2011). The answer is that experts who rely on simple heuristics can exploit structures of environments to make better and faster decisions than novices would. Take-the-best has been shown to match or outperform the predictive accuracy of information-hungry linear models and complex machine-learning methods such as support vector machines when particular situational conditions hold (Brighton & Gigerenzer, 2015). These conditions include having a set of cues or features that differ considerably in their importance—which was the case for the burglars—rather than lots of cues that are all essentially equally important to consider (for details, see Gigerenzer, 2016).

This example once again illustrates the general principle that different heuristics selected from the adaptive toolbox can lead to individual differences in behaviors:

1. *Different heuristics cause individual differences.* Individual differences in the strategies that experts and novices use lead to individual differences in the choices they make.

Furthermore, the typical expectation we may have about the sophistication of expert decision making need not hold in many situations:

2. *Less can be more.* Compared to novices, experts tend to search for less information and process these in simpler, ecologically rational ways.

## Ecological Rationality

The ecological rationality research program illustrated in the previous section leads us to ask three key questions. Given an environment, what heuristics succeed in it? Given a heuristic, in what environments does it succeed? And how and why do particular heuristics and environments fit together to produce good decisions? The answers help us understand the contents of the mind's adaptive toolbox and how those tools are drawn on to tackle particular problems in situations and settings with particular types of structure. In this section we describe the research framework for studying heuristics in the adaptive toolbox, the ways that environment structure can be characterized, and how environments, heuristics, and individual differences may all fit together to produce ecological rationality.

### *Studying Heuristics in the Adaptive Toolbox*

Much of decision research has focused on how people *should* make decisions—normative theories of rationality. But to be able to predict people's behavior, we need to know how people actually *do* make decisions—descriptive theories. Herbert Simon pushed in this direction with his idea of bounded rationality, looking at how people can make decisions in situations where the future is uncertain and with limited information, time, and computational power by using psychologically plausible heuristics (Simon, 1990). These heuristics typically result in good decisions, although they can also lead to mistakes and errors, as emphasized in the heuristics-and-biases research tradition, which has so far neglected analyzing the match between heuristics and environments (Kahneman, Slovic, & Tversky, 1982). From the traditional normative perspective, relying on take-the-best or other heuristics described earlier would indicate irrationality and be misattributed to people's limited cognitive abilities. But by considering the decision environment, it becomes apparent that in situations of *uncertainty* (where we cannot know the future ahead) as opposed to situations with calculable *risk* (such as lotteries, where the probabilities and alternatives to come are known), it can be rational to ignore part of the information—which is what heuristics do.

The crucial influence of the environment setting was too often left out of research on decision making, as it was early on in personality and social psychology—the focus was on what was in the mind, not in the world. The study of ecological rationality (Todd & Gigerenzer, 2012) remedies this inattention by exploring exactly the fit between decision mechanisms and environment structure, enabling predictions of the decisions and choices an individual will make when facing a particular task setting.

Ecological rationality proposes that to make effective decisions and achieve our desired ends in an uncertain world, we stay within our cognitive bounds by using a collection of simple mechanisms. That is, people draw on an adaptive toolbox of decision mechanisms that include fast and frugal heuristics, quick shortcuts, and rough rules of thumb (Gigerenzer & Todd, 1999; Gigerenzer, Hertwig, & Pachur, 2011). Some of these tools are pre-wired for us by evolution, and some are learned through individual experience or through cultural inheritance. They are typically applicable to a range of decision tasks, as defined by their ecological rationality—that is, different tools for different kinds of tasks, because the useful "biases" that heuristics incorporate make them fit well to some environmental settings and not others. Biased heuristics rely on particular structures being present in the environments where they are used, which allow them to work with little information and little processing and nonetheless to produce ecologically rational behavior fit to various settings.

How are the multiple task-specific tools in the mind's adaptive toolbox matched to (and selected for use in) particular environmental settings, and how does this align with notions of different types of situations? One possibility is that the tools are part of domain-specific modules as proposed in evolutionary psychology (e.g., Cosmides & Tooby, 1994), so that some would be used in situations revolving around mating goals, other in food-related situations, and still others in parenting-related situations. We expect, though, that different heuristics are typically activated in response to lower-level underlying environment structures to which they fit, such as statistical patterns among cues (useful information-bearing features) in the environment. In some cases, evolutionarily adaptive domains and statistical environment structures may be uniquely associated, but in other cases, the same environment structure may be found in multiple adaptive domains, as well as in modern constructed domains, implying that the same kind of tool could be used across those domains. For example, the 1/*N* rule described earlier for allocating resources between children can also be used effectively in other situations where allocations must be made across multiple options, such as investing in a portfolio of stocks (Todd & Gigerenzer, 2012). The appropriateness of using particular heuristics in particular situations could be discovered by evolutionary processes (including adapting existing heuristics for new settings; Todd & Miller, 2018) and by selection mechanisms based on learning (see the section "How Environments and Individual Differences Interact").

The ecological rationality research program leads to a range of new findings and new perspectives, including

1. Rethinking heuristics—studying the structure of environments helps to understand when and why individual heuristics work.
2. Rethinking biases—making decisions in biased ways is not always bad, nor is it always good, but rather it depends on the match between biased heuristics and particular environment structures.
3. Understanding apparent paradoxes—knowing how heuristics affect decisions in particular situations can illuminate apparent paradoxes such as in the parental investment example earlier in the chapter, in which an equality heuristic leads to unequal child-care time.
4. Understanding complex behavior—simple rules can create complexity in predictable ways due to interactions with properties of the environment (again as in the population-level inequality produced by simple parental investment rules).

### *Types of Environment Structure*

The aspects of environment structure that have been most studied within ecological rationality so far are primarily statistical patterns of information that can arise from a variety of environmental processes, including physical, biological, social, and cultural sources. Some of these patterns can be described in similar ways across multiple domains (e.g., the distribution of cue values), while others are more specific (e.g., the presence or absence of defaults).

Many of the patterns in the physical environment can be characterized by distributions of cues and cue values (how many there are, what range of values they can take, etc.), cue validities (how often a cue indicates appropriate decisions), redundancies (intercue correlations), and discrimination rates (how often a particular cue distinguishes between alternatives, regardless of its accuracy). Such statistical regularities can be important for making decisions ranging from judging the size of a distant object (Brunswik, 1944) to deciding what camera to buy (Fasolo, McClelland, & Todd, 2007). The number and distribution of available options or events (such as whether a type of prey or rain is common or rare) also influence the mechanisms that people use to reason about them (McKenzie & Chase, 2012). How items are spread out over space or time, such as fish in ponds, bus stops on street corners, or parking spaces available in lots, determines what search heuristic for switching from one resource patch or location to the next will work effectively (Hutchinson, Wilke, & Todd, 2008; Wilke & Barrett, 2009; Hutchinson, Fanselow, & Todd, 2012).

Probably even more important for humans are structures inherent in social environments, as illustrated by the "trust your doctor" white-coat heuristic (Hertwig, Hoffrage, & the ABC Research Group, 2013). We can use heuristics to make decisions about other people as potential mates based on the things we and others have learned about them (Todd, Place, & Bowers, 2012), and on the sequential pattern of people we have previously encountered (Todd & Miller, 1999). Related heuristics can be used in other domains with a similar sequential mutual choice structure, such as job or apartment hunting. Other types of heuristics enable groups to decide about potential employees to hire, based on the distribution of information within the group (e.g., "hidden profiles"—Reimer & Hoffrage, 2013). Much of the information used in social environment settings comes from others, whether from talking with friends or colleagues or gleaned from media. This social information creates patterns in personal knowledge of what things an individual recognizes, with recognition usually being correlated with noteworthy features of the people or things under consideration, such as size, wealth, success, etc. This structure can in turn be exploited by simple heuristics such as the *recognition heuristic* (Goldstein & Gigerenzer, 2002) to decide which of a set of items is biggest, most successful, and so on. As with all heuristics, the recognition heuristic is ecologically rational in particular environments that share the appropriate structure (Pachur, Todd, Gigerenzer, Schooler, & Goldstein, 2012).

Environment structures can also be created by cultures or institutions to influence the behavior of others. For instance, institutions can create choice situations with a clear default option. When this is coupled with the fact that people often use just a single piece of information by using a *default heuristic*, situations can be created that lead to strong patterns of behavior, such as most people becoming potential organ donors in countries where this is the default (Johnson & Goldstein, 2003). In other cases, institutions can create environment structures that do not fit well with people's decision mechanisms, thus voiding their ecological rationality and leading to poor choices. This is seen in the design of casinos, where cues abound that indicate that people are winning at high rates (flashing lights, sounds of cascading coins) and that a winning combination could appear on the next deal or the next pull of a slot machine handle (Bennis, Katsikopoulos, Goldstein, Dieckmann, & Berg, 2012). It is also seen in medical environment described in the section "Trust Your Doctor," where there are strong *incentive structures* set by institutions: the tort law influencing defensive decision making, the reimbursement system of doctors and clinics contributing to conflicts of interest, and the medical school system leading to lack of training in statistical thinking. These structures create an unfriendly and unclear medical decision environment in which health care is not primarily for the benefit of the patient but for the benefit of the industry, clinics, and lawyers (Gigerenzer & Gray, 2011).

Finally, some forms of environment structure emerge without design through the social interactions of multiple decision makers. The application of the 1/*N* heuristic when allocating resources across children can create a strong pattern of inequality, as seen in the parental investment example in the section "Parental Investment." People basing their choices on the choices already made by others (e.g., using imitation or copying heuristics) result in "rich-get-richer" dynamics that create distributions of popularity of choices with just a few winners and many also-rans. Such emergent "J-shaped" distributions, seen in domains from music and book sales to social popularity to website visits, can in turn predictably influence the decisions of others (Salganik, Dodds, & Watts, 2006; Hertwig, Hoffrage, & Sparr, 2012). Similarly, drivers seeking a parking space using a particular search heuristic, as mentioned previously, create a pattern of available spots that is the environment for future drivers, who will search with their own heuristics that may fit that newly created environment structure less well (Hutchinson, Fanselow, & Todd, 2012).

In all of these cases, it is the *perceived* environment structure that interacts with the strategy employed by the individual decision maker and determines the decisions made by that individual. The *objective* environment matters for how successful or appropriate those decisions are, and hence how ecologically rational the strategy is in the current setting. To understand all of these interactions, we must couple careful experimental and field studies of decision making in real situations with precise models of the objective environment, the way that environment is perceived and learned about by the individual, and the decision mechanisms that the individual uses. Together, the empirical data and modeling enable us to predict individuals' choices and behaviors in a particular environment (see, e.g., Dieckmann & Todd, 2012).

### *How Environments and Individual Differences Interact*

The study of ecological rationality involves measuring the performance of particular heuristics in various environmental settings. This requires precisely specifying each heuristic in terms of an information-processing algorithm and each environment in terms of its information structure (cue distributions, validities, option values, defaults, incentives, etc.). The precise algorithmic specification of both decision heuristic (the tool selected from the individual's adaptive toolbox) and environment means that when we know both, we know what decisions will be generated (possibly with some stochasticity). Given that situation research is intended to add predictive power to individual differences of personality by taking the setting into account, the ecological rationality framework can add precision to that endeavor. Here we describe some of the research within this framework on how environment structure and individuals' heuristics combine to predict particular decisions, connecting to questions about personality/situation interactions.

As described in the previous section, a wide range of research has shown that (1) people tend to rely on simple heuristics in the real world, and (2) relying on heuristics can result in better outcomes than complex strategies in situations where the heuristics are ecologically rational (Gigerenzer, Todd, & the ABC Research Group, 1999; Todd, Gigerenzer, & the ABC Research Group, 2012). But research has also been filling in the gap between these two findings, showing that people predictably select and use appropriate heuristics when facing particular environment structures. In terms of Equation 2, these results enable us replace the function $f$ mapping from adaptive toolbox and environment to behavior with a function $s$ that selects a particular tool $T$ from the adaptive toolbox when in a particular environment, and a function $g$ that maps from a specific tool and environment to behavior, as shown in the following equations:

$$\begin{aligned} B &= f(AT, E) = g(T, E) \\ T &= s(AT, E) \\ B &= g(s(AT, E), E) \end{aligned} \tag{4}$$

The selection function $s$ is not yet fully characterized and remains an open area of research (see, e.g., Rieskamp & Otto, 2006; Marewski & Schooler, 2011; Todd & Brighton, 2016). But it is clearly not just a random selection mechanism. A variety of studies have demonstrated that people systematically make different decisions in different environments, and specifically because they are using different decision strategies. The heuristics-and-biases research program showed that people can be reliably made to use an ineffective heuristic (usually not precisely defined) in a particular environment designed to mislead them, and hence be "predictably irrational" (Ariely, 2008; see also the casino example of Bennis et al., 2012, mentioned earlier). In contrast, research on ecological rationality has shown that people typically use an appropriate effective heuristic in realistic settings, if they have experience with the problem or time to learn (Todd et al., 2012). One-reason decision mechanisms (including take-the-best) have been found to be used when people must pay for information (Newell, Weston, & Shanks, 2003), must search for information in memory (Bröder & Schiffer, 2003; Bröder, 2012), or are under time pressure (Rieskamp & Hoffrage, 1999), all situations in which it would be disadvantageous to search extensively for available information if a decision can be made sooner. Moreover, people are sensitive to the distribution of cues in an environment, switching appropriately between take-the-best and a rule that integrates several cues (weighted-additive decision mechanism) when they face a situation with cues of greatly differing versus mostly similar importance, respectively (Rieskamp & Otto, 2006). People can also adjust their heuristic selection based on other aspects of the environment structure: For example, when the validity of the recognition cue is high, the recognition heuristic is appropriate, but otherwise more information should be sought (see Pachur et al., 2012, for a review of results).

There is not only systematicity in the selection of heuristics in particular settings across individuals, there is also predictable variation between individuals. These individual differences in tool use could arise from differences in an individual's selection function $s$, differences in the contents of their adaptive toolbox $AT$, or both. There are some factors known to contribute to individual differences in heuristic use that are relatively stable over time. First, an individual's experience in a certain task environment affects his or her knowledge about the objects or alternatives in the environment, which in turn determines what heuristics can be used. For instance, one can use the recognition heuristic if some choice alternatives are recognized and some are unknown, or heuristics based on differential levels of familiarity or fluency if all items are recognized but nothing else is known about them, or one-reason heuristics such as take-the-best if more information is known about the alternatives (Marewski & Schooler, 2011). Second, individual experience can also enable one to learn which heuristic works best in a given situation. This can vary from limited experience over the course of hours (Rieskamp & Otto, 2006) to more extensive experience that enables an individual to become an expert in some domain. The latter can change the heuristics people use from novice strategies that incorporate many cues to expert strategies that incorporate just a few crucial cues, as in the example of novice and expert burglars described earlier (Garcia-Retamero & Dhami, 2009; see also Shanteau, 1992; Pachur & Marinello, 2013). And third, age alters the heuristics used, such that older adults may use simpler heuristics more often but still adjust their heuristic selection to the structure of the environment appropriately (Mata, Schooler, & Rieskamp, 2007).

Other individual differences in heuristic use are, so far, less predictable. Variation in the heuristics used by different individuals facing the same task environment is commonly observed in studies of decision strategies (e.g., Bröder, 2012), in part because any of multiple heuristics can often produce the same level of performance in particular tasks. Whether or not such use of different heuristics is stable in individuals if they are retested on the same tasks sometime in the future is not known; if this is stable, then further investigation of the reasons for these individual differences is called for.

## Integrating Ecological Rationality and Situation Research

Situation research (Rauthmann et al., 2015) contributes to social psychology's goal of predicting behavior based on Lewin's equation (Eq. 1) by using aspects of the person and of the environment as manifested in situations. Ecological rationality has a similar goal of predicting behavior through the interaction of the mind of the agent and the structure of his or her environment. But there are two major differences between these approaches. The first difference is in how the person is represented: The personality and social psychology model relies on personality traits measured in a variety of ways (often by self-reports), while the ecological rationality program begins with heuristics identified experimentally or by observation. A heuristic such as "trust your doctor" is an action program that tells one what to do, while a score on a personality trait such as "neuroticism" is a disposition which by itself does not specify an action but rather a general tendency for action. The second difference is in how the environment is represented: Some situation research classifies situations in terms of high-level dimensions derived from people's reports (e.g., Rauthmann et al., 2014), while ecological rationality focuses on information structures that are theoretically derived from analysis of the cues present in a given situation. In the rest of this section we consider these two differences in more detail, and discuss ways that the two approaches can be bridged.

Let us consider the first difference—personality trait versus heuristic—via the doctor-patient interaction in the section "Trust Your Doctor." In terms of modern interpretations of Lewin's equation (Eq. 1), a person could report being a patient in a doctor's office, which counts as that person's situation and hence environment $E$, and could be represented by personality scores on the Big Five as a person $P$. In contrast, the situation in the ecological rationality program is not the subjective report of a patient or person, but the relevant features in Equation 3 ($DM$, $CI$, $SI$) that influence the health outcome. Note that patients who are not health literate are not likely to be aware of these crucial features, and thus a self-report would not reveal them. Furthermore, the person is not represented as a set of personality features, but rather in terms of the decision heuristic he or she will employ in this situation. Given the different aspects of the person and environment that the ecological rationality and situation research approaches identify, can the two usefully be integrated?

Theory integration is psychology's most vital challenge to strengthen its theoretical foundation. Psychology today resembles the political map of Germany and Italy before 1870: mostly small und loosely related territories that occasionally battle but mainly ignore each other. In Walter Mischel's (2008) words, "Psychologists treat other people's theories like toothbrushes—no self-respecting person wants to use anyone else's." Psychology has mostly subscribed to Karl Popper's assumption that science progresses by successively eliminating theories until ideally only one survives. The program of theory integration, in contrast, tries to "connect the dots" between theories, creating a stronger theoretical network by bridging rather than by destroying (most of) them (see the special issues of the journal *Decision* devoted to this topic—Gigerenzer, 2017).

One way to go about creating an integrated situation theory from the ecological rationality and situation research approaches could be to detect an association between a personality trait and the preference for using certain heuristics. Bröder (2012) asked the question, do people who use the take-the-best heuristic have a particular personality? The authors had the hypothesis that people who relied on the simple heuristic would score higher in impulsivity and action orientation, while those who relied on more elaborative rules would score higher in achievement motive, self-efficacy, need for cognition, and rigidity. Yet none of the personality traits (nor others from the Big Five) showed a substantial correlation with the use of simple versus complex strategies. The authors later concluded that they may have been asking the wrong question (Bröder, 2012), and instead asked, do individual differences in personality or intelligence explain adaptive strategy use in different environments? And here they found the sought-for association: Cognitive ability (but not personality) was associated with adaptive strategy selection. They concluded that the smartest people used take-the-best in situations in which it is ecologically rational (i.e., in so-called noncompensatory environments where cues differ greatly in importance—see Martignon & Hoffrage, 2002): "Higher intelligence scores were related to greater use of an *appropriate* strategy, not to greater use of a particular strategy" (Bröder, 2012). This result is consistent with the finding described earlier that experts—professional burglars and policemen—who understand the situation and the relevant cues rely on take-the-best while novices do not. Whether there is a relation between aspects of personality (not just intelligence) and adaptive heuristic selection must be explored further. If so, then personality traits (including those on the Big Five, satisficing vs. maximizing, etc.) could be conceived as background dispositions that influence the choice of heuristics (and hence the selection strategy $s$ in Equation 4).

We now turn to the second main difference between the ecological rationality approach and the social psychology situation approaches to predicting behavior: the conception of the environment. As described throughout this chapter, ecological rationality begins its analysis of environment structure with the cues present in a particular decision setting. This is also the starting point for much situation research, with cues as the inputs to an individual's experience of a situation: "Situation cues... are physical or objective elements that comprise the environment. They can be objectively measured and quantified. Cues include (a) persons and interactions (Who?), (b) objects, events, and activities (What?), and (c) spatial location (Where?)" (Rauthmann et al., 2014, p. 679; see also Craik, 1981, for consideration of the physical cues present in situations and Rauthmann, 2016, for important extensions to the influence of *evolutionary motivations on cue importance*). From this common starting point, ecological rationality then focuses on the structure of environmental information present in those cues, including their distributions, correlations, redundancies, validities, and so on. Situation research in contrast often considers how those cues are processed into sets of situation characteristics or dimensions defining a psychological situation, such as those characterized via the Riverside Situational Q-Sort (RSQ) method (Rauthmann et al., 2014).

Prominent situation research approaches base the classification of situations on people's reports—for instance, an individual may report being in a situation such as "I was making lunch for my boyfriend" (in Rauthmann et al., 2014). In contrast, the situations relevant for ecological rationality are theoretically derived (although they could coincide with what people report), such as a situation of defensive decision making and conflicting interests often found in doctor-patient interactions, or the number of children and their spacing in the case of parental investment as described earlier. Most of the situations that people report being in do not explicitly mention decision making (e.g., they do not say "I was deciding what to make for lunch for my boyfriend")—perhaps because making a decision takes up much less time than carrying out the actions that were decided. On the face of it this may seem likely to hinder our ability to build an integrated situation theory incorporating ecological rationality through a mapping between situation dimensions and decision-relevant cues and statistical structures. However, it appears that many of the important features of reported situations do involve decision making—by a rough count, about 20% of the 89 RSQ items are decision relevant. Here we give just a few examples of how these situation items (and the dimensions built upon them) could map onto decision environment structure as studied in ecological rationality.

Some RSQ items indicate that greater or lesser amounts of information processing may be called for in the current decision environment, for example, "Rational thinking is called for" (RSQ item 25), "Affords an opportunity to demonstrate intellectual capacity" (RSQ 13), and "Situation is basically simple and clear-cut" (RSQ 76). Others indicate important environmental features that constrain decision processes such as time pressure: "Things are happening quickly" (RSQ 20). Still others reflect particular aspects of the statistical structure of information in the environment, such as "Minor details are important" (RSQ 11), which suggests that multiple cues have high validity (as opposed to a skewed distribution of cue validity or importance, as in the burglar example earlier), or "Someone else in this situation might be deceitful" (RSQ 38), which suggests that some of the prominent cues may be uninformative (e.g., have low validity). Additionally, some RSQ items may influence the selection mechanism *s*, such as "Social interaction is possible" (RSQ 56), which could enable the selection and use of copying heuristics. Further analyzing the RSQ items (and other measures of situation characteristics) could reveal more connections to decision-making environment structure. These could be used to construct a heuristic version of the Brunswikian lens model (Gigerenzer & Kurz, 2001), mapping distal environment cues onto proximal situation dimensions. Ecological rationality could then focus on the "causal texture" of the environment in terms of relations (and correlations) between the situation cues, how they can substitute for each other, and so on, while a new integrated situation theory could focus on the mapping from the proximal dimensions to subsequent behavior of individuals (with their own particular characteristics) in those situations.

Being able to describe decision situations more precisely in terms of their characteristics will help meet one of the goals of situation research and the RSQ method, namely quantifying "the degree of similarity or dissimilarity between any two situations across a wide range of psychological properties" (Sherman et al., 2010, p. 332). This is also an important concern for the study of ecological rationality, in terms of the robustness of particular heuristics to differences in environments and their underlying structures—simple heuristics are typically more robust than complex mechanisms across similar environments (Todd, Gigerenzer, & the ABC Research Group, 2012; Brighton & Gigerenzer, 2015; Todd & Brighton, 2016). The important aspects of similarity will be deeper than just the surface content of cues—different situations may have essentially the same underlying environment structure and so call for the same kinds of decision-making strategies, just applied to different cues. For example, the same kind of sequential search heuristic could be applied to both job search and mate search, even though their surface content is quite different. In ecological rationality studies, environment similarity has often been measured in terms of the distribution of cue validities or other statistical properties, which could be useful for an integrated situation theory; vice versa, ways of determining situation similarity with the RSQ and other new tools could enhance the predictions of heuristic robustness made by ecological rationality.

A final way to bring these two research streams into closer contact is to ask people to describe situations explicitly in terms of the decisions they are making (either via recall or experience sampling), and also about the strategies they consider using for making those decisions. Similarly, one could directly query people about aspects of the decision environment that define the ecological rationality of their heuristics—such as number and distribution of options and cues, time pressure, social pressure, and so on. This may also help expand the set of cue structures considered in ecological rationality research beyond the statistical to the social, such as the source of cues, trustworthiness of source, whether cues from different sources conflict or repeat the same information (and whether those sources are correlated or independent), and the psychological distance (temporal, spatial, social) of sources of cues from the decision maker.

## Conclusions

Social psychology has long been concerned with how situations and settings influence what people do, as shown in Lewin's early equation (Eq. 1) emphasizing the often ignored message that behavior is a function of both the person and its environment. More recently, approaches to classifying situations have been developed to show how different "active ingredients" (Sherman et al. 2010, p. 331) of situations interact with different personality aspects to produce behavior. From the perspective of decision-making research, though, standard approaches do not care much about situations—their logical strategies and optimizing procedures are expected to work wherever they apply. Ecological rationality takes a different approach, following Simon (1990) in focusing on how the mind and environment fit together to produce good decisions. When we substitute the concept of a logically consistent person by the more specific idea of an adaptive toolbox of decision heuristics fit to particular environmental settings (as we did in Eq. 2), this enables us to determine the relevant aspects of the situation that make decisions successful. Ecological rationality is thus a natural ally for the investigation of situations and their effects on decisions and behavior. It provides a precise way of analyzing and predicting behavior from environment structures and heuristics that has led to surprising findings, such as that less information and computation can be more effective, in predictable situations. In this chapter we have refrained from much of the statistical details and mathematical proofs that have emerged from this research program, but this can be found in Gigerenzer et al. (2011) and Todd et al. (2012). Further evidence of the usefulness of this approach can be seen in its real-world applications, from creating intuitive decision trees for high-stakes emergency unit decisions (e.g., Green & Mehr, 1997) to designing simple rules for a safer world of finance (Aikman et al., 2014) and developing geographic heuristics for profiling of serial offenders (Snook, Taylor, & Bennell, 2004).

Bringing situation (and personality) theory together with ecological rationality opens up an exciting opportunity for asking new questions. Can situations be described as patterns of cues that particular heuristics can exploit? Can personality be considered as a toolbox of components to be matched to the structure of particular situations? Could much of what has been interpreted as noise and inconsistency in individual behavior be explained by understanding the ecological rationality of strategies deployed in specific settings? After all, the consistent use of a heuristic can lead to systematic inconsistencies in observed behavior (Hertwig & Gigerenzer, 2011). And finally, how can situation (and personality) research profit from the study of the mind's adaptive toolbox, and vice versa? Integrating these theories will not only enable us to ask and answer striking questions such as these, but also lead to a stronger, more unified and interconnected, science of psychology.

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