Routledge
Taylor & Francis Group

Journal of Economic Methodology

ISSN: 1350-178X (Print) 1469-9427 (Online) Journal homepage: http://www.tandfonline.com/loi/rjec20

Two types of ecological rationality: or how to best combine psychology and economics

Erwin Dekker & Blaž Remic

To cite this article: Erwin Dekker & Blaž Remic (2018): Two types of ecological rationality: or how to best combine psychology and economics, Journal of Economic Methodology, DOI: 10.1080/1350178X.2018.1560486

To link to this article: https://doi.org/10.1080/1350178X.2018.1560486

© 2018 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

Published online: 25 Dec 2018.

Submit your article to this journal

Article views: 258

View Crossmark data

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=rjec20

JOURNAL OF ECONOMIC METHODOLOGY
https://doi.org/10.1080/1350178X.2018.1560486

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Two types of ecological rationality: or how to best combine psychology and economics

Erwin Dekker and Blaž Remic

Erasmus School of History, Culture & Communication, Rotterdam, Netherlands

ABSTRACT

This paper argues that the notion of 'ecological rationality' as used in (behavioral) economics has two rival meanings. The first type of ecological rationality (ER1) as used by Gerd Gigerenzer, refers to the use of cognitive strategies, heuristics in particular, in real-world decisions. The second type of ecological rationality (ER2) as used in the work of Vernon Smith, refers to the rationality of cognitive systems consisting of multiple individuals, institutions, and social norms. We demonstrate in this paper that their use originates in different psychological (or cognitive) approaches: Brunswikian functionalism and distributed cognition respectively. By uncovering the different psychological underpinnings, we are able to analyze the methodological differences between the two types of ecological rationality, the different ways in which central concepts are employed, and the differences in resulting experimental practices. We conclude with the implications for the various ways in which psychology and economics can be combined.

ARTICLE HISTORY
Received 25 April 2018
Accepted 14 December 2018

KEYWORDS
Ecological rationality; distributed cognition; behavioral economics; bounded rationality; Gerd Gigerenzer; Vernon Smith

JEL
Codes: B21; B41; D91

Introduction

Ecological rationality is a concept used by an increasing number of economists as an alternative to mainstream behavioral economics, in particular to the so-called heuristics-and-biases program rooted in the pioneering work of Kahneman and Tversky. The two main proponents of ecological rationality are Gerd Gigerenzer and Vernon Smith. Both Gigerenzer and Smith refer to each other's work repeatedly to suggest that they are talking about the same concept (Smith, 2003, p. 469; Gigerenzer 2015, pp. 115–116; Berg and Gigerenzer 2010, p. 149), and they both contributed to several of the each other's edited volumes (Gigerenzer and Selten 2001; Plott and Smith 2008). And both authors claim Herbert Simon as an important precursor to their work, although they put different weights on this claim (Smith 1991, p. 877; Gigerenzer and Todd 1999, p. 14). We would thus expect that 'ecological rationality' provides a coherent alternative to the 'heuristics-and-biases' (H&B) program and the associated idea of 'bounded rationality' (Kahneman 2003). And indeed Davis (2011) has argued that Smith *adopted* and *extended* Gigerenzer's ecological rationality.[1] This paper will, on the contrary, argue that the ecological rationality promoted by Gerd Gigerenzer is radically different from the ecological rationality proposed by Vernon Smith. In fact, it is safe to say that the meanings of ecological rationality diverge as much from each other as they do from the H&B program (the difference between ER and H&B is examined by Rich, 2016). This paper sets out to resolve this conceptual confusion by demonstrating the differences between the ecological

CONTACT Erwin Dekker e.dekker@eshcc.eur.nl Erasmus School of History, Culture & Communication, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands

© 2018 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (http://creativecommons.org/licenses/by-nc-nd/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

rationality of the Gerd Gigerenzer type (ER1) and ecological rationality of the Vernon Smith type (ER2). We will also argue that these differences can be best understood as resulting from two different ways of combining psychology and economics, which give rise to different conceptions of rationality and most importantly different experimental methodologies.

The resulting systematic analysis of ER1 and ER2 will also allow us to show different ways in which psychology can be employed in economics. This will undercut the simple claim that the H&B program represents the natural or best way to integrate the two disciplines (see also Hands 2010, p. 645).

Vernon Smith in his Nobel lecture describes ecological rationality as 'an un-designed ecological system that emerges out of cultural and biological evolutionary processes: home grown principles of action, norms, traditions, and "morality"' (Smith 2003, pp. 469–470). Gerd Gigerenzer argues that 'ecological rationality refers to the study of how cognitive strategies exploit the representation and structure of information in the environment to make reasonable judgments and decisions' (Gigerenzer 2000, p. 57). From these two statements, it should be fairly clear that they are talking about quite different research programs, which not only differ in what they study – Gigerenzer mostly cognitive strategies (heuristics), Smith mostly institutional environments – but also in what they seek to explain. Gigerenzer is much closer to psychology and modern decision sciences (including the H&B program), which attempt to explain individual choices and decisions, whereas Smith is primarily interested in social systems and processes of social interaction. For Gigerenzer, the central puzzle is how individuals manage to achieve their tasks given their limited cognitive abilities. For Vernon Smith, the central puzzle is much closer to that of the other Smith, Adam – how can socially beneficial results emerge from actions which are self-centered and based on limited knowledge.

That being said, they share a common rival research program: the H&B program (see Grüne-Yanoff, Marchionni, & Moscati, 2014). This might explain why they have sometimes presented themselves as allies, but we will demonstrate it is an unholy alliance. H&B has become widely accepted as the standard way of integrating psychology and economics (Angner 2018). The H&B program presents itself as a serious challenge to the neoclassical picture of the rational economic man, and argues that a serious reconsideration of rationality is necessary, since individuals are only boundedly rational (Tversky and Kahneman 1974; Kahneman 2003; Camerer, Loewenstein, and Rabin 2004; Mullainathan and Thaler 2000). The proponents of ecological rationality do not seek to challenge this claim of bounded rationality. They fully accept it – in fact, they sometimes go even further in emphasizing the cognitive limitations of individuals. However, they argue that in the interaction with their (social) environment individuals are nonetheless able to make reasonably good, or as good as rational, decisions, because they are able to use the environment to their advantage through cues or institutional features of that environment.

This paper will proceed as follows. In the first section, we provide a broad outline of the different notions of ecological rationality as understood by Gigerenzer and Vernon Smith. In what follows we will focus our attention on these two prominent authors, with occasional reference to their co-authors, since the work of Gigerenzer and Smith provides the clearest contrast between the two types of ER. This has the virtue of making the conceptual contrast clear, but does not imply that there could be no convergence or attempts to bridge between them (i.e. Petracca, 2017). In the second and third section, we will analyze the different psychological theories that lie behind the two types of ecological rationality, we will occasionally contrast this with the cognitivist psychology that underpins the H&B program. In section four we will then provide an analytical overview of the differences between the notions of ecological rationality – the different conceptualizations of the cognitive abilities of the individual and the structure of the environment – as employed in the two accounts.

1. Delineating two types of ecological rationality

To understand the differences between the two types of ecological rationality it is important to understand that they represent different marriages of psychology or cognitive science and

economics.[2] For Gigerenzer's program, this is fairly clear, as he acknowledges the importance of Brunswik and Simon for his work. For Vernon Smith matters are less clear, since thus far the dominant view has been that he tries to keep psychology out of economics. Don Ross (2014b) recently put forward that Vernon Smith's theoretical account is virtually devoid of psychology apart from allowing that the latent individual cognitive processes may be included in the choices individuals make. Similarly, Davis (2011) argues that while Smith's view is that 'interaction between individuals somehow produces or reinforces individuality' by the discovery of preferences through processes of trial-and-error learning and adaptation, his abstract conceptions of socioeconomic institutions make it 'hard to see how they could be associated with any particular conception of the individual' (Davis 2011, p. 154), and consequently, to connect it with a psychological theory. And finally, our argument is at odds with Gul and Pesendorfer (2010), who have argued for a 'mindless economics' and whose perspective is sometimes associated with that of the experimental tradition of Vernon Smith and Charles Plott (Ross 2014a, p. 200). We demonstrate below that the underlying account based on interaction, learning, and adaptation is itself a distinct psychological perspective.

Let us start with ER1 as conceptualized by Gigerenzer. He defines ecological rationality as: 'the study of how cognitive strategies exploit the representation and structure of information in the environment to make reasonable judgments and decisions' (Gigerenzer 2000, p. 57). His focus is not on the individual and his cognitive capacities, which is the central concern in cognitivist psychology and the H&B program, nor on the underlying cognitive structure of the environment central in Smith's work. Rather, it is on the heuristics which operate as an intermediary between the individual and the natural environment. It is tempting to think of heuristics as capturing the cognitive structure of the environment, but as Gigerenzer recently reaffirmed, ecological rationality 'means functionality, not veridicality' (Chater et al. 2018, p. 800). As a consequence, heuristics should be thought of as tools to function in the environment, not parts of the environment. To achieve such functioning, the individual relies on *strategies,* which range from relying on emotions, categorizations, and recognition, to the use of adaptive heuristics. And the latter especially are studied in the fast-and-frugal-heuristics program (Gigerenzer and Todd 1999). But whereas in the H&B program the idea is that heuristics lead to systematic underperformance (as compared to some idealized rationality), Gigerenzer argues that these heuristics are at the very heart of how individuals perform successfully.

Heuristics exploit structures in the environment to facilitate choices in real-world situations. The importance of this real-world aspect is repeatedly stressed by Gigerenzer, and it is reflected in the type of tasks which his subjects are asked to perform: predict the winner of Wimbledon, recognize the names of cities in Switzerland, or predict the outcomes of elections (all mentioned in Gigerenzer & Goldstein, 2011). In these examples, Gigerenzer makes it clear that individuals rely on simple heuristics: who is the first tennis player that comes to mind, what is the most famous city in Germany, or which brand do I recognize. That is, they make smart use of the information they already have in order to make (logically) unwarranted inferences. These nonetheless often prove to work well and, as Gigerenzer likes to stress, frequently even better than more sophisticated cognitive strategies.

The cognitive abilities of the actor receive little attention in Gigerenzer's research program. He has no interest in developing a full picture of the human mind and its internal working, something which is far more prominent in the H&B program, as evidenced by Kahneman's discussion of System I and System II thinking (Kahneman and Frederick 2002). In Kahneman's theory biases result from cognitive structures in the human brain, in Gigerenzer's work they stem from the flawed use of heuristics. Consequently, we find Gigerenzer and others working in this tradition studying messy real-world environments, not the clean laboratory settings which characterize the H&B program. The structure of task environments is conceptualized as a natural environment that contains informational cues that allow individuals to use their heuristics. In the examples above these are formed by the everyday experiential knowledge of individuals and the way in which the environment is structured: what is central or focal?

At this point, we are ready to contrast the notion of ER1 with ER2 as defined by Vernon Smith. He defines ecological rationality as 'an un-designed ecological system that emerges out of cultural and

biological evolutionary processes: home grown principles of action, norms, traditions, and "morality"' (Smith 2003). This is somewhat puzzling, since ecological rationality is defined as a property of the system, rather than a set of strategies or a field of study as in Gigerenzer's definition. Smith proposes to clarify matters with a contrast between *ecological* rationality and *constructivist* rationality. He argues that this distinction is a reformulation of Simon's distinction between *objective* and *subjective* rationality, the former meaning rationality from the experimenter's point of view, and the latter rationality 'given the perceptual and evaluational premises of the subject' (Simon 1956, p. 271).[3] Hence, he argues that ecological rationality simply develops subjective rationality as Simon defined it (Smith 2008, pp. 39–40, 176–177).

However, that hardly gets at the difference between Smith and Gigerenzer, since both might equally argue that their interest is not in optimal decisions, but rather in the strategies of the subject. What is more, in the H&B program the Simonian distinction is equally useful to distinguish between the behavioral prescription of rational choice theory and the biases that determine the actual choices of subjects. Therefore, we have to dig a little deeper. The first experiment that Vernon Smith performed was a classroom experiment in which subjects were free to talk and walk around. Its purpose was not to test a particular response to a choice setting but to observe exchange behavior as participants learn from experience. While the subjects were given particular behavioral constraints about minimal selling prices and maximum buying prices, they were apart from these restrictions left free to do what they desired. The focus was on the exchange process and learning within the constraints by using these constraints to one's advantage (Smith 1962). In later experiments, the institutional market setting was refined and varied, but the basic idea remained the same: the design of experiments resembled particular market settings. The outcome Vernon Smith was interested in was not individual choices, but instead emergent market prices, suggesting that for him the interesting feature was the way in which institutional settings influence behavioral outcomes and learning (Smith 1967). What emerges is rational because there is a convergence to price level predicted by neoclassical market theory, not because every individual makes a rational choice. This puts him at odds with the H&B tradition, although both perform lab experiments (Smith, 2008, Chapter 7; see also Svorenčík, 2016).

Smith, therefore, had a very different notion of the relevant environment, which had to match some stylized market institution, rather than a particular choice situation. The subjects in the experiment were performing a semi-open task, such as trading. This semi-open task was facilitated by the task-environment, which was nonetheless closer to an economic-model situation than a real-world task. Smith, too, is interested in the extent to which market participants are capable of performing these tasks, but more importantly, he wanted to test under what institutional conditions the predictions about equilibrium prices held. When he limited the amount of information provided to the experimental subjects, it was not to purify the experiment, but instead to see if with this more limited information prices still converged to a predicted equilibrium-level. And when he varied the environment in other ways, it was to test how robust the outcome of price convergence was to changes in the environment. Vernon Smith accepted that individuals had limited capabilities, but was interested to see when the institutional environment would still lead to rational outcomes on the market level (Smith 2008).

This means that Vernon Smith thinks of ecological rationality as rationality that results from the interaction of individuals under different institutional settings, moral norms, and conventions. It is a property of the institutional setting, the system, rather than of individual choices. Like Gigerenzer, he is little interested in the cognitive structure of the human brain, but unlike him, he is more interested in the rules that are part of the environment. And, unlike Gigerenzer, Smith believes that the (experimental) environment has to be varied to investigate the consequences of different institutions and norms. This means that he is not restricted to 'real-world settings', and – more importantly – that he does not highlight 'informational cues' as essential to the structure of the environment, but instead focuses on a variety of stylized settings and the 'institutional rules and norms', which make up the structure of the environment.

We have now arrived at the point where we know enough about the two different approaches to ecological rationality that we can explore their psychological underpinnings. In section four we will then return more systematically to the differences between the two approaches.

2. Gigerenzer and Brunswik

While important references to Simon's bounded rationality feature prominently in Gigerenzer's approach, there is an even more important influence from Egon Brunswik. Gigerenzer himself constantly refers to and praises Brunswik's work in his writings, he nevertheless seems to suggest that the influence does not go much beyond the level of inspiration, except for Brunswik's idea on probability which he discusses at length (Gigerenzer and Todd 1999; Gigerenzer 2000). However, in this section, we demonstrate that, on the contrary, the approach of Gigerenzer is thoroughly Brunswikian. So much so, that we can hardly make sense of the program if we do not understand the underlying functionalist psychology of Brunswik.

Before we discuss Brunswik's particular approach it is worth briefly revisiting the difference between cognitivist and functionalist psychology. Functionalism is primarily associated with the American pragmatists: William James and John Dewey. It is less interested in the structure of the mind and more in its capabilities, how well it functions in its environment (Levin 2016). Functionalism's main explanatory purpose is adaptive behavior as expressed in action. As such, it occupies a position between behaviorism, which neglects cognitive psychology altogether, and cognitivism, which seeks to study the structure of the mind. This focus on the structure of the mind within cognitivism includes both conscious and non-conscious forms of reasoning. One might say that Gigerenzer, as far as he is interested in cognition, emphasizes the non-conscious forms.

The contrast between functionalism and cognitivism is drawn well by Brunswik[4] when he states: 'Both historically and systematically psychology has forgotten that it is a science of organism-environment relationships, and has become a science of the organism' (Brunswik 2001, pp. 300–301).[5] He seeks to resolve this by his own brand of functionalist psychology, which he dubs 'probabilistic functionalism', which brings together (1) his view that perception of environmental cues by the observer is probabilistic in nature, and (2) functionalism's emphasis on achievement – getting the task done. Brunswik's work builds on the smaller European strand of functionalism based on the notion that 'any given stimulus … will be perceived differently when placed against a different contextual background' (Leary 1987, p. 118). The classic example would be the difference between a wink and a blink, which as stimuli might be identical, but have nevertheless a radically different meaning. In such case, the challenge for the subject is to act correctly on the cues present in the environment.

In the following, we will address what we identify as four central topics in Brunswik's theory, and elaborate how they each map onto the approach of Gigerenzer's research program. Those topics are (1) *achievement* – as opposed to knowing – as the key goal for the individual, (2) the *environment as a probabilistic texture of cues*, (3) the central place for *perception,* and (4) the critique of the standard *experimental design*.

1. Achievement. In Brunswik's view, the key problem of psychology is not that of knowing, but rather that of the adjustment of the organism to a complex environment. The primary goal of the study is to understand how the subject achieves her task, rather than whether she understands it. This difference becomes clear when we think about a simple everyday task, such as climbing the stairs. For Brunswik, the important criterion is whether we manage to climb the stairs, not whether we 'know' how to climb the stairs. The cognitive problem thus extends beyond what the mind knows, and should include the full scope of achievement problems (Brunswik 2001, pp. 300–312). This is also of crucial importance for economics, since if the emphasis is on achievement it might turn out that there are multiple ways to achieve a particular task. Cognition is one means toward achievement, but achievement can also be reached by making use of cues within the environment. The study of these different strategies became the focus of Brunswik's scientific efforts. As we saw, the most important of such strategies that Gigerenzer develops is the use of heuristics. The very

characterization of heuristics as 'fast and frugal' tools for decision making implies that the goal is not any form of certainty or perfect knowledge, but simply a satisfactory level of correspondence of the inferences to the real-world problem. Therefore, it is *functioning* – and not *knowing* – that is essential to Brunswik's and Gigerenzer's accounts of human decision-making.

2. *The environment as a probabilistic texture of cues*. Brunswik has a peculiar way of thinking about the environment. Firstly, it is important to realize that he thinks strongly in terms of natural environments, rather than social or institutional environments. Secondly, in Brunswik's terminology cues function *vicariously,* meaning that they derive their usefulness from their relations and inter-substitutability with other cues in the environment. This is well illustrated by Brunswik's experiment where he had the subject followed around the campus by an assistant who asked the subject to estimate sizes of various objects (Brunswik 2001, pp. 68–105). The results thus obtained demonstrated that we are much better at inferring size of objects than the results of the lab experiments that isolate objects from their environments would have us believe. The height of a building was not just estimated based on the number of stories it had, but also whether it was big compared to nearby trees and other buildings. For Brunswik this means that cues should not be isolated from their environment. Brunswik refers to this as the texturedness of environments (Brunswik 2001, pp. 17–35). A final element of this theory of cues is that they might be somewhat incoherent, and thus redundancy plays an important role. When asked to estimate the weight of an object we have to weigh several cues against one another: it looks big, but feels light. Exactly which cue gets utilized for inference will remain to a large extent uncertain. Thus, environments rich in cues providing an excess of information will enable more accurate inference. This leads him to propose that the perception of the environmental texture of cues is probabilistic in nature, a point that is of great importance for Gigerenzer.

One might think that the emphasis on the probabilistic environment also means that Gigerenzer would be heavily interested in artificial environments, and indeed much of his other research deals with the foundation of statistics. Nonetheless, his interest regarding ecological rationality is predominately about real-world environments and representation. A good example is his paper on whether children can solve Bayesian problems, which varies the way in which frequencies are presented to children (Zhu and Gigerenzer 2006). His paper on the recognition heuristic formulates the heuristic as an abstract decision rule, but argues that recognition itself is based on personal memory and recognition of a person's natural environment '*before* entering the laboratory' (Gigerenzer and Goldstein 2011, p. 101).

Brunswik's theory also diverges in one sense from that of Gigerenzer. Whereas Brunswik focused much of his efforts on a theory of perception of the environment, Gigerenzer thinks that heuristics *mediate* between the individual and the environment.[6] But, as in the work of Brunswik, we find in Gigerenzer's approach the study of the utilization of environmental cues to be the prime factor in successful decision making. And in his critique of the conjunction fallacy, the so-called 'Linda-problem', Gigerenzer relies on the probabilistic texture of cues (Hertwig and Gigerenzer 1999).

3. *Perception is key*. In order to address the problem of the inability to provide a full causal account of cognitive achievement, Brunswik distinguishes between two cognitive processes: intuitive perception and analytical reasoning, which are fit for tasks that require estimation with some degree of uncertainty and certainty, respectively. In an experiment meant to illustrate this point, Brunswik assigned half of the respondents to infer the size of a pole 'intuitively', and the other half by triangulating (Brunswik 2001, pp. 260–271). While the former resulted in the normal distribution of error (nobody being excessively off the mark), the latter resulted in half of the group being precise with the other half being *very* wrong. In his words, this demonstrated 'one of the pitfalls of reasoning, namely, the going off in the wrong direction by being right about something else' (Brunswik 2001, p. 261). Thus, Brunswik concludes that what more successfully guides behavior is 'intuitive' perception, not reasoning and thinking. The emphasis on intuition should not be overdrawn, it is really perception based on cues that does the work. A book title like Gigerenzer's *Gut Feelings* (2007) also

suggests that intuition is central, but for Gigerenzer, too, it is the process of perception of cues in the environment that matters, not pure intuition.

This view maps almost perfectly to Gigerenzer's notion of *variance-bias trade-off,* which implies that heuristic reasoning can indeed be biased, but will also be characterized by the low variance of results, thus providing more robust and homogenous outcomes. As such, in contrast to the data-hungry complex models that decrease bias at the expense of increased variance, it might even result in a lower total error – a phenomenon he calls the *less-is-more effect* (Gigerenzer and Gaissmaier 2011).

4. *Representative design of experiments.* As will be clear by now, Brunswik was a proponent of experiments in real-world settings. Human perception functions best when it can rely on a variety of cues, rather than in a clean experimental set-up. Furthermore, in order for the experiment to be valid, he introduced an additional requirement: not only the sample of the participants has to be representative (as is usual in experimental social sciences), but also the *conditions themselves.* This did not mean a variety of lab experiments, but instead a variety of real-world environments, since in each different situation the availability of cues will be different. Gibson (1950), who started along Brunswikian lines and later developed his highly influential *ecological psychology,* has argued that, in order to account for the fact that 'there is literally no such thing as a perception of space without the perception of a continuous background surface' (p. 6), experiments need to be performed 'outdoors' and not in the context-less lab. After all, as Hogarth (2005) points out, abstract experimental tasks test the only abstract theory, while the more important step should be to test the theory in the situations that are representative of the real economy. This is well reflected in Gigerenzer's work on the recognition heuristic (Gigerenzer and Goldstein 2011).

To put it in terms of ecological rationality, the individual acts ecologically rational to the extent that she uses the right heuristics adapted to various real-world environments. If we want to test organismic achievement in reading environmental cues, conditions must mimic those of the environments in which the organisms typically operate. Brunswik was a fierce critic of the clinical design of psychological experiments, because they either remove or radically simplify the environment in terms of cues provided.

The most striking contrast between the H&B experiments that are often based on game-theoretic and choice-theoretic situations, and the 'dirty' ER1 experiments, is their approach to experimental design. But now that we understand the underlying functionalist psychology of Brunswik, we are able to better understand the rationale for Gigerenzer's focus on real-world tasks rather than abstract choice-situations. For him, the functioning of heuristics is always dependent on particular choice environments. For this reason, the tasks in the experiments are so specific: name the capital of Germany; catch a ball; which has more cholesterol cake or pie? (Gigerenzer 2008).

There is, however, one curious aspect which is shared by the program of Brunswik and Gigerenzer, and which makes it (somewhat) less suited for the social sciences. They both think of the environment in mostly naturalist terms. Their theories largely avoid the problems of symbolic processing, and hence efforts by humans to make the world more (easily) navigable are left out of the picture they paint. It is one thing to infer the size of a building, but quite another to strategize about the prices of copper, or trust a stranger to deliver what promised. It is those type of issues that are central in ER2.

3. Vernon Smith and distributed cognition

In contrast to both cognitivism and functionalism, Vernon Smith focuses on properties of the system rather than the cognitive capabilities of the individual or her achievements. Therefore, he is interested in more open-ended problems, where the outcome emerges out of interactions of individuals and their (institutional) environment. By an institutional environment, Smith means typically a market-setting in a laboratory. He does not study different actual market-settings; instead, he is changing

the institutional rules within the laboratory market to allow for different types of interaction – to allow for resales, for example. Therefore, it is tempting to believe that psychology plays no significant role in Smith's account, and that he simply builds on a longer tradition in economics which has shunned psychology altogether. As such, we might be tempted to categorize Smith's work as what Gul and Pesendorfer (2010) have described as 'mindless economics'. Although later in his career Vernon Smith does call for a fitting psychological account for his program he has not developed anything substantial in that direction (Smith 1991, p. 880). Ross (2014b) has suggested that the approach of Vernon Smith and other market experimenters allows for psychological factors to be *included in,* rather than *identified with* (as, for example, in H&B approach), the processes that generate choice data. But for Ross, too, it remains a desideratum, not a developed program.

We argue that the research program of Vernon Smith is, on the contrary, highly compatible with an existing approach in psychology called 'distributed cognition', and hence not at all mindless or anti-psychological. This psychological underpinning is not only relevant for the theory to provide a complete alternative to both the H&B and ER1 programs, but also for us to provide a full understanding of 'ecological rationality' in the sense that Smith uses the term. Distributed cognition is a more recent approach that developed as a critique of cognitivism and the associated focus on the study of the individual mind. It challenges, somewhat similar to functionalism, the idea that human cognition can be separated from the environment in which it is situated (Hutchins 1995). But it goes a step further and emphasizes not the structure of the individual mind, but rather the cognitive properties of the interaction of the individual and the environment. This might still sound rather abstract, but those familiar with Hayek's views on the working of the price system will quickly recognize that in his account prices are an essential part of the cognitive system that allows rational action to take place (Hayek 1937, 1945). As such, Hayek's work is a precursor to this type of thinking about cognitive properties, and can be usefully reinterpreted in the context of distributed cognition.

Distributed cognition is associated with a number of related approaches called 'situated', 'embodied', or 'grounded' cognition (Barsalou 2008; Anderson 2003; Robbins and Aydede 2009) where the common trait can be found in the emphasis on the contextual and interactionist understanding of the mind in its environment. Wilson's (2002) review article provides an excellent introduction to the developing field and the outstanding issues that researchers are grappling with, and it is not our intention to arbitrate between the various approaches here. What crucially differentiates distributed cognition from functionalism is its focus is on the *system*, rather than the individual (Rogers 2006). So, when the system selects or rewards a particular type of behavior, we can also say the system has certain cognitive properties that differ from the cognitive properties of its elements (Menary 2006). In the following, we will address some key points of the distributed cognition approach that will enable us to show why it fits so well as a psychological account of Vernon Smith's theory.

1. *Situatedness, distribution, and interaction.* In the distributionist approach, the situated nature of activity is the starting point. Although not quite as pragmatic as the functionalist approach, and hence less interested in 'mere achievement', the emphasis here, too, is on the fact that cognition is always related to particular tasks, material environments, and institutional settings (Osbeck and Nersessian 2014, 89 ff.). But this approach is far less individualistic and highlights the distributed nature of the cognitive processes, where new cognitive properties emerge from the interaction among the elements of the system (Hutchins 2014; Hollan, Hutchins, and Kirsh 2000).[7] This interaction can take the form of learning, usage of tools, imitation of others, or responding to incentives. Hutchins' (1995) seminal example is the study of the navigation of a large ship, where many individuals perform separate tasks and use specific tools without direct central control. Together they are involved in the joint cognitive process of navigating the ship that is more than the sum of those individual contributions.

It is clear that the market experiments of Vernon Smith allow for interaction with others where learning takes place, such as in the repeated trading games. But even within one trading round, the market experiments provide information to the subjects: is my offer rejected or accepted? Is

the price I am asking too high? At what price have other exchanges taken place? In Smith's own words, his work studies the 'interactive *experience* in social and economic institutions' (Smith 1991, p. 878). In doing so he is constructing an experimental account of the utilization of the Hayekian socially distributed knowledge. The experimental setting is so designed that it replicates essential institutional features of the market economy, but not the complete causal texture that Brunswik and Gigerenzer are interested in (Smith 1994).

2. *Off-loading and cognitive scaffolding*. Where the first point emphasizes social interaction between people, and interaction between people and their environments, the distributed cognition approach also emphasizes the cognitive properties of the environment. To describe this, they argue that individuals 'off-load' cognition to the environment by using and modifying the environment (Hollan, Hutchins, and Kirsh 2000). This alters fundamentally how we think of cognition, since there is no longer a single (internal) representation. Instead, the distributed cognition approach starts from the idea that the environment itself is a cognitive structure that has been shaped by previous interpretations and interventions. In the literature, these are called *external representations* (Zhang, 1991). Streets have names, houses numbers, and cars are equipped with navigational systems. These external representations are themselves part of interpretive structures, sometimes overlapping, sometimes at odds with one another. The individual 'plugs in' to this cognitive system when he is able to 'read' these external representations. But the individual also contributes to these cognitive structures by numbering his house, for example. The focus is thus not on internal representations, but rather on the cognitive structures of social systems. Rather than being just an external memory aid, external representations are the central feature of the cognitive system (Kirsh 2010).

The way to think about this is to think not about individual trades, or individuals maximizing their utility, but rather to think about 'the price system'. Hayek has argued that we can use prices as shorthand for the availability of a particular resource. An increase in the price is a signal that it has become more scarce, yet we do not need to know the cause of it, or all the uses and different markets in which the resource is used more generally. Hayek turns this into a more general point about the cognitive structure of the environment: 'We make constant use of formulas, symbols and rules whose meaning we do not understand and through the use of which we avail ourselves of the assistance of knowledge which individually we do not possess' (Hayek 1945, p. 528).[8] This system is the cognitive structure of the environment, and individuals merely plug in and rely on the system. In Vernon Smith's work, we see a similar emphasis on 'the price system' rather than individual actions (Smith 2015; see also Plott 2001).

In a somewhat extreme form, this view has also been labeled 'the extended mind hypothesis', where the crucial emphasis is precisely on seeing the coupling of the individual and the external artifact as a new cognitive entity in its own right (Clark and Chalmers 1998). Vernon Smith certainly does not completely abandon an individualist methodology, but does recognize the cognitive properties of the environment. John Davis has suggested that a 'distributive cognition' view might entail a more serious revision of individualism in economics. He argues that a genuine distributionist perspective entails we can no longer stick to a notion of independent individuals (Davis 2016, p. 28, see also Davis 2010). This would mean that the internalist-externalist distinction would dissolve and that we would instead study distributed socio-cognitive structures consisting of multiple interrelated individuals and a cognitively rich environment (see also Davis 2010). We recognize the importance of these implications, but in this paper, we will not explore such a distributionist perspective further since it does not fit Vernon Smith's notion of ecological rationality. It is, however, worth noting that such an attempt has been undertaken by Bardone (2011; see also Petracca 2017).

Ross (2014b) has highlighted a similar insight by evoking the notion of 'cognitive scaffolding' from the cognitive philosopher Andy Clark (see also Davis 2010). Cognitive scaffolding is the process by which human beings use and transform their environment to their cognitive needs. We thus develop ways in which to navigate our environment, say a particular path through the grocery store to avoid missing essentials and to not overspend, or we transform our environment to make

it more navigable, say through the use of signs at an airport. This is a far cry from the naturalistic way of thinking about the environment in the work of Brunswik and Gigerenzer, but it has interesting parallels to the concept of 'choice architecture' in the H&B program.[9]

3. *Environmental pressures.* In her overview article on situated and other related types of cognition, Wilson (2002) emphasizes the importance of time pressure for shaping cognition, but we can make the point somewhat more general here: environments exert pressure. Tasks have to be performed and decisions cannot be postponed forever, so the resources to make decisions and to perform tasks are limited. As Wilson puts it succinctly: 'When situations demand fast and continuously evolving responses, there may simply not be time to build up a full-blown mental model of the environment, from which to derive a plan of action' (Wilson 2002, p. 628). Distributed cognition provides an answer to this in terms of redundancy of the capabilities of the elements in the cognitive system (Rogers and Ellis 1994, p. 123). When navigating a ship, people performing particular tasks have knowledge also of some of the others, and this redundancy is crucial for the functioning of the system and thus the emergence of the larger-scale cognitive capacities (Hutchins 1995).

That is, so to say, one side of the coin. The other side is that environments select for certain types of behavior. The extent to which they do so is a contested issue in economics. If one takes this perspective to its extreme the environment contains the rationality, and that is indeed what some economists have suggested. Famous are the experiments by Gode and Sunder (1993) which simulate a market in which the only market rationality required of agents – or achievable for their simulated 'zero-intelligence traders' – is that they not bid beyond their budget constraints. They explicitly suggest that the institutional structure of markets is a *substitute* for individual rationality. That argument has origins in work by Chicago economist Alchian who argued that 'there may have been no motivated individual adapting but, instead, only environmental adopting' (Alchian 1950, p. 214). In fact, Vernon Smith was criticized by others that the way his initial experiments were set-up was so institutionally constrained that convergence to the equilibrium price was inevitable.

In psychology, this is matched by those who argue that the environment does all the cognitive work, and in terms of the methodology it leads to a pure form of behaviorism (Norman 2002). Vernon Smith sometimes comes quite close to adopting a view of rationality that places it entirely in the environment. In a particularly strong statement to this effect, he states: 'The current manager does not know about opportunity cost or even why the policy is what it is; only that he learned it from the last manager. He is an instrument of the "law" of one price in a market' (Smith 1991, p. 892).

The tension between the rationality of the individual and the rationality of the environment fact runs even deeper, since in the scaffolding view above, the individual becomes rational through the use of the environment, and rationality is thus to be located on the level of the individual. In the environmental pressure view, on the other hand, rationality emerges in the aggregate; in markets, for example, through the forces of competition. Vernon Smith seems to toggle between these two notions. On the one hand, he suggests that individuals learn to make rational decisions by relying on human institutions and practices. But he also emphasizes that reason is a limited guide, and that the process of evolution is necessary 'to serve the process of selection' (Smith 2008, p. 38).

The two views need not be mutually exclusive, and might, in fact, be reconciled or complement one another. Smith recognizes that there is more mediation between the environment and the individual than a selection-only view suggests. This provides scope for the study of the interaction between the individual and the environment that is central to the distributed cognition perspective. The environment is thus important for two reasons: for its cognitive properties (the feedback it provides) and for the selection pressures it exerts. This means that this approach will be less voluntaristic than both the Brunswikian and the H&B approaches – the individual is more constrained by the situation, and acts 'in accordance' with the situation. Consequently, this type of psychology aligns more easily with institutional economics than with accounts derived from rational-actor models.

In this section, we have demonstrated how central aspects of the distributed cognition approach in psychology map to the market experimental approach of Vernon Smith and others. In particular,

the focus on the joint system of individuals and the environment, rather than the individual in relation to her environment, distinguishes this approach from those of Brunswik and of cognitivism.

4. Different combinations of economics and psychology

We are now in a position to put the different combinations of psychology and economics together. We have provided a conceptual overview in Table 1, in which we have contrasted the two approaches discussed with the H&B program. The overview and our analysis so far should have made it clear that the question whether economics needs psychology is rather misguided. Instead, we should ask what type of psychology should be combined with economic analysis. Just like economics is characterized by different approaches, this is true in psychology as well. As a consequence, we should gain a better understanding of the different approaches in psychology, and how to best set up a conversation between economics and psychology, instead of mindlessly adopting a particular type of psychology. For this paper, it is of crucial importance to see that the concept of 'ecological rationality', which has been suggested as an alternative to the H&B program, is a result of two different combinations of psychology and economics. And hence, it gives rise to two fundamentally different understandings of the term.

Gigerenzer's use of ecological rationality stems from a functionalist tradition, which although critical of cognitivism accepts the latter's methodological focus on the choices and acts of individuals. This means that, like cognitivists, we end up with an individualistic perspective on human cognition, although that of Gigerenzer is far more focused on the ability to perform specific tasks than on the cognitive ability to make more abstract decisions. Vernon Smith's idea of ecological rationality is a radical departure from this perspective since it does not locate rationality in the individual mind, but rather conceives of it as a property of a system: a combination of individuals and environment. Contrary to Davis (2011) who interprets Smith's account in terms of institutional environments enabling individuals to be ecologically rational, we can say that particular market outcomes are rational despite the fact that individual choices are not. Since there is an opportunity for learning, imitation and there are feedback mechanisms in the system individual errors are corrected.

What Gigerenzer is particularly interested in is how individuals use heuristics to perform specific tasks in what he calls the natural environment. As he states, ecological rationality is the ability 'to exploit the structure of the information in natural environments' (Gigerenzer and Todd 1999, p. 24). This means that he is less interested in social tasks, although he occasionally touches on them, and has very little to say about the transformation of environments by humans, or what we might call the cultural, that is non-natural, part of the environment. The heuristics that humans use have evolved in natural environments and hence rely on cues in natural environments, but this does not mean that the heuristics themselves can be regarded as 'cultural'. As far as the recognition heuristic relies on cultural aspects of the experienced environment, those cultural aspects are treated as 'natural' parts of the environment.

That is different for Vernon Smith, whose approach is far less focused on the natural environment and more on the (constructed) institutional environment. So, when he discusses the challenges of psychology to economics, he emphasizes that risk-preference is dependent on the institutional

Table 1. Three combinations of Economics & Psychology.

	Distributed cognition & Smith	Brunswikian functionalism & Gigerenzer	Cognitivism & 'heuristics-and-biases'
Level of analysis	Systems	Individual choices and tasks	Individuals choices
Cognitive Problem	Rationality of the system	Achievement	Knowing
Guiding behavior	Rule-following	Perception	Reasoning
Normative Benchmark	Competitive market outcomes	Good Enough/Better than	RCT
Type of Environment	Institutional context	Real-world Complexity	Information patterns
Guiding Metaphor	Interaction & emergence	Fast & Frugal Heuristics	Cognitive biases

context, so that it will differ depending on different economic settings; and that some psychological effects, such as the 'endowment effect', tend to disappear when the institutional pressure is sufficiently strong (Plott and Smith 2008). But most importantly, Vernon Smith does not try to locate the rationality on the level of the individual. His early classroom experiments tested the convergence of the observed prices in his experiment to the predicted market equilibrium price, and rationality was the outcome of a process of interactions in a system guided by certain rules, not a property of the acts of the individual. For him, rationality is to be found at the level of the system, like it is for the modern theorists of distributed cognition.

Just like in a democracy we do not think it is important that everybody holds the same or the right view, but that through discussion and deliberation we will reach a well-informed decision at the collective level, so Vernon Smith argues that rationality emerges as a property of systems (Smith 2008). As much should be clear from his definition of ecological rationality, which talks of 'the system', but our analysis of distributed cognition makes us better able to understand what that means. On the contrary, for Gigerenzer, ecological rationality is a property of individual decisions, which occur through heuristics. It shares the focus on individual decisions with cognitivism, but contrary to cognitivism, it is not interested in whether the subject can reason her way toward the superior alternative, but rather whether she reaches, achieves, this decision. Its criterion is far more pragmatic than that of the cognitivists, who are interested in the way in which a particular choice is made.

This directly impacts how the three programs think about normative issues, and what standard they use to evaluate choices: the normative benchmark. This benchmark is more or less shared between Vernon Smith and the H&B program. The benchmark for them is the rational choice as laid out by neoclassical economics, with the exception that Vernon Smith, like we argued, is less interested in individual choices and more in aggregate outcomes. So, the benchmark he ends up using are the equilibrium outcomes of market models based on rational-choice theory. This is different from Gigerenzer, who has toyed with the idea that heuristic decision-making leads to better than rational choices, but in more recent years has emphasized that heuristics are superior for a certain domain of tasks in which the solution is either intractable, there is an estimation error because of small number of occurrences, or, finally, because the problem is ill-specified. Gigerenzer believes that most human choices suffer from at least one of these three problems. The relevant benchmark for him, therefore, cannot be rational-choice theory, and instead, he proposes that given strategies perform good enough, or better than the alternatives (Gigerenzer and Todd 2012; see also Hands 2014). The normative benchmark is not that of optimization in some abstract sense, but whether the functioning is achieved or the task completed. Implicit in this notion is an evolutionary account in which strategies have to be good enough to survive, but not necessarily optimal.[10]

This completes our contrast of the two types of ecological rationality. ER1, part of Gigerenzer's fast-and-frugal heuristics approach, is based on the picking up of cues in the environment, which are inputs for heuristics used to arrive at quick decisions. The individual is 'ecologically rational' to the extent that the strategies, the heuristics, used are well adapted to her environment. ER2, part of the market-experimental approach developed by Smith, Plott and others, is based on institutional constraints and social and cultural norms, which help the individual to navigate his social environment. The system is 'ecologically rational' to the extent that it facilitates this navigation by the individual by means of embedded norms, learning or feedback mechanisms, and leads to outcomes that are efficient in the aggregate. Both the institutional rules and in particular the social norms emerge in the process of social interaction, and represent the cognitive content that is off-loaded to the environment.

Conclusion

It is tempting to accept the standard narrative that modern behavioral economics is the reintroduction of psychology into economics. However, that narrative relies heavily on the idea that there is one economics and one psychology. In this paper, we demonstrate that this narrative is severely

complicated when we look at the two conceptions of ecological rationality, which are offered as alternatives to modern behavioral economics and accounts of 'bounded rationality'. As we have demonstrated, these present two alternative combinations of economics and psychology. The methodological question for economists, therefore, shifts from a concern over whether economics needs psychology to what type of integration of the two fields is desirable and fruitful. This paper does not aim to provide guidelines for what the best integration might be, but it does show the choices and stakes involved.

Firstly, we have demonstrated that 'ecological rationality' does not present a uniform challenge to the idea of 'bounded rationality'. Instead, there are two different conceptions of ecological rationality, which represent different ways of integrating psychology and economics. What we have called ER1, ecological rationality as promoted by the FFH-program associated with Gerd Gigerenzer, is a merger between the functionalist psychology of Brunswik and an individualist economics focused on specific real-world tasks. What we have called ER2, ecological rationality as promoted by the market-experimental program associated with Vernon Smith, is a merger between the psychological approach 'situated cognition' and a more institutional economics. We have repeatedly contrasted them with the H&B approach which represents a merger between cognitivist psychology and the individualist economics associated with rational-choice theory.

Secondly, we have argued that these different combinations of psychology and economics have important consequences for relevant methodological practices. They impact the level of analysis, the way in which experiments are conducted, the perceived central problem to be explained, and the way in which central concepts, such as the individual and the environment, are conceptualized. To move forward the fruitful discussion between these different programs, it is important to realize that such deep methodological differences exist. Psychology is and will remain relevant to economics, as is by now broadly accepted. But importing parts of another discipline, or even merging the two, should not and cannot occur without a good understanding of which goods we are importing.

Notes

1. Smith (2003) himself, however, points to Norman (2002) as the initial source for his constructivist-ecological distinction.
2. Psychology and cognitive science have considerable overlap if one looks at it from the perspective of cognitivist psychology. We do not explore the differences between the two here.
3. Simon first developed this distinction in his early book 'Administrative Behavior' (Simon 1997, p. 324).
4. Egon Brunswik came of age in the post WWI Vienna and later emigrated to the United States where, in the years before his premature and tragic death, he fully developed his own branch of functionalist psychology. For a biographical account see Leary (1987) and Gigerenzer's contribution to Brunswik (2001).
5. Here and below we refer to the collection of Brunswik's writings from 2001 rather than the original papers.
6. As a consequence, these heuristics can be transferred from one environment to another and as such provide a stable factor that we can study.
7. Hutchins argues that additional cognitive flexibility is made possible through interaction: "a phenomenon that is entirely missed by research paradigms that, for good reasons, intentionally limit the methods subjects may use to perform a task" (Hutchins 1995, 289).
8. Hayek, on who Vernon Smith draws so heavily, was himself engaged in serious psychological inquiries. He saw psychology as interactionist and his book 'The Sensory Order' anticipated later development in neurology and artificial intelligence (Hayek 1952; Steele 2002).
9. For an attempt to bridge some of these differences see Arnau, Ayala, and Sturm (2014).
10. For a more radical position see Cosmides and Tooby (1994).

Acknowledgements

This paper has benefitted from the thoughtful comments by two anonymous reviewers, the participants of the Econ & Culture seminar at Erasmus University, and the PhD seminar at the Erasmus Institute for Philosophy and Economics, the ESHET session in Antwerp, especially John Davis and Annie Cot, and Ivan Boldyrev. Any remaining errors are the authors' responsibility.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Erwin Dekker is post-doctoral research at the Erasmus School of Economics and working on the intellectual biography of Jan Tinbergen. He has previously published on topics at the intersection of culture and economics, including the history of the Austrian School, the economics of the arts, and the importance of the commons for the functioning of markets.

Blaž Remic is a PhD candidate and a lecturer in cultural economics at Erasmus University Rotterdam. His current research is on the interplay between intrinsic motivation and institutional and social environments. Being a former jazz musician, he often draws inspiration for thinking about the processes in the socioeconomic world from his understanding of music improvisation.

References

Alchian, A. A. (1950). Uncertainty, evolution, and economic theory. *Journal of Political Economy*, *58*, 211–221.

Anderson, M. L. (2003). Embodied cognition: A field guide. *Artificial Intelligence*, *149*(1), 91–130. doi:10.1016/S0004-3702(03)00054-7

Angner, E. (2018). "We're All Behavioral Economists Now." https://doi.org/10.2139/ssrn.3130071

Arnau, E., Ayala, S., & Sturm, T. (2014). Cognitive externalism meets bounded rationality. *Philosophical Psychology*, *27*(1), 50–64.

Bardone, E. (2011). *Seeking chances: From biased rationality to distributed cognition*. Berlin: Springer Verlag.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*(1), 617–645.

Berg, N., & Gigerenzer, G. (2010). As-if behavioral economics: Neoclassical economics in disguise. *History of Economic Ideas*, *18*(1), 133–166.

Brunswik, Egon. (2001). *The essential Brunswik : Beginnings, explications, applications*. In K. R. Hammond, & T. R. Stewart (Eds.). Oxford: Oxford University Press.

Camerer, C. F., Loewenstein, G., & Rabin, M. (2004). *Advances in behavioral economics*. Princeton, NJ: Princeton University Press.

Chater, N., Felin, T., Funder, D. C., Gigerenzer, G., Koenderink, J. J., Krueger, J. I., Noble, D., et al. (2018). Mind, rationality, and cognition: An interdisciplinary debate. *Psychonomic Bulletin and Review*, *25*(2), 793–826. doi:10.3758/s13423-017-1333-5

Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis*, *58*(1), 7–19.

Cosmides, L., & Tooby, J. (1994). Better than rational: Evolutionary psychology and the invisible hand. *The American Economic Review: Papers and Proceedings*, *84*(2), 327–332.

Davis, J. B. (2010). Neuroeconomics: Constructing Identity. *Journal of Economic Behavior & Organization*, *76*, 574–583.

Davis, J. B. (2011). *Individuals and identity in economics*. Cambridge: Cambridge University Press.

Davis, J. B. (2016). Economics, neuroeconomics, and the problem of identity. *Schmollers Jahrbuch*, *136*(1), 15–31.

Gibson, J. J. (1950). *The perception of the visual world*. Cambridge, MA: Riverside Press.

Gigerenzer, G. (2000). *Adaptive thinking: Rationality in the real world*. Oxford: Oxford University Press.

Gigerenzer, G. (2007). *Gut feelings: The intelligence of the unconscious*. New York: Viking.

Gigerenzer, G. (2008). *Rationality for mortals: How people cope with uncertainty*. Oxford: Oxford University Press.

Gigerenzer, G. (2015). *Simply rational: Decision making in the real world*. Oxford: Oxford University Press.

Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology*, *62*(1), 451–482.

Gigerenzer, G., & Goldstein, D. G. (2011). The recognition heuristic : A decade of research. *Judgment and Decision Making*, *6*(1), 100–121. http://www.sas.upenn.edu/~baron/journal/11/rh15/rh15.pdf

Gigerenzer, G., & Selten, R. (2001). *Bounded rationality: The adaptive toolbox*. Cambridge, MA: MIT Press.

Gigerenzer, G., & Todd, P. M. (1999). *Simple heuristics that make us smart*. Oxford: Oxford University Press.

Gigerenzer, G., & Todd, P. M. (2012). Ecological rationality: The normative study of heuristics. In P. M. Todd & G. Gigerenzer (Eds.), *Ecological rationality: Intelligence in the world* (pp. 487–497). New York: Oxford University Press.

Gode, D. K., & Sunder, S. (1993). Allocative efficiency of markets with zero-intelligence traders: Market as a partial substitute for individual rationality. *Journal of Political Economy*, *101*, 119–137.

Grüne-Yanoff, T., Marchionni, C., & Moscati, I. (2014). Introduction: Methodologies of bounded rationality. *Journal of Economic Methodology*, *21*, 325–342. doi:10.1080/1350178X.2014.972140

Gul, F., & Pesendorfer, W. (2010). The case for mindless economics. In A. Caplin & A. Schotter (Eds.), *The foundations of positive and normative economics: A handbook* (pp. 3–42). Oxford: Oxford University Press.

Hands, D. W. (2010). Economics, psychology and the history of consumer choice theory. *Cambridge Journal of Economics*, *34*(4), 633–648.

Hands, D. W. (2014). Normative ecological rationality: Normative rationality in the fast-and-frugal-heuristics research program. *Journal of Economic Methodology*, *21*(4), 396–410. doi:10.1080/1350178X.2014.965907

Hayek, F. A. (1937). Economics and knowledge. *Economica*, *4*(13), 33–54.
Hayek, F. A. (1945). The use of knowledge in society. *The American Economic Review*, *35*(4), 519–530.
Hayek, F. A. (1952). *The sensory order: An Inquiry into the foundations of theoretical psychology*. Chicago: Chicago University Press.
Hertwig, R., & Gigerenzer, G. (1999). The 'conjunction Fallacy' Revisited: How Intelligent inferences look like reasoning errors. *Journal of Behavioral Decision Making*, *12*(4), 275–305.
Hogarth, R. M. (2005). The challenge of representative design in psychology and economics. *Journal of Economic Methodology*, *12*(2), 253–263.
Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: Toward a new foundation for human-computer interaction research. *Distributed Cognition: Toward a New Foundation for Computer-Human Interaction Research*, *7*(2), 174–196. doi:10.1145/353485.353487
Hutchins, E. (1995). *Cognition in the Wild*. Cambridge, MA: MIT Press.
Hutchins, E. (2014). The cultural Ecosystem of human cognition. *Philosophical Psychology*, *27*(1), 34–49.
Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review*, *93*, 1449–1475.
Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive Judgment* (pp. 49–81). Cambridge, MA: Cambridge University Press.
Kirsh, D. (2010). Thinking with external representations. *AI & Society*, *25*, 441–454.
Leary, D. E. (1987). From Act psychology to Problematic functionalism : The place of Egon Brunswik in the history of psychology. In M. G. Ash, & W. R. Woodard (Eds.), *Psychology in twentieth-century thought and society* (pp. 115–142). Cambridge, MA: Cambridge University Press.
Levin, J. (2016). "Functionalism." *The Stanford Encyclopedia of Philosophy*. https://plato.stanford.edu/archives/win2016/entries/functionalism/
Menary, R. (2006). Attacking the bounds of cognition. *Philosophical Psychology*, *19*(3), 329–344.
Mullainathan, S., & Thaler, R. H. (2000). "Behavioral Economics." 7948. *NBER Working Paper Series*.
Norman, J. (2002). Two visual systems and two theories of perception: An attempt to reconcile the constructivist and ecological approaches. *Behavioral and Brain Sciences*, *25*(1), 73–144.
Osbeck, L. M., & Nersessian, N. J. (2014). Situating distributed cognition. *Philosophical Psychology*. doi:10.1080/09515089.2013.829384
Petracca, E. (2017). A cognition paradigm clash: Simon, situated cognition and the interpretation of bounded rationality. *Journal of Economic Methodology*, *24*, 20–40.
Plott, C. R. (2001). *Market institutions and price discovery*. London: Edward Elgar.
Plott, C. R., & Smith, V. (2008). *Handbook of experimental economics results. Handbooks in economics* Vol. 1. New York: Elsevier.
Rich, P. (2016). Axiomatic and ecological rationality: Choosing costs and benefits. *Erasmus Journal for Philosophy and Economics*, *9*(2), 90–122.
Robbins, P., & Aydede, M. (2009). *The Cambridge handbook of situated cognition*. Cambridge: Cambridge University Press.
Rogers, Y. (2006). Introduction to distributed cognition and communication. In K. Brown (Ed.), *The Encyclopedia of Language and Linguistics* (2nd ed., pp. 181–202). Oxford: Elsevier.
Rogers, Y., & Ellis, J. (1994). Distributed cognition -an alternative framework for analyzing and explaining collaborative working. *Journal of Information Technology*, *9*(2), 119–128. doi:10.1057/jit.1994.12
Ross, D. (2014a). *Philosophy of economics*. New York: Palgrave Macmillan.
Ross, D. (2014b). Psychological versus economic models of bounded rationality. *Journal of Economic Methodology*, *21*, 411–427.
Simon, H. A. (1956). A comparison of game theory and learning theory. *Psychometrika*, *21*(3), 267–272.
Simon, H. A. (1997). *Administrative behavior: A study of decision-making processes in Administrative Organizations* (4th ed.). New York: The Free Press.
Smith, V. L. (1962). An experimental study of competitive market behavior. *The Journal of Political Economy*, *70*(9), 111–137.
Smith, V. L. (1967). Experimental studies of discrimination versus competition in sealed-bid auction markets. *The Journal of Business*, *40*(1), 56–84.
Smith, V. L. (1991). Rational choice: The contrast between economics and psychology. *Journal of Political Economy*, *99*, 877–897.
Smith, V. L. (1994). Economics in the laboratory. *Journal of Economic Perspectives*, *8*(1), 113–131.
Smith, V. L. (2003). Constructivist and ecological rationality in economics. *The American Economic Review*, *93*, 465–508.
Smith, V. L. (2008). *Rationality in economics*. Cambridge: Cambridge University Press.
Smith, V. L. (2015). Conduct, rules and the origins of institutions. *Journal of Institutional Economics*, *11*(3), 481–483.
Steele, G. R. (2002). Hayek's sensory order. *Theory & Psychology*, *12*, 387–409.
Svorenčík, A. (2016). The Sidney Siegel tradition: The divergence of behavioral and experimental economics at the end of the 1980s. *History of Political Economy*, *48*, 270–294. doi:10.2139/ssrn.2768991

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124–1131.
Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review*, *9*, 625–636.
Zhang, J. (1991). *The interaction of internal and external representations in a problem solving task*. Proceedings of the 13th Annual Conference of Cognitive Science Society, Chicago, IL: LEA, 954–958.
Zhu, L., & Gigerenzer, G. (2006). Children can solve Bayesian problems: The role of representation in mental Computation. *Cognition*, *98*(3), 287–308.