

**Entrepreneurs as scientists:
A pragmatist approach to producing value out of uncertainty**

Thomas Zellweger

University of St. Gallen
thomas.zellweger@unisg.ch

Todd Zenger

University of Utah
todd.zenger@eccles.utah.edu

forthcoming in the *Academy of Management Review*

We would like to thank Greg Fisher, our associate editor, and the three anonymous reviewers for their extremely helpful feedback during the review process. We also thank Howard Aldrich, Alexander Braun, Marc Gruber, Urs Fueglistaller, Isabella Hatak, Josh Hsueh, Thibault Huber, Tobias Palm, Christine Scheef, Dean Shepherd, Vangelis Souitaris, and Joakim Wincent for their comments on earlier versions of the paper. The second author also thanks Teppo Felin for long standing collaborations on topics related to this paper.

Entrepreneurs as scientists:

A pragmatist approach to producing value out of uncertainty

Abstract

Building on pragmatism, we advance an entrepreneur-as-scientist perspective and depict entrepreneurs as engaging in causally inferential action by forming beliefs, testing these beliefs, and responding to the feedback received. However, this sequence of entrepreneurial actions arrives with a set of companion doubts, namely doubt about product-market fit because the entrepreneurs' beliefs are self-chosen, doubt about feedback validity from false positives or false negatives, and doubt about over- and underfitting in responses to feedback. We discuss the rationality of heuristics deployed by the entrepreneur to overcome these doubts. Our insights contribute to the micro-foundations of entrepreneurial action and strategy by explaining how entrepreneurs generate the information to produce value out of uncertainty.

It is not certain that everything is uncertain. - Blaise Pascal

Action under uncertainty is endemic to entrepreneurship. Indeed, McMullen and Shepherd (2006) conclude that entrepreneurship requires action and that such action unfolds under what Knight varyingly describes as “absolute unpredictability” (1921, p. 310) and “true” (1921, p. 232), non-probabilistic uncertainty. Yet, while there is agreement about uncertainty as the common state in which entrepreneurship occurs, there is less agreement about what actions entrepreneurs should deploy in the face of it (Shepherd, 2015). In fact, our understanding of entrepreneurial action is contested (Townsend, Hunt, McMullen, & Sarasvathy, 2018), as evidenced by debate about whether entrepreneurial action follows causal (Delmar & Shane, 2003) or effectual logic (Sarasvathy, 2001), and whether it demands primarily thinking, such as ideation (Kier & McMullen, 2020) and personal judgment (Foss & Klein, 2012), or simply exploratory action (Murray & Tripsas, 2004) followed by related learning (Ott, Eisenhardt, & Bingham, 2017). Beyond such debates, we lack insight into how singular entrepreneurial actions combine to form a coherent entrepreneurial process through which entrepreneurs seek and produce value under uncertainty (Packard, Clark, & Klein, 2017; Townsend et al., 2018).

Recent literature that characterizes entrepreneurial action as quasi-scientific provides a potential path forward. Here entrepreneurs act like scientists. They develop theories, test

hypotheses, validate them, and experiment to create value under uncertainty (e.g., Camuffo, Cordova, Gambardella, & Spina, 2020; Felin, Gambardella, Stern, & Zenger, 2019; Felin & Zenger, 2009; Ries, 2011). However, this emerging literature is itself fragmented with some pointing to the benefit of rapid iterative testing as discussed in the lean startup literature (e.g., Blank, 2013; Kerr, Nanda, & Rhodes-Kropf, 2014; Leatherbee & Katila, 2020), and others highlighting theory formation and problem framing that might precede such experimentation (Felin, Gambardella, & Zenger, 2020; Felin & Zenger, 2009). Prior work has yet to articulate the broad set of actions inherent to a scientific approach to entrepreneurship, and has failed to discuss how these actions are sequenced and combined through a quasi-scientific entrepreneurial process. For instance, while entrepreneurs may form hypotheses and test them, “interpreting the results of these tests” is, as Shepherd and Gruber (2021, p. 968) note, both challenging and deserving of more research.

Our aim in this paper is to build an integrative entrepreneur-as-scientist perspective of entrepreneurial action. The perspective we advance explores the scope of science-like behavior deployed by entrepreneurs and clarifies the related inferential challenges that complicate value creation under uncertainty. Our entrepreneur-as-scientist perspective explores how entrepreneurs use distinct categories of “scientific” action to generate the information necessary for them to transform uncertainty into risk (Ellsberg, 1961). Much like academic scientists who advance knowledge by composing and testing theories about what is presently unknown (Felin et al., 2020), entrepreneurs similarly craft beliefs about a problem in the market and its solution. Then, because of uncertainty about the fit of their beliefs to the market, entrepreneurs seek to test their beliefs, from which they progressively learn about the belief’s value and update the belief correspondingly (Felin et al., 2019; Gans, Stern, & Wu, 2019; Packard et al., 2017). The challenge for the entrepreneur is that this sequence of actions is complicated by the self-selection or endogeneity of the entrepreneur’s choice of beliefs, by false positives or false negatives in feedback from testing, and by the possibility of over- or underfitting in selecting a response.

The theoretical foundations of our perspective are found in classical pragmatism (Dewey, 1915; Peirce, 1931-1958) and in cognitive psychology's view of the human brain as a theory testing and error minimization device (Brunswik, 1956; Oaksford & Chater, 2007). Pragmatism represents a theoretical cornerstone for our theorizing given deep connections between Knight's (1921) landmark research program on uncertainty, and the core tenets of pragmatism, such as the practical value of resources in solving problems at hand, parallels between common sense inquiry and scientific inquiry, and the role of experimentation for learning (Dewey, 1938; Nash, 2003; Nash & Rybak, 2010). Cognitive psychology (Hohwy, 2013; Navarro & Perfors, 2011) complements our reasoning by showing that we see the world through "theories in use"—theories which function as "priors", which we then update in order to minimize prediction error between our theories and the data we generate (Clark, 2013; Hastie & Dawes, 2010). We thus suggest that entrepreneurs are more likely to pursue valuable beliefs when they compose well-structured theories through which they select experiments, filter and interpret feedback from these experiments, and ultimately update their beliefs.

We seek to contribute to the literature in three ways. First, we help build a theory of entrepreneurial action in which entrepreneurs act like scientists (McMullen & Shepherd, 2006; Ott et al., 2017; Packard et al., 2017; Shepherd, 2015). We clarify such a theory's microfoundations rooted in pragmatism and cognitive psychology and propose a taxonomy of entrepreneurial action composed of belief formation, belief testing, and response (Foss, Klein, & Bjørnskov, 2019). We explore how these categories of action aggregate into a robust entrepreneurial process (Gross, 2009), one that helps entrepreneurs generate the information necessary to elevate their prospects for producing value under uncertainty (Ellsberg, 1961; Savage, 1954). Second, we show that despite these productive categories of actions, the entrepreneur still carries doubts that correspond to each of these actions, namely doubt about how well their self-selected beliefs actually fit the market, doubt about the validity of the feedback they receive about that fit, fearing both falsely positive and falsely negative feedback, and doubt

about the rationality of the response they choose, fearing their responses may either overfit or underfit the feedback received. We also propose a classification of heuristics and map these to the three categories of action and related doubts they seek to remedy, thereby further clarifying the rationality and value of heuristics in entrepreneurship (Bingham & Eisenhardt, 2011; Luan, Reb, & Gigerenzer, 2019). Finally, we advance an emerging entrepreneur-as-scientist perspective (Camuffo et al., 2020; Felin et al., 2020) depicting entrepreneurs as scientists who actively form beliefs, test these beliefs, and respond to the feedback received, thereby progressing from ex ante opaqueness to ex post clarity about the value of business opportunities (Dimov, 2011; Rindova & Courtney, 2020). By linking uncertainty to the actions that entrepreneurs take (Dequech, 2011; Packard et al., 2017), we suggest that entrepreneurs are in essence managers of the uncertainty they confront, as they consciously and reflexively deploy and test inferential theories through which they first exploit and then mitigate uncertainty (Bingham & Eisenhardt, 2011). In this way we establish a tighter link between uncertainty, entrepreneurial action, and value creation.

THEORETICAL FOUNDATIONS

Our theorizing starts with the observation that entrepreneurship takes place under uncertainty. While there is ample research proposing definitions and dimensionalities of uncertainty (Kozyreva & Hertwig, 2019; Milliken, 1987; Townsend et al., 2018; Walker et al., 2003), many scholars agree with Knight's (1921) observation that under uncertainty reliable information both on available options and their probabilities is not available a priori so that individuals must act based upon their own judgments (Rindova & Courtney, 2020). This line of thought suggests that entrepreneurship as a field should focus on beliefs about what constitutes an entrepreneurial opportunity (Foss & Klein, 2017), and on how entrepreneurial actions generate the information necessary to determine whether or not a business idea actually represents a valuable entrepreneurial opportunity (Rindova & Courtney, 2020; Van den Steen, 2005).

Entrepreneurship scholarship and practice have enthusiastically embraced such a belief and action-oriented view of entrepreneurship. What the “theory-based” (Felin & Zenger, 2009),

“judgment-based” (Foss & Klein, 2012), “lean” (Ries, 2011), “procedural” (Dimov, 2011; McMullen & Dimov, 2013), and “experimental” (Gans et al., 2019; Kerr et al., 2014) perspectives of entrepreneurship seem to share is that entrepreneurs must deploy a set of actions through which they seek to illuminate the value of a potential opportunity (Foss et al., 2019; Gartner, 1985; Packard et al., 2017; Shepherd, 2015). When considered in its entirety, this literature appears to describe the entrepreneurial process as quasi-scientific—a process in which entrepreneurs act like scientists, developing theories, testing hypotheses, and validating to create value. Some authors highlight the role of experimentation, including rapid, iterative, trial and error testing as discussed in the lean startup literature (e.g., Blank, 2013; Camuffo et al., 2020; Kerr et al., 2014), while others highlight cognitive tasks such as imagination, sensemaking and theory formation (Cornelissen & Clarke, 2010; Felin & Zenger, 2009; Grégoire, Corbett, & McMullen, 2011). What we lack, however, is an integrative entrepreneur-as-scientist perspective that outlines the categories of actions required, how they are sequentially deployed, and the inferential problems that attend to each, thereby explaining how entrepreneurs, much like scientists seek, but often fail, to produce value amidst uncertainty.

PRAGMATIST FOUNDATIONS OF ENTREPRENEURIAL ACTION

To further develop a scientific perspective of entrepreneurial action, we build on classical pragmatism (Dewey, 1915, 1939; James, 1890), and the view in cognitive sciences of the mind as a theory testing device (Knill & Richards, 1996; Oaksford & Chater, 2007). Entrepreneurship scholars have repeatedly pointed to pragmatism to explain entrepreneurial processes (e.g., Rubleske & Berente, 2017; Sarasvathy, 2001; Shepherd, 2015), but have failed to fully engage with pragmatism’s conceptual richness as well as complementary advances in cognitive sciences (e.g., Clark, 2013; Csaszar & Levinthal, 2016; Hohwy, 2013; Karelaia & Hogarth, 2008). Extant entrepreneurship literature uses ‘pragmatism’ rather casually to imply that entrepreneurs are practical and down to earth, rather than engaging with pragmatism as a philosophy of science

with a unique ontology, epistemology, and method of inquiry (Hands, 2006; Kraaijenbrink, 2012; Watson, 2013).¹ In what follows, we lay out the pragmatist foundations of our theory.

Pragmatist ontology. In defining the nature of the world, and what we see as real, pragmatism agrees with objectivism's claim that opportunities exist independent of the entrepreneur (James, 1908). Yet, pragmatism acknowledges that opportunities are hard to uncover as entrepreneurs have legitimate doubts that opportunities they see are in fact valuable. At the same time, pragmatism aligns with realism in claiming that what is "empirically observed is only a subset of the actual" (Ramoglou & Tsang, 2016; p. 412)—essentially a subset of what is possible. Therefore, what is real is more than what we presently know (Bhaskar, 1975; Watson, 2013). Pragmatism suggests that because the functionality of the solutions proposed are ex ante indeterminate, entrepreneurs must engage in inferential action to discover whether what they conceive as valuable actually is valuable. In pragmatism, hence, ontology is emergent, shaped by problems identified and the active investigation of solutions (Dewey, 1938). Through the direction of attention, effort, and purpose (Emirbayer & Mische, 1998), entrepreneurs actively compose and take up problem-focused "theories in use" (Argyris & Schon, 1974).

To understand the role that theories play in pragmatism, it is useful to remember that what scholars today call "true" uncertainty, Knight actually called "estimated probability", referring to situations where there is "no valid basis of any kind of classifying instances" (Knight, 1921, p. 225). Even in these circumstances, entrepreneurs routinely form judgments about probability (Arrow, 1951; Ellsberg, 1961; LeRoy & Singell Jr, 1987). They compose theories that allow them to act 'as-if' they can estimate probabilities—theories that allow them to narrow the range of options, and chart a path forward (Ellsberg, 1961; Savage, 1954). The cognitive psychology literature that views perception as causal inference following Bayesian rationality (Karelaia & Hogarth, 2008; Navarro & Perfors, 2011) generates a similar prediction. If entrepreneurs can

¹ The oversight of pragmatism in the study of entrepreneurial action is unfortunate because Knight himself proposed that "the theory of knowledge upon which the proposition of uncertainty is based is a functional or pragmatic view" (1921, p. 200).

form plausible subjective distributions *ex ante*, then “uncertainty can be treated in a way similar to risk” (Hertwig, Pleskac, & Pachur, 2019, p. 356)—a logic that prompts Ellsberg (1961, p. 645) to suggest that “for a ‘rational’ man all uncertainty can be reduced to risks”. To generate this cognitive transformation, our mind formulates beliefs or theories about what could work. These become our “priors”, and then like scientists we seek to minimize the prediction error of these theories in light of feedback gathered with the goal of maximizing posterior fit between belief and real world (Hohwy, 2013; Knill & Richards, 1996).

Pragmatist epistemology. Consistent with a pragmatist conception of the limits of what we can know, entrepreneurs thus form theories or beliefs about what could be opportunities (Shepherd, McMullen, & Jennings, 2007; Wood, McKelvie, & Haynie, 2014). Such beliefs are tentative, of a hypothetical nature, or what Knight (1921, p. 199) describes as “opinion, of greater or lesser foundation and value, neither entire ignorance nor complete and perfect information, but partial knowledge.” Because entrepreneurs’ opportunity beliefs are theory-laden, uncertainty allows entrepreneurs to see what fits into their organized knowledge of the world (Knight, 1925). Pragmatists recognize that observation never occurs with an innocent eye, but is instead always shaped by beliefs (Felin, Koenderink, & Krueger, 2017; Rothschild, 2013). Yet, these beliefs are also practical in that they target and frame a problem (Hsieh, Nickerson, & Zenger, 2007), an approach consistent with Simon’s (1996, p. 376) recognition that problem formulation and theory are near substitutes. For pragmatists, beliefs are deliberate projections that motivate and guide action toward what could be (Joas, 1996).

Forming an opportunity belief empowers the entrepreneur to draw inferences and identify a set of possible options—a process that pragmatists call ‘fixing’ (Smith, 1978), one that allows the entrepreneur to cognitively move from uncertainty to ambiguity. While under uncertainty both the options and their probabilities are unknown, under ambiguity the now “fixed” options are known, and only their probabilities remain unknown (Holm, Opper, & Nee, 2013). But even with options fixed, the pragmatist entrepreneur recognizes that ivory tower theorizing or

undirected creative imaginativeness (Kier & McMullen, 2018; Thorndike, 1962) is insufficient, and that beliefs require updates from experimentation and feedback. At the same time, pragmatist entrepreneurs are not blind empiricists who wander about, running experiments and inductively pivoting their way to value (Kerr et al., 2014; Ries, 2011). Instead, the pragmatist entrepreneur subscribes to a form of radical empiricism whereby truth, including that related to the value of an opportunity belief, is found through active cognitive inquiry and assertion (Wilson, 2016). To create value under uncertainty, the pragmatist entrepreneurs observe a problem and use abduction to form a theory to solve this problem (Peirce, 1931-1958). Thereafter, they use logical deduction to derive testable hypotheses, and then induction to reach a verdict on the merits of these theory-induced hypotheses based on accumulating data. Thus, pragmatist epistemology suggests that the entrepreneur's mode of inquiry leads from abduction to deduction to induction, thereby combining cognitive, agentic and reflective inference, or belief formation, testing, and updating.

Pragmatists view theories as a way to see what others cannot and to enact novel resource combinations. Of course, economic theory rooted in the equilibrium paradigm assumes that resources available to entrepreneurs are perfectly priced, and exhausted of any possibilities for creating value through action (Arrow & Debreu, 1954; Barney, 1986; Leiblein, 2011), a useful abstraction for commodities traded in liquid markets, or for small world problems (Gigerenzer, 2019; Savage, 1954). However, pragmatism views it as unlikely that markets and individuals within them foresee, specify and price all possible current and future resource uses (Felin, Kauffman, Mastrogiorgio, & Mastrogiorgio, 2016), through some form of “exhaustive entrepreneurship” (Denrell, Fang, & Winter, 2003), or an all-seeing eye to resource pricing (Felin et al., 2016; Felin et al., 2017; Foss, Klein, Lien, Zellweger, & Zenger, 2021). Rather, by projecting their beliefs about a problem, seeing the world not as it is, but as it could be, entrepreneurs develop truly novel, never-tested ideas about resource affordances that reveal unpriced value in resources (Van den Steen, 2010, 2017). Resource value is thus neither objective nor subjective,

but belief-specific, based on what Dewey describes as “value in judgment”(Dewey (1915, p. 516), defined by their use as “tools or means, and instrumentality.” Thus, in pragmatism, it is not the resource per se that is priced, but the usage of the resource towards solving a problem (Sen, 1982; Shook, 2003).

Pragmatist method of inquiry. Pragmatism suggests our beliefs or theories are “instruments” to be used in scientific-like inquiry (Dewey, 1915). In fact, pragmatism rejects any real distinction between common sense inquiry and scientific inquiry suggesting that any difference lies solely “in the problems with which they are directly concerned, not in their respective logics” (Dewey, 1938, p. 81). For pragmatists, science is the universal and systematic method through which we resolve doubt (Dewey, 1910; Tomlinson, 1997). Specifically, the pragmatist scientific mode of inquiry suggests that when we face a problem, we must first describe its key elements and their interrelationships, thereby drawing a map or theory of the problem through which a solution is sought (Dewey, 1938). Thereafter, the pragmatist sets about verifying the assumptions and propositions that underlie a solution, testing whether they are valid (strong, effective) or invalid (weak, inadequate).

Pragmatists recognize a need for both theory and testing through which they experientially learn. For pragmatists there are no universal, objectively defined actions, but action is rather instrumental, probabilistically rational, and guided by causal inference about what works in the specific situation (Hands, 2006), what Dewey (1936) called ‘learning by doing’. Because the envisaged future is impossible to precisely predict, and the entrepreneur’s judgment is, as Knight (1921, p. 202) suggests, “fortunately or unfortunately” inaccurate, entrepreneurs must update their theory-guided priors as they collect feedback about their beliefs. Entrepreneurs must explore various functional, means-ends relations inherent to their theory, engage in experiments to limit the harm of failure, and update their plans thereafter (Mousavi & Garrison, 2003). Ends from one round of experimental action then become the means for the next cycle of activity,

which may range from a creative revision of the idea to its complete abandonment (Nash & Rybak, 2010).

We view the pragmatist's method of inquiry as distinct from both objective and subjective perspectives of entrepreneurial action as it is concerned with problem-driven, iterative advancement towards truth, i.e. what works to solve the specific problem identified by the entrepreneur. In objectivism, which informs the causation perspective of entrepreneurship, entrepreneurial action is centrally concerned with discovering an opportunity, then exploiting it—a task best performed by individuals with superior alertness (Barreto, 2012). In contrast, in subjectivism, which informs the effectuation perspective of entrepreneurship, entrepreneurial action is concerned with the exploration of affordances from available resources—a task best performed by those with superior creativity and the capacity to socially construct an opportunity through coalition and consensus building around it (Wood & McKinley, 2010). In pragmatism, entrepreneurial action follows an approach termed “radical empiricism” (James, 1908)—a concept whereby data and belief are intertwined, with data only interpretable through the causal relationships inherent to a belief, and the belief in turn updated by the data received. Truth is thereby uncovered as initial beliefs are tested and updated (Dewey, 1938). To predictably succeed in this process, alertness is insufficient as discovering fully formed opportunities ready to be exploited is nearly impossible. At the same time, pragmatist philosophy would disavow the idea that entrepreneurs should primarily be concerned with the creative, even blind, reconfiguration of available resources (Alvarez & Barney, 2007), or with an objectification process focused on peers, such as family and friends (Ramoglou & Tsang, 2016; Wood & McKinley, 2010). For pragmatists, this effectual approach is overly random, and excessively focused on resources at hand and on creativity in resource recombination (Kier & McMullen, 2018), instead of what practically works towards solving the identified problem regardless of the resources' origin.

Pragmatism charts a unique path that partly bridges the divide between empiricist causation and subjectivist effectuation, in line with the pragmatist goal to solve the dilemma between what

James (1907, p. 9ff) called ‘tough-minded empiricism’ and ‘tender-minded idealism’. By sequentially forming, testing and updating beliefs, the entrepreneur thus first exploits uncertainty, then reduces it. The distinctiveness of our pragmatist scientific perspective from causation and effectuation is summarized in Table 1.

----- Insert Table 1 about here -----

ENTREPRENEURIAL ACTIONS AND ATTACHED DOUBTS

The above foundations derived from pragmatism provide the groundwork on which we propose an entrepreneur-as-scientist perspective in which the entrepreneur engages in three categories of action (Csaszar & Laureiro-Martínez, 2018; Mintzberg, Raisinghani, & Theoret, 1976; Packard et al., 2017), namely (1) belief formation, (2) belief testing, and (3) responding. We show that through each category of action the entrepreneur obtains important new information about value, but must also wrestle with unique doubts that correspond to each category. Through these categories of action entrepreneurs actively seek to determine whether their beliefs actually represent valuable opportunities (Arrow, 1951) (see Figure 1).

----- Insert Figure 1 about here -----

1. Belief formation and doubt about product-market fit

Belief formation. A central implication of the pragmatist foundations of our theory is that entrepreneurial action is reasoned and judgmental, and that the entrepreneurial process starts with the active formation of an opportunity belief (Foss & Klein, 2012; Gruber, MacMillan, & Thompson, 2008; Langlois & Cosgel, 1993)—one derived from a causal theory about how to solve a formulated problem (Felin & Zenger, 2009). The belief constitutes a conjecture about what could represent a novel, value creating resource configuration to introduce in the market, hence a conjecture about what could be an opportunity (Casson, 1982; Grégoire, Shepherd, & Schurer Lambert, 2010; Shane & Venkataraman, 2000; Shepherd et al., 2007; Wood et al., 2014), or a promising new business idea (Barreto, 2012; Dimov, 2007). Extant research focuses on how entrepreneurs select from an array of beliefs available for someone (third-person opportunities),

those beliefs that fit them (first-person opportunity) (McMullen & Shepherd, 2006; Wood & McKelvie, 2015), in light of environmental, opportunity-related and personal evaluation cues (Grégoire & Shepherd, 2012; Williams & Wood, 2015; Wood et al., 2014). Pragmatism instead suggests that entrepreneurs form an opportunity belief through a bottom-up abductive thought process, whereby entrepreneurs deploy practical imagination to compose a theory that solves a problem in the market (Beckert, 2016; Emirbayer & Mische, 1998; Felin & Zenger, 2017; Kier & McMullen, 2018). In their search for value, our entrepreneurs are not engaged in an exhaustive search in the environment, in hopes of identifying the optimal new resource configuration—one that maximizes value (V_{\max}), an exercise that would require an all-seeing eye and extraordinary processing capacity to undertake. Rather, our entrepreneurs are pragmatic; they spot a problem in the market, often from direct experience with that problem, and compose a belief about how to solve it.

Much like a scientist who first theorizes about a problem before taking up efforts to test that theory, our entrepreneurial scientist first engages in deliberate cognitive action to frame a problem and formulate a theory to solve it. In this sense, the initial primary concern for the pragmatist scientist is assessing whether the opportunity belief he or she composes logically solves the problem he or she selects, and in this sense fits the market. As an illustration of this bottom up abductive process of belief formation, consider this reflection from Brian Chesky (2015; 04:13), co-founder of Airbnb:

“We went to this conference website, and we notice in the conference website, they had like a hotels tab and we clicked on the hotels tab. And in the hotels tab, there are always hotels and next to every hotel, it said, ‘sold out’, ‘sold out’, ‘sold out.’ And at that point, we just had this idea. We said, ‘Well, designers need a place to stay.’ So, we thought, what if we just created a bed and breakfast for the design conference?”

Here Chesky identifies the broad outlines of a problem and expresses the beginnings of a belief about how to solve it. The next step is to compose a belief that solves this problem in the market. To fulfill this task, the entrepreneur seeks to specify assumptions inherent to this belief—assumptions about needs in the market and required product features that will serve these needs

(Grégoire & Shepherd, 2012; Pindyck, 1993). In this way, the entrepreneur specifies the causal logic or theory underlying the opportunity belief (Felin & Zenger, 2017), composed of assumptions about a pressing problem or underserved important need in the market on one hand, and how the features of the envisaged product match this need on the other hand. Note that the narrative here contrasts with what might emerge from effectuation or discovery logic. Chesky does not start with resources in mind and focus on being creative with them, or try to predict market prices for resources surrounding him in hopes of exploiting opportunities where they are underpriced. Rather, Chesky sees a problem, cognitively composes a tentative solution, and then sets about testing it.

In the belief formation stage, the cognitive task for the entrepreneur is thus to form a causal theory—a logically consistent mental model about the path to value with the new offering (Gary & Wood, 2011; Gavetti, 2005). The theory thereby derived provides a strategic “blueprint” enabling the entrepreneur to conceptualize how the interdependent elements that constitute the theory mesh together (Ott et al., 2017; Van den Steen, 2005). Forming an opportunity belief in this causal way is useful in evaluating the belief’s value. It directs attention toward a sparse set of critical assumptions on needs in the market and product features to address these needs, hence on what has to be critically true for the product to “work” (Ott & Eisenhardt, 2020), which moves nonessential elements to the background, eliminates distractions, and fosters learning (Felin & Zenger, 2017; Ott & Eisenhardt, 2020). This belief focuses efforts in testing towards interpretable experiments and provides an initial basis upon which to reject a belief, even before testing and data, consistent with the insight that those who create problem-specific cognitive representations before trying to resolve them are more successful (Chi, De Leeuw, Chiu, & LaVancher, 1994; Chi, Feltovich, & Glaser, 1981). Hence, in contrast to lean startup, which propagates rapid testing and updating of ideas, our perspective stresses the impact and value of carefully forming opportunity beliefs before testing them in the market.

From a Bayesian perspective, the opportunity belief is the prior, or the belief held by the entrepreneur *prior* to generating data about its match in the environment, or in economic terms, it is the production function or supply side of the belief (left hand part of Figure 1). We view $V(E)$ —the value of the belief perceived by the entrepreneur—as composed from the entrepreneur’s assumptions about a problem or needs in the market (Needs (E)), and required product features derived from the identified needs that the entrepreneur believes will solve the problem (Features (E)). The resulting belief model can be written as $V(E) = \text{Needs (E)} * \text{Features (E)}$. $V(E)$ thus hinges on the internal consistency of the belief composed of assumptions about needs in the market and product features foreseen to address these needs. All else equal, valuable beliefs reveal product features consistent with articulated assumptions about underserved needs in the market. In accordance with arguments from the hypothesis generation literature (Thomas, Dougherty, Sprenger, & Harbison, 2008), entrepreneurs thus do not need accurate knowledge of their entire business environment, only a strong theory of how the strategic elements of a new offering causally fit together to solve an identified problem in the market.

Doubt about product-market fit. While the pragmatist entrepreneur seeks to reduce uncertainty by actively forming a well-structured belief, this belief forming effort introduces its own form of uncertainty. Unlike exogenous uncertainty that exists independent of entrepreneurs and largely outside their control (Downey, Hellriegel, & Slocum Jr, 1975), this form of uncertainty is endogenous, as the belief is self-selected from the myriad imaginable (Arikan, Arikan, & Koparan, 2020; Gans et al., 2019; Packard & Clark, 2020a), and therefore reflects the idiosyncratic background, experience, and biases of the entrepreneur. The selected belief is often new and contrarian (Christensen & Knudsen, 2020)—a feature most often necessary (though not sufficient) to generate value, but one that also easily allows those choosing beliefs to claim bad ones are good, which greatly complicates objective evaluation of the belief (Benner & Zenger, 2016). Brian Chesky’s (2015) reflections on the novel idea of Airbnb nicely illustrate the dilemma:

“I can say everyone at the time seemed to say it was the worst idea ever, and it worked, so maybe that’s the nice connection, it’s the worst idea that ever worked.” (00:55) “All these

really good ideas or big ideas often sound like stupid ideas. Somebody once told me in the early days, don't worry about anyone stealing your idea. If it's any good, everyone will dismiss it. And that was exactly the truth." (09:16).

Of course, most often ideas fail to generate value, but this endogenously-generated uncertainty is the inevitable price to pay when seeking to pursue a novel and potentially value-creating idea whose success is both hard to predict and whose assumptions on market needs and associated feature combinations are most likely errant (Aldrich & Ruef, 2018).

Selected beliefs will most often underfit the target market (Grégoire & Shepherd, 2012), and accordingly doubts about product-market fit will likely doom an idea to failure from the outset. Doubts will generally reflect two concerns. First, beliefs that underfit the market may reflect implausible assumptions about demand and needs in the market, hence on the importance and shape of the "problem" to be solved (Csaszar & Laureiro-Martínez, 2018), which results in selection biases, omissions, and ultimately inflated estimates about value (Hamilton & Nickerson, 2003). Because ideas are self-selected entrepreneurs may overlook the limitations of their beliefs as imposed by the market (Alvarez & Parker, 2009; Davidsson, 2015), ignoring relevant data. Many beliefs may sound highly plausible, but in the end fail to fit with the market (Hacking, 1983; Oaksford & Chater, 2007). As an illustration, consider an entrepreneur who believes in a business wherein students sublet their dorms when away. In support of this belief, the entrepreneur makes several assumptions about demand in the market: (1) there is unmet demand for small apartments or single rooms in that location, (2) demand is present during the time when the students are not on campus, such as summer, and (3) students' desire for extra money is sufficient to have them bother with subletting. While these demand-shaping assumptions may sound plausible, the environment in which the student dorm business is launched may reveal otherwise. For instance, it may be legally forbidden for students to sublet their apartments, or there may be low demand for dorms during summer months when students are away. Brian Chesky of Airbnb similarly recounts flawed assumptions in his initial belief and problem framing. He initially assumed that a key element of the problem he sought to solve involved finding roommates when renting,

prompting initial solution concepts centered around social networks. Eventually, he decides that he “had the wrong mental model” (Chesky, 2015; 91:45), and determines that the finding housing problem was far more pressing in the market than the finding roommates problem.

Second, lack of product-market fit may result from poor assessments of the feasibility of composing the novel features for the imagined product to “work” in solving the targeted problem (Csaszar & Laureiro-Martínez, 2018; Ott & Eisenhardt, 2020). For the example of subletting student dorms, the entrepreneur may imagine a website that displays the dorms available for rent, an online payment system, and a convenient process for securing access to dorm rooms. While composing these features sounds quite feasible today, their feasibility seemed less obvious when Airbnb was founded. Booking with a stranger and arranging reliable and secure payment involved features with unknown technical feasibility (Chesky, 2015; 10:01). In other words, for many novel beliefs the obstacles imposed by the novel features imagined by the entrepreneur are significant, and sometimes insurmountable.

In sum, actors in the market collectively evaluate the entrepreneur’s belief, which the entrepreneur then discovers by testing the belief in the market—a process that ultimately reveals the accuracy of assumptions about market needs, the feasibility of product features, and fit of product features to market needs. We denote the market’s view of the belief as the market model, or in economic terms the demand function for the belief, with $V(M) = \text{Needs}(M) * \text{Features}(M)$ (right hand part of Figure 1).² The weighting of the needs and feature assumptions underlying

² Note that the entrepreneur’s problem framing in the form of the belief both reveals and limits market feedback. The entrepreneur’s assumptions on market needs and on product features enable and generate feedback that would otherwise remain unseen absent the entrepreneur’s belief, but at the same time the feedback is limited to responses to the assumptions proposed. Consider the case of AirBnB: The original belief held by Brian Chesky and his co-founders was to offer airbeds for conference participants. In Chesky’s own words (2015; 04:56) “Let’s create a designer bed and breakfast for the conference. Unfortunately, I didn’t have any beds. Joe had, he just moved up there. It would be like a floor and breakfast. That’s like not the best thing. And so, Joe had three air beds. He had gone camping, and he had kept some air beds. And we pulled the air beds out of the closet, we inflated the air beds, and we called it The Air Bed and Breakfast. And that’s where the name comes from Airbedandbreakfast.com.” But the problem with this problem framing was that it led the AirBnB founders to require all their hosts to have airbeds, and to only focus on cities with large conferences. The feedback they received from the market

$V(M)$ typically differs from that of $V(E)$ because the belief is self-generated by the entrepreneur, resulting in a misfit between $V(E)$ and $V(M)$. Hence the true value of the opportunity belief (V) is proportional to the fit between $V(E)$ and $V(M)$, with fit being the correlation between $V(E)$ and $V(M)$, what we define as product-market fit. The entrepreneur may thus hypothesize a promising product, based on plausible assumptions about demand and a host of features deemed feasible to satisfy the demand, such that $V(E)$ is high. But such an idea may still fail to create value when, as is often the case at the outset, the assumptions about demand and features inherent to the belief model fail to fit the revealed market model (low correlation between $V(E)$ and $V(M)$). The value of an opportunity belief (V) is thus $V \propto \text{correlation}(V(E), V(M))$.

Viewing the value of an opportunity belief as scaled by its fit to the market is aligned with cognitive sciences and lens models of human judgment, which denote the fit of a judgment as the extent to which the mental representation matches the environment (Brunswik, 1956; Csaszar & Laureiro-Martínez, 2018; Kozyreva & Hertwig, 2019; Shepherd & Zacharakis, 2002). This view of belief fit is aligned with Todd and Gigerenzer's (2012) idea of ecological rationality, defined as the fit between a cognitive tool and the environment (Hertwig et al., 2019). Relative to this work, our notion of fit is more problem or belief specific—how well hypothesized solutions solve specific market problems. We thus view product-market fit as the correlation between (1) the entrepreneur's own projections about the value creation capacity of assumed needs and associated product features, and (2) the revealed value creation capacity of these needs and features in the market. We call the former the belief model (Figure 2-left), and the latter the market model of the belief (Figure 2-right).

----- Insert Figure 2 about here -----

2. Belief testing and doubt about false positives and false negatives in feedback

were to these product features and market assumptions underlying their belief, and that feedback was rather negative, indicating a low product-market fit of this particular belief.

Belief testing. Since at the outset a belief remains at best an internally consistent conjecture, the entrepreneur must assess a belief's merits or fit by testing its assumptions in the external environment (Gross, 2009; Hertwig et al., 2019; Shepherd, Haynie, & McMullen, 2012). Definite scientific proof of the belief would require an exhaustive falsification strategy (Popper, 1972), essentially testing all alternative solutions or resource configurations and find them inferior to the one envisioned. Of course, the myriad resource configurations conceivable, reflected in an enormous variety of demand and feature combinations, makes this strategy prohibitively costly or outright intractable.

Our pragmatic or scientific entrepreneurs pursue an alternative path. They generally pursue a positive test strategy, seeking confirmatory evidence for a chosen belief. While a positive test strategy may violate orthodox scientific principles of falsification, it is widely used in science, and may prove particularly effective in the entrepreneurship context because the belief most often is what Klayman and Ha (1987) calls a 'minority phenomenon'—a phenomenon for which the probability of success is often quite low (e.g., Kerr et al., 2014). Klayman and Ha (1987, p. 212) shows that “when concrete, task-specific information is lacking, or cognitive demands are high, people rely on the positive test strategy as a general default heuristic”, as a pragmatic way forward (see also Navarro & Perfors, 2011; Oaksford & Chater, 2007). The downside of such a focused positive test strategy is, however, foreseeable: the entrepreneur places excessive weight on supportive evidence and discounts that which disconfirms, leading to excessive confidence in the belief, and the omission of alternative, better beliefs (Miller & Tsang, 2011; Nisbett & Ross, 1980; Puranam, Stieglitz, Osman, & Pillutla, 2015).³

³ The following example illustrates the benefit of engaging in a positive test strategy, and the attendant opportunity costs from overlooking more valuable alternatives. In the belief to sublet student dorms the entrepreneur may think that only dorms in the city center will create demand. If the entrepreneur checked only city center dorms and found the demand to be good and, on this basis, decided to focus with his/her business only on city center dorms, one could say s/he has not made an adequate test of his/her belief. This is because s/he did not rule out the possibility that also dorms outside the city center will find customers. But if the main goal is to avoid enlisting dorms that do not find customers, proving him-/herself right with regard to the city center dorms suffices. Not enlisting dorms outside the city center does not invalidate the choice to just enlist city center dorms. The positive test strategy, however, comes

Problems in testing beliefs are exacerbated because feedback is inevitably collected from parties with incomplete information. Whether industry experts, prospective clients, suppliers, or capital providers, these individuals are not equipped with a full grasp of the belief's structure and theoretical composition (Dimov, 2010; McBride & Wuebker, 2020; McMullen & Shepherd, 2006), which prompts Knight (1921, p. 251) to note that "The decisive factors in the case are so largely on the inside of the person making the decisions that the 'instances' are not amenable to objective description and external control." Particularly valuable beliefs are most often uncommon and contrarian. These attributes make a belief of greater potential value and often more difficult to imitate, but also render its value difficult to convey to others (Benner & Zenger, 2016), reducing the likelihood that the belief will receive external support and funding (Litov, Moreton, & Zenger, 2012). Of course, accessing feedback is also constrained by the fact that providing sufficient explanation to enable feedback, also enables the listener to "steal the idea, walk away with clients, or mimic the entrepreneur's management style, and start up a rival concern" (Rajan & Zingales, 2001, p. 805). To make matters worse, the most accessible sources of feedback, such as family and friends (Wood & McKinley, 2010), may provide overly favorable feedback (Zuckerman, Knee, Hodgins, & Miyake, 1995), rather than the more objective feedback comparative strangers might provide.

Doubt about false positives and false negatives in feedback. In light of the feedback distortions described above, the challenge for the entrepreneur in updating beliefs is to decide what feedback to believe and what feedback to doubt. As Dewey (1896, p. 106) indicates, "Now the response is not only uncertain, but the stimulus is equally uncertain." For instance, for the case of subletting student dorms, perhaps during an initial test launch, there was a festival in town that generated abnormally high demand, incorrectly suggesting success. Or perhaps the launch took place over the Christmas season during which there was abnormally low demand, incorrectly suggesting failure. Whether feedback is positive or negative, entrepreneurs will at least partly

with opportunity costs in that the entrepreneur potentially settles on a suboptimal belief and misses out on a more valuable belief.

remain in the dark about the validity of the feedback (Autio, Dahlander, & Frederiksen, 2013; Denrell & Fang, 2010). Despite testing, the outcome probability for the belief remains ambiguous (Kozyreva & Hertwig, 2019; Packard et al., 2017). Feedback ambiguity is tantamount to doubt about how closely feedback reveals the belief's fit in the market. The fact that feedback can teach the wrong lessons is well established in the learning literature, which suggests that feedback can lead to myopia and traps (Anand, Mulotte, & Ren, 2016; Levinthal & March, 1993), thereby challenging the entrepreneur to constantly reason from feedback received to its hidden causes.

Inconclusive, ambiguous feedback may bring the entrepreneur to pursue unviable beliefs, or abandon viable ones. Thus, feedback comes in two main forms of misrepresentation: false positives and false negatives (Klayman & Ha, 1987). A false positive or 'Type 1 error, also labeled an error of commission, is feedback that suggests a given assumption holds, when it does not (Christensen & Knudsen, 2010). For example, the market feedback for an idea is positive (hence $V(F) > 0$; $V(F)$ is the value of the belief as per evaluators) when in fact its value in the market is negative (hence $V(M) < 0$). False positives are costly as they falsely suggest pursuit of the belief will lead to success. In contrast, a false negative or type 2 error, also labeled an error of omission, is feedback that erroneously suggests pursuit of the belief will lead to failure. Airbnb co-founder Brian Chesky recounts receiving such false negatives; as he describes (2015; 13:09):

“So we were trying to sell 10% of the company for about \$150,000 and of the 15 people we got introduced to...I think about six, seven or eight of them didn't even reply to the email so we never heard from them again. About seven or eight replied, of those, half of them said, 'This doesn't fit my investment thesis.' Which is weird, because their investment thesis was like consumer internet companies, we were consumer internet. So, I assumed that we fit their thesis, but we didn't. Or they said the market wasn't big enough. One person said, 'I'm just not excited about travel as a category.' So we're like, 'Okay.' And then we ended up meeting a few more investors and they all passed on us.”

In responding to false negative feedback—a type 2 error, the entrepreneur misses a valuable opportunity but does not incur actual losses. In contrast, in responding to false positive feedback—a type 1 error, the entrepreneur incurs misguided investment and actual losses. Figure 3 illustrates the complete set of combinations of feedback and market values conceivable.

----- Insert Figure 3 about here -----

3. Responding and doubt about total error in the response

Responding. How should the entrepreneur thus synthesize the inconclusive feedback and respond? The entrepreneur's challenge is to decide whether to trust the feedback from testing. If feedback suggests low product-market fit, entrepreneurs must decide whether to revise the belief in hopes of generating a belief of higher fit and greater value (Harrison & Rouse, 2015), abandon the belief altogether, or seek new test data. The importance of belief updating has led Packard et al. (2017) to suggest that entrepreneurial judgment is not static or discrete, but involves experimentation, alterations, and learning. This self-directed creative belief revision is popularly referenced as "pivoting" (Grimes, 2018; Ries, 2011). The entrepreneur adopts a "stay-lose, shift-win" approach with a philosophy that under uncertainty having a completely fixed belief is ill-advised (Lohrke, Carson, & Lockamy, 2018).

However, there is abundant evidence that entrepreneurs are hesitant to update their beliefs, even in the face of unsupportive data. Several existing arguments explain this response. Composed experiments are often belief-specific and the investments required to build products or infrastructure necessary to conduct an experiment are lost if the entrepreneur chooses to change course. Similarly, entrepreneurs may fear that changing direction will cause resource providers to question their capacity as entrepreneurs (McDonald & Gao, 2019), and withdraw their contributions (Hampel, Tracey, & Weber, 2020). Moreover, imprinting effects often make strategies of new ventures inertial, because the strategy that an organization first adopts circumscribes later change (Milanov & Fernhaber, 2009). Relatedly, founders are concerned with externally-imposed changes to their ideas because such changes question the entrepreneur's identity and are literally "taken personally" by the entrepreneur (Grimes, 2018; Kirtley & O'Mahony, 2019). Our argument however is different. We suggest that because of uncertainty in the validity of feedback itself, or variance in how well matched experiments are to beliefs (Hacking, 1983), entrepreneurs may rationally decide that evidence challenging their belief is

insufficient to warrant updating it. Rather than pivot in response to challenging feedback, entrepreneurs may rationally decide to persist.

Doubt about total error in the response. Doubt in the response phase thus arises with regard to how extensively entrepreneurs should respond to feedback from testing. While insensitivity to negative feedback may divorce beliefs from reality and leave beliefs underfitting the data, a high level of adaptation may lead to beliefs that are modified to overfit the data. While in the former case, the entrepreneur disregards information about how to improve the belief, in the latter case the entrepreneur uncritically responds to noisy feedback. In the extreme case, the entrepreneur perfectly accommodates all feedback received, leading to an over-specified, suboptimal solution (Contigiani & Levinthal, 2019; Martignoni, Menon, & Siggelkow, 2016). Of course, the classic problem with an aggressive response to sample data is that the results that prompt this response will not be replicated in new, out-of-sample tests. Consider how this might play out in our case of subletting student dorms. Assume the entrepreneur tests the belief during the Christmas season and finds demand for large dorms that accommodate extended families. The entrepreneur may now be tempted to refocus the offering to register only large dorms for which demand is low during the rest of the year. The problem of overfitting is that in responding to current feedback, too many irrelevant features enter the belief, adding features that distract and unnecessarily tie up resources.

In synthesizing data from testing, entrepreneurs must therefore balance over- and underfitting to minimize total error in belief revision. Similar to the challenge of overfitting in machine learning (Choudhury, Allen, & Endres, 2018), entrepreneurs must choose between model complexity and parsimony (Tidhar & Eisenhardt, 2020; Varian, 2014).⁴ The inferential problem underlying this tension is a bias-variance tradeoff. The intuition is that entrepreneurs must decide how to modify and match their theories to problem spaces for which they do not

⁴ Dewey (1915, p. 510) already recognized this problem when suggesting that “to include too much, or what is irrelevant, is a violation of the demand for accuracy quite as well as to leave out—to fail to discover what is important.”

have the full data, but a biased sample. Highly-revised theories may have a high fit with the biased sample, but come at the cost of poorly explaining the full problem as reflected in the full data (Ehrig & Schmidt, 2021b). Overfitted models are tuned to statistical noise and overly complex. In contrast, simpler theories may capture the full problem space better, but at the cost of explaining less of the available sample (Varian, 2014). When entrepreneurs update their beliefs, “less is often more” in the sense that simple models may capture the underlying data structure better than complex ones (Hafenbrädl, Waeger, Marewski, & Gigerenzer, 2016). Entrepreneurs thus must strike a balance between a low and high level of precision in their responses to feedback, and hence balance overfitting (i.e. models with high variance) and underfitting (i.e. models with high bias) to minimize total error in updated beliefs (Figure 4).

----- Insert Figure 4 about here -----

HEURISTICS IN ENTREPRENEURIAL ACTION

As described above, the entrepreneurial mind is an inferential system that conjectures what could constitute a valuable belief and then updates based on feedback obtained from testing. With the help of this feedback the entrepreneur then minimizes the prediction error between belief and sampling. In this process of forming, testing and updating opportunity beliefs, the central challenge for the entrepreneur is how to diminish doubt—(1) doubt about the self-selected belief’s product-market fit, (2) doubt about false positives or false negatives in the feedback received from testing, and (3) doubt about whether updates to the belief are justified by the response data. In this sense, our entrepreneur acts much like a scientist who in seeking to understand some identified problem forms a theory but questions its veracity because it was self-selected, conducts experiments and gathers data but worries about its bias, and updates that theory but fears a response that either overfits or underfits the sample.

To streamline these efforts and mitigate the three types of doubts, entrepreneurs draw from a toolbox of inferential heuristics (Feduzi, Faulkner, Runde, Cabantous, & Loch, 2021; Goldstein & Gigerenzer, 2002; Hertwig et al., 2019). The categories of heuristics we propose are

matched to the inferential problems they are expected to solve, hence the three canonical doubts associated with the three categories of entrepreneurial action. Our discussion of heuristics thus focuses on the fit between a particular heuristic and the specific inferential problem it is meant to solve, taking into account the actual limitations in the available information as entrepreneurs progress from forming, to testing, to updating beliefs (e.g., Artinger, Petersen, Gigerenzer, & Weibler, 2015; Bingham & Eisenhardt, 2011; Gavetti, Levinthal, & Rivkin, 2005).

Belief formation heuristics. Belief formation heuristics streamline the entrepreneur's efforts to form valuable opportunity beliefs with a high level of product-market fit prior to testing in the market. Such heuristics push entrepreneurs to carefully formulate a distinct problem and then craft a logically clear, compelling, and novel theory about how to solve it. One heuristic that pushes the entrepreneur toward novelty in beliefs asks a question like: "What important truth do very few people agree with you on?" (Thiel & Masters, 2014), which may prompt responses of the form: "Most people believe in X, but the truth is Y." Such a heuristic often illuminates the source of novelty in a belief. Of course, with the source of novelty highlighted, the entrepreneur can now focus on logically supporting why Y is indeed correct, and why X is not, to justify that this novelty indeed implies value (O'Hagan et al., 2006).

Consistent with standard guidance to scientists on theory building, entrepreneurs should follow the heuristic to make assumptions explicit (Hacking, 1983). This task may be supported by answering questions such as "To justify this business idea, I must assume the following ..." or "What has to be true for the belief to work?" and "What technical obstacles do I need to overcome to be able to produce my product?" (Felin et al., 2020). Framing the opportunity belief in this transparent, well-structured way facilitates the assessment of the plausibility of assumptions on market needs and on the feasibility of product features. In specifying key assumptions underlying their beliefs, entrepreneurs need to bear in mind that inference under uncertainty works best with a sparse set of cues, such as with one to three key elements of a belief (Artinger et al., 2015; Karelaia & Hogarth, 2008).

Of course, there are some widely used tools like formal business plans or the business model canvas that seek to provide some structure to the process of composing and presenting a belief (Delmar & Shane, 2003; Osterwalder & Pigneur, 2010). Depending on how well these tools are implemented, they may help illuminate the inner causal structure and coherence of a belief, and help the entrepreneur recognize inconsistencies or omitted variables, and make the belief more amenable to interpretable testing in a next step. Such self-explanation has been found to be positively related to individual achievement with other uncertain tasks because it gives actors occasions to see conflicts in the causal structure of their arguments, motivate the integration of new information, which helps avoid blind spots and omitted variable problems (Chi et al., 1994).

To streamline the theory development process and to address endogeneity issues in belief formation, entrepreneurs may also benefit from engaging in ethnographic customer interviews and observations, thus conducting empathetic vicarious mental simulations of others' experience (Packard & Burnham, 2021), through which entrepreneurs seek to understand deep underlying needs and problems in the market (Grandori, 2010), emotional expressions of dissatisfaction with existing offerings (pain points), and ideas about how to improve the situation (Camuffo et al., 2020). Airbnb's Chesky again provides an illustration:

“I think learning how to move forward changes from intuition to being data informed. Because I think when you're starting and building a product, I think data is not the most important thing. I know people do a lot of A/B tests to try to figure out a product. I really feel like pre-product market fit data is not the most important thing. It wasn't for us. We were really going off of person-to-person interactions.” (Chesky, 2015; 54:49).⁵

⁵ Brian Chesky (2015; 10:23) further describes his compassionate customer interaction which allowed him to better grasp the problem in the market: “At the time, there was no payments and you had to stay in an airbed. And a bunch of people was telling me a bunch of things. They said, “Why do I have to ... like, I want to go to London, but there's no conference.” And we're like, “Why does this have to be for conferences?” At the time, that wasn't even obvious. Why would anyone stay in anyone's home if there wasn't a conference? It would be too weird. And then we thought, “Wait, why does it have to be on air beds?” At the time actually, we had a rule. You had to have an air bed, so you had to inflate an air bed and put it on your mattress. And everybody was like, “Why am I putting air beds on my mattress? It's so uncomfortable. And I wake up on one side of the bed and I wake up and the other it's like rolled around me, it's hot.” We're like, “OK, fine. You don't need to have an air mattress. You may have a real bed.”

The essence of such a theory building exercise can then be summarized in a value proposition composed of the market targeted, the problem market participants face, and finally how the belief promises to solve that problem.

Taken together, while entrepreneurs are unable to engage in an exhaustive search for the opportunity belief with highest value, entrepreneurs can, with the aid of the heuristics and tools described above, engage in an exercise to develop a deep understanding of the problem space and a consistent causal structure about how the proposed product addresses it. In the hope of at least partially addressing the fact that beliefs are self-selected, the goal is to come up with more informative beliefs (Gelman et al., 2013; McCann & Schwab, 2020)—beliefs that are supported by a coherent, qualitatively informed, causal architecture of assumptions on market needs and product features that promise to fit the market.

Testing heuristics. Entrepreneurs deploy testing heuristics to counter the ambiguous feedback they receive, seeking to detect and reduce both type 1 and type 2 errors in their response decisions. By deploying testing heuristics, entrepreneurs more efficiently spot true opportunities and more quickly exit worthless beliefs (Joseph & Gaba, 2020). A challenge for the entrepreneur is that product features are seldom simply additive in their capacity to solve a targeted problem, but rather demonstrate complementarity in patterns unknown to the entrepreneur *ex ante*. The challenge is thus to compose a testing strategy that validates and provides feedback on the causal structure inherent to a belief. This may require the entrepreneur to deploy testing heuristics such as a series of A/B tests that map product features to demand, thereby effectively ranking features (Camuffo et al., 2020), and allowing startups to either scale or fail faster (Koning, Hasan, & Chatterji, 2019).

Rent a Runway (RTR), an online service that rents designer dresses, is an interesting case regarding the deployment and sequencing of experiments. Eisenmann and colleagues (2012) report that in a first test the RTR founders borrowed dresses and invited undergraduates to “trunk shows” where they could rent the dresses. From this test, the founders learned that

women would rent previously worn dresses and would return them undamaged, which were key assumptions of their belief. However, this first test had not provided feedback on another key assumption, namely whether women would rent dresses online, without being able to try them on? At a second trunk show, women could then view, but not try on the dresses. Hence, the RTR founders iteratively tested key assumptions underlying their belief in discrete experiments that provided rather unambiguous feedback. The RTR example reminds us that in designing experiments and in evaluating feedback, entrepreneurs should look for signals with important effect size (Feldman & Friston, 2010; Thomke & Manzi, 2014), especially on the sparse key assumptions about demand and about key features underlying the belief. Efforts to validate too many elements at once impair the capacity to determine causal linkages between need-feature combinations and value in the market (Ott & Eisenhardt, 2020).

Another central challenge in belief testing is ensuring that those providing feedback have sufficient understanding of the belief to generate worthwhile feedback. To increase the odds of useful feedback, the entrepreneur may deploy a testing heuristic such as drafting a pitch deck or developing a minimum viable product or prototype (Ries, 2011). These artifacts need to provide a sufficiently robust compilation of features to allow an evaluation of their value generating capacity in aggregate (Berglund, Bousfiha, & Mansoori, 2020; Nicolini, Mengis, & Swan, 2012). Entrepreneurs may also point at an analogous, established offering (e.g., “we are the Airbnb for student dorms”), which provides evaluators with an interpretive frame to develop a more informed understanding about the value of the belief (Gavetti et al., 2005).

While experiments and artifacts help generate valid feedback on product-market fit, they say little about clients’ willingness to pay and on the costs associated with the offering. To access such feedback, entrepreneurs may deploy tools such as unit economics analysis that examines the value of a single client using the product, calculated as the customer lifetime value generated with a single client minus the costs to acquire that client. Lingering uncertainty around product market fit and the belief’s value may encourage entrepreneurs to adopt staged investments that

progressively improve feedback quality from belief testing and minimize losses from pursuing poor beliefs (Dew, Sarasvathy, Read, & Wiltbank, 2009). In this way, entrepreneurs progressively illuminate the fit and value of the causal architecture that undergirds their beliefs.

In testing their beliefs and in assembling and interpreting feedback, entrepreneurs must be aware of both their own and evaluators' limits. Entrepreneurs must recognize their own tendency to highlight feedback that verifies their ideas and ignore feedback that invalidates them. They must also recognize that feedback is limited by evaluators' inability to imagine precisely what the entrepreneur sees and can articulate, and by evaluators' inability to effectively respond to what is not presented to them (Cao, Koning, & Nanda, 2021; Thomke & Manzi, 2014). False positives may also result from a tendency of evaluators to simply acquiesce, providing socially desirable responses in the form of more yes than no answers to the entrepreneur's often confirmatory questions about the belief's attractiveness (Zuckerman et al., 1995). Hence, as a productive heuristic, entrepreneurs are wise to give greater weight to feedback from those without a vested interest in the venture's success or failure.

Of course, the field of statistics provides its own set of heuristics around optimal sample sizes from which to draw inferences. Larger samples increase the power of statistical tests because larger samples more accurately represent the total population (Van Voorhis & Morgan, 2007). Because the collection of feedback is expensive, the entrepreneur must strike a balance between generating sufficient power and the costs associated with garnering large samples. In this context, entrepreneurs deploy a heuristic like take up the least costly experiment first (Agrawal, Gans, & Stern, 2021), or sequence experiments by testing first a theory's weakest assumption before moving to the next weakest (Ehrig & Schmidt, 2021a).

Finally, entrepreneurs need to be mindful of the interconnectedness of type 1 and type 2 errors. To avoid type 1 errors and forestall errant entry, entrepreneurs may be tempted to set high thresholds of support or expected value before deciding to invest or pursue an idea. Doing so reduces the likelihood of type 1 errors, which is equivalent to increasing $V(F)$ in Figure 3.

However, increasing selectivity in belief pursuit is not cost free, because it increases the likelihood of type 2 errors—missing out on valuable opportunities (see Figure 3). In other words, from concerns over sinking the boat, the entrepreneur risks missing the boat (Mullins & Forlani, 2005). Hence, an important testing heuristic is to define an appropriate threshold for a belief to be retained versus rejected. In this vein, Camuffo et al. (2020) reports that a commonly used decision rule is to retain a belief if more than 60% of the evaluators provide corroborating evidence from a sample of 50, while Csaszar et al. (2006) suggests an approval threshold of 80% for retaining a belief and a 40% threshold for rejecting or revising it.

Response heuristics. Response heuristics assist the entrepreneur in avoiding under- and in particular over-fitting their belief to the available data generated through testing. The problem of overfitting arises when entrepreneurs errantly tune their beliefs to available feedback data. In doing so, they fit their theories to the error terms instead of the true structure of the data. Just as observed for scientists, entrepreneurs who overfit to the feedback become myopically focused on finding statistically significant results, and often fail to understand the practical and theoretical importance of their findings (Bettis, 2012).

The fundamental tradeoff for the entrepreneur is to balance between minimizing bias and minimizing variance. The essence of the tradeoff lies in the fact that underfitted models suffer from biased performance, as they only weakly capture the structure of the full data, while models that fit the sample data very well suffer from high variance as they are tightly tuned to that sample (Geman, Bienenstock, & Doursat, 1992). Gigerenzer and Brighton (2009, p. 120) summarize the balancing between bias (from adopting simple beliefs with few assumptions) and variance (from adopting complex beliefs with a multitude of assumptions) by stating that “the more uncertain the criterion is, or the smaller the sample size available, the more a cognitive system needs to protect itself from variance over bias” (Gigerenzer & Brighton, 2009, p. 125). Hence, in the response phase the need for replacing very detailed versions of the belief with more abstract ones is not primarily about securing strategic flexibility or maintaining neural plasticity (Bingham &

Eisenhardt, 2011), but about curbing variance in the refined model by avoiding overfitting, essentially composing a belief that scales beyond the original feedback sample.

In navigating this dilemma between bias and variance reduction in responding to feedback, entrepreneurs have two options, namely (1) to partition the sample, or (2) to purposefully introduce bias. Partitioning the sample into sufficiently large subsamples allows the entrepreneur to tune the belief to multiple subclasses of the data (Goldfarb & King, 2016), such as by creating multiple customer cohorts to allow systematic feedback comparison across these cohorts. In analogy to cross validation and regularization techniques from machine learning (Choudhury et al., 2018), the idea is that a first version of the intended product may be conceptualized with the aid of a sample that is different from the sample used to test it. Of course, higher numbers of partitions can be created, such as in the case of k-folds cross-validation, whereby the parameter estimates are averaged across all samples for the final estimate.

As an illustration, consider how the founders of Rent the Runway engaged in sequential cohort analysis: at the first show about 1/3 of 125 attendees rented dresses. From these rentals the founders learned about which brands, sizes, styles, colors, and price points were popular with early adopters. At a second show, women could view but not try on the dresses before renting. As Eisenmann and colleagues (2012) report, about 3/4 of attendants rented in this trial, which offered more of the style that had been popular in the first test. By comparing the unit economics of early and later client cohorts in terms of customer retention, customer acquisition costs, and sales, the entrepreneurs observed the progress they made from modifying the product.

Entrepreneurs' alternative to sample partitioning is to introduce bias, hence making bets on which patterns will persist and which will not in the out of sample data (Geman et al., 1992). To “keep variance within acceptable limits” (Gigerenzer & Brighton, 2009, p. 121), entrepreneurs may adopt heuristics that seek parsimony and work with little past information. When adopting such frugal heuristics the entrepreneur's response becomes partly insensitive to the peculiarities of the sample available, which reduces the risk of overfitting by introducing bias (Gigerenzer,

2019; Gigerenzer & Brighton, 2009). In other words, the refined belief is not optimized in respect to every result revealed in testing (Ott & Eisenhardt, 2020), but rather the product is pruned and simplified to avoid overcomplexity in the response (Bingham & Eisenhardt, 2011).

To discriminate between alternatives in responding to feedback, entrepreneurs may draw from frugal heuristics such as take the best (“take what appears to be the dominating option”); take the first successful (“a bird in the hand is worth two in the bush”); equal allotment (“do not put all eggs in one basket”); or focus on non-compensatory features (“consider the feedback on assumptions about needs or features that cannot be outweighed by an individual other cue or the combination of other cues”) (Artinger et al., 2015; Gigerenzer, 2019; Volz & Gigerenzer, 2012).

To determine the extent of belief updating, the entrepreneur may refer to similarity based heuristics (Artinger et al., 2015), such as updating towards imitating analogical successful offerings (“take the option that you recognize”) (Gavetti et al., 2005); satisfice (“update until the product is good enough”) (Grandori, 2010; Savage, 1954); update taking into account the affordable loss (“don’t throw good money after bad money”) (Dew et al., 2009); or combine such heuristics (Åstebro & Elhedhli, 2006). These heuristics provide a basis for the decision of which way to go in responding by providing a rule when to stop searching for a (presumably) better solution.

----- Insert Table 2 about here -----

DISCUSSION

The purpose of this paper has been to clarify how entrepreneurs by deploying action produce value out of uncertainty (Shepherd, 2015). We suggest that entrepreneurs act like scientists who address uncertainty by composing theories (Felin & Zenger, 2009) and then testing them. Building on pragmatism and Bayesian rationality, we depict entrepreneurs as economic actors who endogenously populate a belief about what could constitute an opportunity. Then, by acting in the world to gather relevant data, entrepreneurs test their beliefs (Feldman & Friston, 2010), generating feedback from which they update their beliefs and respond.

Our paper contributes towards a theory of entrepreneurial action by clarifying its pragmatist foundations, and by breaking down entrepreneurial action into three constituent categories, belief formation, testing, and response. Through these categories of action entrepreneurs actively capitalize on and then reduce uncertainty, thereby progressively removing doubt about the capacity to create value under uncertainty. With each of these actions, doubts of differing form remain, which explains why, despite the deployment of sophisticated action, entrepreneurship remains failure prone. First, the beliefs that entrepreneurs initially form are largely self-generated from an indefinite range of possibilities. This self-selected choice of beliefs therefore generates endogenous uncertainty and doubt about their fit in the market. Second, entrepreneurs are unable to effectively communicate the structure of their beliefs to third party resource holders, who may in turn provide biased feedback, leading to the possibility of errant rejection (false negatives) and errant acceptance (false positives). And third, when deciding how to update beliefs in response to feedback drawn from a biased sample, the entrepreneur faces an uncertain tradeoff between variance and bias in the response.

Previous work on entrepreneurial action stresses a progression from subjective to objective perceptions of opportunities (e.g., McBride & Wuebker, 2020; McMullen & Shepherd, 2006), points to a series of actions required (e.g., Autio et al., 2013; Gartner, 1985; Packard et al., 2017), and discusses the problem of (im)mitigable uncertainty (e.g., Packard & Clark, 2020a; Packard & Clark, 2020b; Rindova & Courtney, 2020). We integrate these discussions and elucidate how entrepreneurs both exploit uncertainty inherent to novel configurations of resources, and reduce uncertainty as it stands in the way of efforts to exploit the value that entrepreneurs believe exists in these new configurations. The transition from subjective to objective value takes place through a pragmatic scientific process of belief formation, testing and responding, and not some up front objectivation effort that fails to generate the data necessary to overcome doubt.

Our theorizing sides with Arrow (1951) in diminishing the risk vs. uncertainty distinction. As Arrow (1951, p. 417) notes “Knight’s uncertainties seem to have surprisingly many of the

properties of ordinary probabilities, and it is not clear how much is gained by the distinction” (see also Rindova & Courtney, 2020). We do though concur with Knight’s conclusion that coping with uncertainty demands imagination and judgment. However, uncertainty as a concept has played a problematic role in entrepreneurship, as it has led many to conclude that not much can be done in the face of it other than rather blindly explore (Rapp & Olbrich, 2020), and that entrepreneurs must humbly accept this. We take issue with such fatalistic conclusions. We view successful entrepreneurs as astute managers and exploiters of uncertainty, and not just uncertainty mitigators, the dominant paradigm today (Menon, 2018). We see entrepreneurship as a knowledge problem with a double twist. As a first step, the entrepreneur must compose a novel belief or theory thereby creating a new element of uncertainty—a conjecture whose value is inherently uncertain. Thereafter, the entrepreneur tests and responds, generating the information necessary to determine whether the belief actually represents a valuable entrepreneurial opportunity (Rindova & Courtney, 2020). Via belief formation, testing and responding, entrepreneurs thus diminish uncertainty to a point where assigning probabilities to the outcomes of actions, albeit with lingering doubts, becomes possible. We thus agree with Packard and Clark (2020b, p. 10) who suggest that “while risk is, inherently, mitigable, much of Knightian uncertainty is also.” Our paper begins to suggest how this is done.

Belief formation, testing and response supported by attendant heuristics provide entrepreneurs with the pragmatic scientific means to deal with the uncertainty germane to entrepreneurship. These heuristics support each of the critical categories of entrepreneurial action, namely forming a compelling belief while reducing bias imposed by its self-creation, testing the belief with useful evidence while avoiding false positives and false negatives in feedback, and carefully updating the belief while balancing over- versus underfitting in response. While Eisenhardt and colleagues suggest that heuristics help capture opportunities and reduce error in the entrepreneurial process (Bingham, Eisenhardt, & Furr, 2007), we map heuristics to the critical entrepreneurial tasks they support (Bingham & Eisenhardt, 2011). We thus further

clarify the functional use of heuristics in entrepreneurship by making novel predictions about when in the process of value generation under uncertainty particular heuristics are effective (Artinger et al., 2015; Volz & Gigerenzer, 2012).

Bayesian rationality proves helpful in understanding entrepreneurial reasoning. Consistent with Bayesian logic, entrepreneurial action rests on beliefs or priors that are updated as entrepreneurs incorporate information they gather. Entrepreneurs start with a belief that often only they hold. They generate feedback from rather limited and potentially biased sources, leaving them keenly interested in effect sizes and degrees of belief, an outcome that is more difficult to achieve via frequentist approaches involving null hypothesis testing (Alvarez & Parker, 2009; Kruschke, Aguinis, & Joo, 2012). Bayesian thinking also proves fruitful as it makes us aware that it is not enough for the entrepreneur to test the feasibility or attractiveness of product features, for instance by ranking them through conjoint analysis. The entrepreneur must test the underlying assumptions about market needs upon which the logical structure of the belief rests—assumptions which if false invalidate the entire exercise.

We clarify the distinctiveness of an entrepreneur-as-scientist perspective from fundamentally objective and subjective perspectives of opportunities. We agree with the trend that entrepreneurs switch from more creative to more analytical action modes as they progress (Packard & Clark, 2020b; Packard et al., 2017; Sarasvathy, 2001). However, this should not be confounded with a deliberate change in strategy but evidence of an inferential process wherein entrepreneurs form beliefs, test, and update their beliefs. The pragmatist maxim with its focus on inferential practice (Putnam, 1995) suggests we should view entrepreneurship as the deployment of problem-focused practices through which beliefs are framed, asserted, tested, defended, perhaps rejected—and, eventually, come to be called valuable (Hsieh et al., 2007). While many people have beliefs and identify problems to solve, entrepreneurs are those who have opportunity beliefs held with sufficient conviction to generate a willingness to act upon these beliefs, that is,

to test them and then refine them. Certainty about the (in)existence of an opportunity is thus brought about by a visionary, agentic, and learning entrepreneur.

Our theorizing speaks to the popular “lean startup” perspective in entrepreneurship (Leatherbee & Katila, 2020; Ries, 2011; Shepherd & Gruber, 2021). As with lean startup, we see testing and pivoting as part of entrepreneurs’ repertoire of actions; in this way we contribute to a theoretical foundation for the lean startup perspective (Felin et al., 2019). However, the lean startup perspective underappreciates the value of thoughtfully crafting a theory amenable to efficient testing and careful feedback interpretation. What we call belief formation is not the spreading of bets to diversify risks over multiple beliefs, as advocated by lean startup (Ries, 2011). By pointing to the joint importance of assumptions on market needs and required product features underlying beliefs, i.e. what has to be critically true for the idea to work, we shed novel light on the design complexities and the quality of opportunity beliefs. While the lean startup approach emphasizes that entrepreneurs need to “act and learn”, our approach stresses that they need to “think, act and learn”. The primary concern for the entrepreneur is thus not acceleration and fast trial and error, as advocated in lean startup, because such a procedure likely leads to lower quality outcomes (Hartmann, Krabbe, & Spicer, 2019). The more appropriate entrepreneurial process often involves delaying feedback and pivots, as an entrepreneur carefully structures the problem that underlies a belief thereby enabling very low cost “thought experiments”, well composed physical experiments, and more effective interpretation of feedback (McDonald & Eisenhardt, 2020). Also, the lean startup perspective glosses over the inferential challenges tied to entrepreneurial action. Our discussion of false positives / false negatives in feedback reminds us that updating may be justified even in case of supportive feedback, and that updating may not be justified even with negative feedback, which explains why pivoting is a weak predictor of entrepreneurial success (Kirtley & O'Mahony, 2019). Relatedly, the lean startup approach fails to adequately acknowledge the problem of overfitting in responding.

Our paper also sheds novel light on the concept of product-market fit, a popular concept in practice, but one which unfortunately has attracted only limited attention in research (Grégoire & Shepherd, 2012; Grégoire et al., 2010). We define product-market fit as the extent to which the opportunity belief held by the entrepreneur matches the market's response. In statistical terms, we view product-market fit as the correlation between belief and market model, in line with lens model arguments. The belief's true value is proportional to this fit (Naman & Slevin, 1993; Zott & Amit, 2008). In turn, the entrepreneur's focus is not just on demand-side market conditions but on the fit of product and market (Ramoglou & Tsang, 2018), such that entrepreneurship is an exercise in fitting product and market (Gimmon & Levie, 2020).

Our theory speaks to a process perspective of entrepreneurship (Lichtenstein, Carter, Dooley, & Gartner, 2007; McMullen & Dimov, 2013) by depicting an inferential entrepreneurial process guided by a belief about an opportunity. We view beliefs as the primary level of analysis in entrepreneurship research (Foss & Klein, 2012; Ramoglou, Gartner, & Tsang, 2020). We agree with McBride and Wuebker (2020; p. 28) that a core task of the entrepreneur is “to push an idea, theory or plan from something epistemically subjective into the realm of epistemically objective”. While these authors emphasize the role of persuasion and rights allocation to motivate stakeholder buy in, we stress that the choice and development of a belief, and the inferential work required to find out about its value are at the core of the entrepreneurial process. Such efforts are central to yielding the persuasive beliefs that will enable resource accumulation. What we call entrepreneurial action is aligned with what Steyaert (2007) calls ‘entrepreneuring’, whereby a first cycle of belief formation, testing and responding may lead into a next cycle of action, such that the dependent variable becomes the independent in a next cycle (see also Dewey, 1938; Gartner, 2010). Our theorizing opens the door to explore the role of computational tools in entrepreneurship. While forming a plausible novel belief or a well formulated problem remains a strength of the human mind (see however Shrestha, He, Puranam, & von Krogh, 2021),

algorithmic and computational tools may augment testing efforts (such as by conducting online A/B tests) and help derive appropriate responses to bias-variance tradeoffs.

Our theorizing suggests that belief formation, testing, and response, are cumulatively important for entrepreneurial success (Lazear, 2004). Entrepreneurship without solid belief lacks focus, which will lead to an untargeted trial and error process (McBride & Wuebker, 2020). In turn, without careful testing, entrepreneurs risk cherishing false hopes. Finally, without astuteness in synthesizing feedback from testing, entrepreneurs likely settle on a suboptimal path forward. Hence, the entrepreneur's job is cognitively demanding because it requires creativity, interpersonal skills necessary for customer empathy, and also analytical flexibility (Hegde & Tumlinson, 2020), for which there is important recent evidence (Levine & Rubinstein, 2017). Variation in these skills should have bearing on the capacity of entrepreneurs to compose and pursue valuable beliefs. Our theory also points to three roles entrepreneurs play in advancing a belief toward value creation, namely as visionary (as a first believer in a new problem solution), as an evangelist (propagating the belief and building consensus around it), and as learner (willing to update what may be deeply held beliefs). Highlighting these roles may prove useful to research on personal attributes of entrepreneurs, and for research comparing solo versus team foundings (Leatherbee & Katila, 2020). This diversity of roles also reveals a particular challenge for the single entrepreneur who must combine these distinct roles, and illuminates the potential advantages of entrepreneurial teams where these roles may be split in complementary fashion.

Our paper informs literature on the micro-foundations of entrepreneurial strategy (Gans et al., 2019; Nickerson & Argyres, 2018), and about whether entrepreneurs primarily strategize by thinking (using cognitive structures to guide strategizing) or by doing (flexibly taking action) (Eisenhardt & Bingham, 2017; Ott & Eisenhardt, 2020). Our approach bridges these two perspectives, suggesting that a pragmatist or scientific approach to entrepreneurship will combine cognitive, agentic, and reflective approaches. We show how entrepreneurs develop mental representations that allow the generation of strategic foresight even under uncertainty (Csaszar &

Laureiro-Martínez, 2018; Csaszar & Levinthal, 2016). While the idea of bounded rationality has been influential in strategic management, we discuss how the entrepreneurial mind works to overcome its apparent boundedness (Alvarez & Porac, 2020; Csaszar, 2018). Our scientific perspective also picks up the idea and importance of theory building in the entrepreneurial process, as proposed in Felin and Zenger (2009; 2017). Here we particular emphasize that testing and updating of beliefs are also integral parts of the entrepreneurial process. In that way, our theory is about entrepreneurs as scientists, who are at once theorists and empiricists.

Practical contributions. Our paper is useful to practitioners by highlighting the importance of a logically consistent belief—one with product features consistent with articulated market needs, which urges entrepreneurs to think through the assumptions that are critical for an idea to work. Hence, the sequential deployment of (1) a value creation theory supported by testable hypotheses, (2) testing of these hypotheses, and (3) an effective response to update the belief provides the entrepreneur with a path to manage uncertainty and explore a belief's value. Our reflections on the inferential problems underlying the three steps, and the heuristics to address them, raise entrepreneurs' awareness about judgmental problems and empower entrepreneurs to address these problems.

Limitations and future research. One may argue that given the ill-structuredness of the entrepreneurship context, our paper is too empirical in spirit and proposes an overly scientific understanding of entrepreneurship. But if we accept that perceptual inference is how our mind works (Clark, 2013), then we view our approach as a rather logical and even unsurprising description for how entrepreneurship works. After all, as Hohwy (2013, p. 46) nicely argues: “the brain uses a kind of scientific-style trial and error method, and learns from its errors.” This idea is well aligned with evidence that entrepreneurs are both visionaries and realistic actors who test their beliefs and learn to succeed. Also, it may seem odd to argue that entrepreneurs infer or theorize, especially when Bayes' rule does not come naturally to us (Kahneman, Slovic, Slovic, & Tversky, 1982). But again, this is something our mind engages in subconsciously—it is something

we and entrepreneurs can do without knowing about Bayes (Hastie & Dawes, 2010; Lohrke et al., 2018; Oaksford & Chater, 2007). Further, our theory is built on the premise that entrepreneurial action is underpinned by reasoned intentionality, thereby paying less attention to non-deliberative, impulse-driven action (Hunt & Lerner, 2018; Lerner, Hunt, & Dimov, 2018). While we may argue that even impulsiveness results in some belief, future research may for instance compare product-market fit of reasoned versus impulse-driven entrepreneurial action.

Future research could also test the functionality of the three actions, their probabilistic problems, the usefulness of the proposed heuristics, and how boundary conditions such as well-being, experience, and ambiguity tolerance, just as intermittent reinforcement, entrepreneurs' identity, socialization pressures and also environmental uncertainty interfere in entrepreneurial action (Aldrich, 2020; Dimov, 2007; Gavetti et al., 2005; Zuzul & Tripsas, 2020). It also appears interesting to revisit the link between entrepreneurs' cognitive skills with entrepreneurs' capacity to pursue valuable beliefs. Furthermore, we encourage future research to study in more detail how the internal complexity of the business idea and the complexity of the market environment alter the effectiveness of entrepreneurial actions (Martignoni et al., 2016). We encourage future research to explore whether our reasoning generalizes beyond new venture creation. With their resource base, established firms may test simultaneously multiple and complex beliefs. Yet, established firms may not be as creative in coming up with new beliefs, and less flexible and fast in learning from feedback (Chesbrough & Tucci, 2020). For established firms, acceleration in the entrepreneurial process may be the main concern, while for nascent firms it may be deceleration, and thoughtful belief formation, testing and responding. Our understanding of entrepreneurship would also benefit from more research on the concept of product-market fit (Dennehy, Kasraian, O'Raghallaigh, & Conboy, 2016; Grégoire & Shepherd, 2012), and the link between fit and value. While the value of a belief is scaled by its product-market fit, this value should also hinge on the magnitude of the problem it solves in the market (Chattopadhyay, Glick, & Huber, 2001).

Conclusion. We propose that entrepreneurs commonly act under uncertainty, but by carefully composing theories that filter what they attend to, the experiments they run, and the updates they make from feedback, they increase their odds of value creation. While the future may be unknowable, it is neither unimaginable, nor fully untestable. Echoing the quote by Blaise Pascal at the outset of our paper, we believe that when entrepreneurs act like scientists it becomes quite certain that not everything must remain uncertain.

References

- Agrawal, A., Gans, J. S., & Stern, S. 2021. Enabling entrepreneurial choice. *Management Science*, forthcoming.
- Aldrich, H. 2020. Guidepost: What Sustains A Belief in Success Among the Unsuccessful? *Academy of Management Discoveries*(forthcoming).
- Aldrich, H. E., & Ruef, M. 2018. Unicorns, gazelles, and other distractions on the way to understanding real entrepreneurship in the United States. *Academy of Management Perspectives*, 32(4): 458-472.
- Alvarez, S., & Porac, J. 2020. Imagination, indeterminacy, and managerial choice at the limit of knowledge. *Academy of Management Review*, 45(4): 735-744.
- Alvarez, S. A., & Barney, J. B. 2007. Discovery and creation: alternative theories of entrepreneurial action. *Strategic Entrepreneurship Journal*, 1(1-2): 11-26.
- Alvarez, S. A., & Parker, S. C. 2009. Emerging Firms and the Allocation of Control Rights: A Bayesian Approach. *Academy of Management Review*, 34(2): 209-227.
- Anand, J., Mulotte, L., & Ren, C. R. 2016. Does experience imply learning? *Strategic Management Journal*, 37(7): 1395-1412.
- Argyris, C., & Schon, D. A. 1974. *Theory in practice: Increasing professional effectiveness*. Jossey-Bass.
- Arikan, A. M., Arikan, I., & Koparan, I. 2020. Creation Opportunities: Entrepreneurial Curiosity, Generative Cognition, and Knightian Uncertainty. *Academy of Management Review*, 45(4): 808-824.
- Arrow, K. J. 1951. Alternative approaches to the theory of choice in risk-taking situations. *Econometrica*, 19: 404-437.
- Arrow, K. J., & Debreu, G. 1954. Existence of an equilibrium for a competitive economy. *Econometrica*: 265-290.
- Artinger, F., Petersen, M., Gigerenzer, G., & Weibler, J. 2015. Heuristics as adaptive decision strategies in management. *Journal of Organizational Behavior*, 36(1): 33-52.
- Åstebro, T., & Elhedhli, S. 2006. The effectiveness of simple decision heuristics: Forecasting commercial success for early-stage ventures. *Management Science*, 52(3): 395-409.
- Autio, E., Dahlander, L., & Frederiksen, L. 2013. Information exposure, opportunity evaluation, and entrepreneurial action: An investigation of an online user community. *Academy of Management Journal*, 56(5): 1348-1371.
- Barney, J. B. 1986. Strategic factor markets: expectation, luck, and business strategy. *Management Science*, 32(10): 1231-1241.
- Barreto, I. 2012. Solving the entrepreneurial puzzle: The role of entrepreneurial interpretation in opportunity formation and related processes. *Journal of Management Studies*, 49(2): 356-380.
- Beckert, J. 2016. *Imagined futures: fictional expectations and capitalist dynamics*. Harvard University Press.
- Benner, M. J., & Zenger, T. 2016. The lemons problem in markets for strategy. *Strategy Science*, 1(2): 71-89.
- Berglund, H., Bousfiha, M., & Mansoori, Y. 2020. Opportunities as artifacts and entrepreneurship as design. *Academy of Management Review*, 45(4): 825-846.
- Bettis, R. A. 2012. The search for asterisks: Compromised statistical tests and flawed theories. *Strategic Management Journal*, 33(1): 108-113.
- Bhaskar, R. 1975. *A Realist theory of science*. Leeds: Blackwell Science.
- Bingham, C. B., & Eisenhardt, K. M. 2011. Rational heuristics: the 'simple rules' that strategists learn from process experience. *Strategic Management Journal*, 32(13): 1437-1464.
- Bingham, C. B., Eisenhardt, K. M., & Furr, N. R. 2007. What makes a process a capability? Heuristics, strategy, and effective capture of opportunities. *Strategic Entrepreneurship Journal*, 1(1-2): 27-47.
- Blank, S. 2013. Why the lean start-up changes everything. *Harvard Business Review*, 91(5): 63-72.
- Brunswick, E. 1956. *Perception and the representative design of psychological experiments*. Univ of California Press.
- Camuffo, A., Cordova, A., Gambardella, A., & Spina, C. 2020. A scientific approach to entrepreneurial decision making: Evidence from a randomized control trial. *Management Science*, 66(2): 564-586.

- Cao, R., Koning, R. M., & Nanda, R. 2021. Biased sampling of early users and the direction of startup innovation, *Working paper*. National Bureau of Economic Research.
- Casson, M. 1982. *The entrepreneur: An economic theory*. Rowman & Littlefield.
- Chattopadhyay, P., Glick, W. H., & Huber, G. P. 2001. Organizational actions in response to threats and opportunities. *Academy of Management Journal*, 44(5): 937-955.
- Chesbrough, H., & Tucci, C. L. 2020. The interplay between open innovation and lean startup, or, why large companies are not large versions of startups. *Strategic Management Review*, 1(2): 277-303.
- Chesky, B. 2015. Blitzscaling 18: Brian Chesky on Launching Airbnb and the Challenges of Scale. In R. Hoffmann (Ed.), *Stanford* Youtube: Stanford University.
- Chi, M. T., De Leeuw, N., Chiu, M.-H., & LaVancher, C. 1994. Eliciting self-explanations improves understanding. *Cognitive Science*, 18(3): 439-477.
- Chi, M. T., Feltovich, P. J., & Glaser, R. 1981. Categorization and representation of physics problems by experts and novices. *Cognitive Science*, 5(2): 121-152.
- Choudhury, P., Allen, R., & Endres, M. 2018. Developing theory using machine learning methods, *Working Paper*. Harvard Business School.
- Christensen, M., & Knudsen, T. 2010. Design of decision-making organizations. *Management Science*, 56(1): 71-89.
- Christensen, M., & Knudsen, T. 2020. Division of roles and endogenous specialization. *Industrial and Corporate Change*, 29(1): 105–124.
- Clark, A. 2013. Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences*, 36(3): 181-204.
- Contigiani, A., & Levinthal, D. A. 2019. Situating the construct of lean start-up: adjacent conversations and possible future directions. *Industrial and Corporate Change*, 28(3): 551-564.
- Cornelissen, J. P., & Clarke, J. S. 2010. Imagining and rationalizing opportunities: Inductive reasoning and the creation and justification of new ventures. *Academy of Management Review*, 35(4): 539-557.
- Csaszar, F., Nussbaum, M., & Sepulveda, M. 2006. Strategic and cognitive criteria for the selection of startups. *Technovation*, 26(2): 151-161.
- Csaszar, F. A. 2018. What makes a decision strategic? Strategic representations. *Strategy Science*, 3(4): 606-619.
- Csaszar, F. A., & Laureiro-Martínez, D. 2018. Individual and organizational antecedents of strategic foresight: A representational approach. *Strategy Science*, 3(3): 513-532.
- Csaszar, F. A., & Levinthal, D. A. 2016. Mental representation and the discovery of new strategies. *Strategic Management Journal*, 37(10): 2031-2049.
- Davidsson, P. 2015. Entrepreneurial opportunities and the entrepreneurship nexus: A re-conceptualization. *Journal of Business Venturing*, 30(5): 674-695.
- Delmar, F., & Shane, S. 2003. Does business planning facilitate the development of new ventures? *Strategic Management Journal*, 24(12): 1165-1185.
- Dennehy, D., Kasraian, L., O'Raghallaigh, P., & Conboy, K. 2016. *Product market fit frameworks for lean product development*. Paper presented at the Proceedings of R&D Management Conference.
- Denrell, J., & Fang, C. 2010. Predicting the next big thing: Success as a signal of poor judgment. *Management Science*, 56(10): 1653-1667.
- Denrell, J., Fang, C., & Winter, S. G. 2003. The economics of strategic opportunity. *Strategic Management Journal*, 24(10): 977-990.
- Dequech, D. 2011. Uncertainty: a typology and refinements of existing concepts. *Journal of Economic Issues*, 45(3): 621-640.
- Dew, N., Sarasvathy, S., Read, S., & Wiltbank, R. 2009. Affordable loss: Behavioral economic aspects of the plunge decision. *Strategic Entrepreneurship Journal*, 3(2): 105-126.
- Dewey, J. 1896. The reflex arc concept in psychology. *Psychological Review*, 3(4): 357.
- Dewey, J. 1910. *How we think*. Courier Corporation, reprint 1997.
- Dewey, J. 1915. The logic of judgments of practise. *The Journal of Philosophy, Psychology and Scientific Methods*, 12(19): 505-523.
- Dewey, J. 1936. *Democracy and education*. New York: MacMillan.
- Dewey, J. 1938. *Logic: The Theory of Inquiry*. Read Books.
- Dewey, J. 1939. Theory of valuation. *International encyclopedia of unified science*.

- Dimov, D. 2007. Beyond the Single-Person, Single-Insight Attribution in Understanding Entrepreneurial Opportunities. *Entrepreneurship: Theory & Practice*, 31(5): 713-731.
- Dimov, D. 2010. Nascent entrepreneurs and venture emergence: Opportunity confidence, human capital, and early planning. *Journal of Management Studies*, 47(6): 1123-1153.
- Dimov, D. 2011. Grappling With the Unbearable Elusiveness of Entrepreneurial Opportunities. *Entrepreneurship Theory and Practice*, 35(1): 57-81.
- Downey, H. K., Hellriegel, D., & Slocum Jr, J. W. 1975. Environmental uncertainty: The construct and its application. *Administrative Science Quarterly*, 20(4): 613-629.
- Ehrig, T., & Schmidt, J. 2021a. How Strategists Revise and Reconcile Theories About the Future of their Business. *Strategy Science*, forthcoming.
- Ehrig, T., & Schmidt, J. 2021b. Making biased but better predictions: The trade-offs strategists face when they learn and use heuristics. *Strategic Organization*, 19(2): 263-284.
- Eisenhardt, K. M., & Bingham, C. B. 2017. Superior strategy in entrepreneurial settings: Thinking, doing, and the logic of opportunity. *Strategy Science*, 2(4): 246-257.
- Eisenmann, T. R., Ries, E., & Dillard, S. 2012. Hypothesis-driven entrepreneurship: The lean startup. *Harvard Business School Entrepreneurial Management Case*(812-095).
- Ellsberg, D. 1961. Risk, ambiguity, and the Savage axioms. *Quarterly Journal of Economics*: 643-669.
- Emirbayer, M., & Mische, A. 1998. What is agency? *American Journal of Sociology*, 103(4): 962-1023.
- Feduzi, A., Faulkner, P., Runde, J., Cabantous, L., & Loch, C. 2021. Heuristic methods for updating small world representations in strategic situations of Knightian uncertainty. *Academy of Management Review*, forthcoming.
- Feldman, H., & Friston, K. 2010. Attention, uncertainty, and free-energy. *Frontiers in Human Neuroscience*, 4: 215.
- Felin, T., Gambardella, A., Stern, S., & Zenger, T. 2019. Lean startup and the business model: Experimentation revisited. *Long Range Planning*, forthcoming.
- Felin, T., Gambardella, A., & Zenger, T. 2020. Value Lab: The Science of Entrepreneurial Strategy. *Management & Business Review*, forthcoming.
- Felin, T., Kauffman, S., Mastrogiorgio, A., & Mastrogiorgio, M. 2016. Factor markets, actors, and affordances. *Industrial and Corporate Change*, 25(1): 133-147.
- Felin, T., Koenderink, J., & Krueger, J. I. 2017. Rationality, perception, and the all-seeing eye. *Psychonomic Bulletin & Review*, 24(4): 1040-1059.
- Felin, T., & Zenger, T. R. 2009. Entrepreneurs as theorists: on the origins of collective beliefs and novel strategies. *Strategic Entrepreneurship Journal*, 3(2): 127-146.
- Felin, T., & Zenger, T. R. 2017. The theory-based view: Economic actors as theorists. *Strategy Science*, 2(4): 258-271.
- Foss, N. J., & Klein, P. G. 2012. *Organizing entrepreneurial judgment: A new approach to the firm*. Cambridge: Cambridge University Press.
- Foss, N. J., & Klein, P. G. 2017. Entrepreneurial discovery or creation? In search of the middle ground. *Academy of Management Review*, 42(4): 733-736.
- Foss, N. J., Klein, P. G., & Bjørnskov, C. 2019. The context of entrepreneurial judgment: organizations, markets, and institutions. *Journal of Management Studies*, 56(6): 1197-1213.
- Foss, N. J., Klein, P. G., Lien, L., Zellweger, T., & Zenger, T. 2021. Ownership competence. *Strategic Management Journal*, 42(2): 302-328.
- Gans, J. S., Stern, S., & Wu, J. 2019. Foundations of entrepreneurial strategy. *Strategic Management Journal*, 40(5): 736-756.
- Gartner, W. B. 1985. A Conceptual Framework for Describing the Phenomenon of New Venture Creation. *Academy of Management Review*, 10(4): 696-706.
- Gartner, W. B. 2010. A new path to the waterfall: A narrative on a use of entrepreneurial narrative. *International Small Business Journal*, 28(1): 6-19.
- Gary, M. S., & Wood, R. E. 2011. Mental models, decision rules, and performance heterogeneity. *Strategic Management Journal*, 32(6): 569-594.
- Gavetti, G. 2005. Cognition and hierarchy: Rethinking the microfoundations of capabilities' development. *Organization Science*, 16(6): 599-617.
- Gavetti, G., Levinthal, D. A., & Rivkin, J. W. 2005. Strategy making in novel and complex worlds: The power of analogy. *Strategic Management Journal*, 26(8): 691-712.
- Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. 2013. *Bayesian data analysis*. CRC press.

- Geman, S., Bienenstock, E., & Doursat, R. 1992. Neural networks and the bias/variance dilemma. *Neural computation*, 4(1): 1-58.
- Gigerenzer, G. 2019. Axiomatic rationality and ecological rationality. *Synthese*: 1-18.
- Gigerenzer, G., & Brighton, H. 2009. Homo heuristics: Why biased minds make better inferences. *Topics in cognitive science*, 1(1): 107-143.
- Gimmon, E., & Levie, J. 2020. Early indicators of very long term venture performance: A 20 year panel study. *Academy of Management Discoveries*, forthcoming.
- Goldfarb, B., & King, A. A. 2016. Scientific apophenia in strategic management research: Significance tests & mistaken inference. *Strategic Management Journal*, 37(1): 167-176.
- Goldstein, D. G., & Gigerenzer, G. 2002. Models of ecological rationality: the recognition heuristic. *Psychological Review*, 109(1): 75.
- Grandori, A. 2010. A rational heuristic model of economic decision making. *Rationality and Society*, 22(4): 477-504.
- Grégoire, D. A., Corbett, A. C., & McMullen, J. S. 2011. The cognitive perspective in entrepreneurship: An agenda for future research. *Journal of Management Studies*, 48(6): 1443-1477.
- Grégoire, D. A., & Shepherd, D. A. 2012. Technology-market combinations and the identification of entrepreneurial opportunities: An investigation of the opportunity-individual nexus. *Academy of Management Journal*, 55(4): 753-785.
- Grégoire, D. A., Shepherd, D. A., & Schurer Lambert, L. 2010. Measuring opportunity-recognition beliefs: Illustrating and validating an experimental approach. *Organizational Research Methods*, 13(1): 114-145.
- Grimes, M. G. 2018. The pivot: How founders respond to feedback through idea and identity work. *Academy of Management Journal*, 61(5): 1692-1717.
- Gross, N. 2009. A pragmatist theory of social mechanisms. *American Sociological Review*, 74(3): 358-379.
- Gruber, M., MacMillan, I. C., & Thompson, J. D. 2008. Look before you leap: Market opportunity identification in emerging technology firms. *Management Science*, 54(9): 1652-1665.
- Hacking, I. 1983. *Representing and intervening: Introductory topics in the philosophy of natural science*. Cambridge University Press.
- Hafenbrädl, S., Waeger, D., Marewski, J. N., & Gigerenzer, G. 2016. Applied decision making with fast-and-frugal heuristics. *Journal of Applied Research in Memory and Cognition*, 5(2): 215-231.
- Hamilton, B. H., & Nickerson, J. A. 2003. Correcting for endogeneity in strategic management research. *Strategic Organization*, 1(1): 51-78.
- Hempel, C. E., Tracey, P., & Weber, K. 2020. The art of the pivot: How new ventures manage identification relationships with stakeholders as they change direction. *Academy of Management Journal*, 63(2): 440-471.
- Hands, D. W. 2006. Frank Knight and pragmatism. *The European Journal of the History of Economic Thought*, 13(4): 571-605.
- Harrison, S. H., & Rouse, E. D. 2015. An inductive study of feedback interactions over the course of creative projects. *Academy of Management Journal*, 58(2): 375-404.
- Hartmann, R. K., Krabbe, A. D., & Spicer, A. 2019. Towards an Untrepreneurial Economy? The Entrepreneurship Industry and the Rise of the Veblenian Entrepreneur. *Copenhagen Business School Working Paper*.
- Hastie, R., & Dawes, R. M. 2010. *Rational choice in an uncertain world: The psychology of judgment and decision making*. London: Sage.
- Hegde, D., & Tumlinson, J. 2020. Information frictions and entrepreneurship. *Strategic Management Journal*, forthcoming.
- Hertwig, R., Pleskac, T. J., & Pachur, T. 2019. *Taming uncertainty*. MIT Press.
- Hohwy, J. 2013. *The predictive mind*. Oxford University Press.
- Holm, H. J., Opper, S., & Nee, V. 2013. Entrepreneurs under uncertainty: An economic experiment in China. *Management Science*, 59(7): 1671-1687.
- Hsieh, C., Nickerson, J. A., & Zenger, T. R. 2007. Opportunity discovery, problem solving and a theory of the entrepreneurial firm. *Journal of Management Studies*, 44(7): 1255-1277.
- Hunt, R. A., & Lerner, D. A. 2018. Entrepreneurial action as human action: Sometimes judgment-driven, sometimes not. *Journal of Business Venturing Insights*, 10: e00102.
- James, W. 1890. *The principles of psychology*. New York: Holt.

- James, W. 1907. *Pragmatism: A New Name for some Old Ways of Thinking*. Cambridge, MA: Harvard University Press, 1975.
- James, W. 1908. The meaning of the word 'truth'. *Mind*, 17(3): 455-456.
- Joas, H. 1996. *The creativity of action*. University of Chicago Press.
- Joseph, J., & Gaba, V. 2020. Organizational structure, information processing, and decision-making: A retrospective and road map for research. *Academy of Management Annals*, 14(1): 267-302.
- Kahneman, D., Slovic, S. P., Slovic, P., & Tversky, A. 1982. *Judgment under uncertainty: Heuristics and biases*. Cambridge University Press.
- Karelaia, N., & Hogarth, R. M. 2008. Determinants of linear judgment: A meta-analysis of lens model studies. *Psychological Bulletin*, 134(3): 404.
- Kerr, W. R., Nanda, R., & Rhodes-Kropf, M. 2014. Entrepreneurship as experimentation. *Journal of Economic Perspectives*, 28(3): 25-48.
- Kier, A. S., & McMullen, J. S. 2018. Entrepreneurial imaginativeness in new venture ideation. *Academy of Management Journal*, 61(6): 2265-2295.
- Kier, A. S., & McMullen, J. S. 2020. Entrepreneurial imaginativeness and new venture ideation in newly forming teams. *Journal of Business Venturing*, 35(6): 106048.
- Kirtley, J., & O'Mahony, S. 2019. What is a pivot? Explaining when and how entrepreneurial firms decide to make strategic change and pivot. *Strategic Management Journal*, forthcoming.
- Klayman, J., & Ha, Y.-W. 1987. Confirmation, disconfirmation, and information in hypothesis testing. *Psychological Review*, 94(2): 211.
- Knight, F. 1921. *Risk, uncertainty and profit*. New York: August M. Kelley, reprinted 1985, page numbers refer to reprinted version.
- Knight, F. H. 1925. Economic psychology and the value problem. *Quarterly Journal of Economics*, 39(3): 372-409.
- Knill, D. C., & Richards, W. 1996. *Perception as Bayesian inference*. Cambridge University Press.
- Koning, R., Hasan, S., & Chatterji, A. 2019. Experimentation and startup performance: Evidence from A/B testing. *Working paper*. National Bureau of Economic Research.
- Kozyreva, A., & Hertwig, R. 2019. The interpretation of uncertainty in ecological rationality. *Synthese*: 1-31.
- Kraaijenbrink, J. 2012. The nature of the entrepreneurial process: causation, effectuation, and pragmatism. In A. Groen, Oakey, R., van der Sijde, P., Cook, G. (Ed.), *New Technology-Based Firms in the New Millennium*: 187-199: Emerald.
- Kruschke, J. K., Aguinis, H., & Joo, H. 2012. The time has come: Bayesian methods for data analysis in the organizational sciences. *Organizational Research Methods*, 15(4): 722-752.
- Langlois, R. N., & Cosgel, M. M. 1993. Frank Knight on risk, uncertainty, and the firm: a new interpretation. *Economic Inquiry*, 31(3): 456-465.
- Lazear, E. P. 2004. Balanced skills and entrepreneurship. *American Economic Review*, 94(2): 208-211.
- Leatherbee, M., & Katila, R. 2020. The Lean Startup Method: Early-Stage Teams And Hypothesis-Based Probing Of Business Ideas. *Strategic Entrepreneurship Journal*, 14(4): 570-593.
- Leiblein, M. J. 2011. What do resource-and capability-based theories propose? *Journal of Management*, 37(4): 909-932.
- Lerner, D. A., Hunt, R. A., & Dimov, D. 2018. Action! Moving beyond the intendedly-rational logics of entrepreneurship. *Journal of Business Venturing*, 33(1): 52-69.
- LeRoy, S. F., & Singell Jr, L. D. 1987. Knight on risk and uncertainty. *Journal of Political Economy*, 95(2): 394-406.
- Levine, R., & Rubinstein, Y. 2017. Smart and illicit: who becomes an entrepreneur and do they earn more? *Quarterly Journal of Economics*, 132(2): 963-1018.
- Levinthal, D., & March, J. G. 1993. The myopia of learning. *Strategic Management Journal*, 14(4): 95-112.
- Lichtenstein, B. B., Carter, N. M., Dooley, K. J., & Gartner, W. B. 2007. Complexity dynamics of nascent entrepreneurship. *Journal of Business Venturing*, 22(2): 236-261.
- Litov, L. P., Moreton, P., & Zenger, T. R. 2012. Corporate strategy, analyst coverage, and the uniqueness paradox. *Management Science*, 58(10): 1797-1815.
- Lohrke, F. T., Carson, C. M., & Lockamy, A. 2018. Bayesian analysis in entrepreneurship decision-making research. *Management Decision*, 56(5): 972-986.
- Luan, S., Reb, J., & Gigerenzer, G. 2019. Ecological rationality: Fast-and-frugal heuristics for managerial decision making under uncertainty. *Academy of Management Journal*, 62(6): 1735-1759.

- Martignoni, D., Menon, A., & Siggelkow, N. 2016. Consequences of misspecified mental models: Contrasting effects and the role of cognitive fit. *Strategic Management Journal*, 37(13): 2545-2568.
- McBride, R., & Wuebker, R. 2020. Social objectivity and entrepreneurial opportunities: implications for entrepreneurship and management. *Academy of Management Review*, forthcoming.
- McCann, B. T., & Schwab, A. 2020. Bayesian analysis in strategic management research: Time to update your priors. *Strategic Management Review*.
- McDonald, R., & Gao, C. 2019. Pivoting isn't enough? Managing strategic reorientation in new ventures. *Organization Science*, 30(6): 1289-1318.
- McDonald, R. M., & Eisenhardt, K. M. 2020. Parallel play: Startups, nascent markets, and effective business-model design. *Administrative Science Quarterly*, 65(2): 483-523.
- McMullen, J. S., & Dimov, D. 2013. Time and the entrepreneurial journey: The problems and promise of studying entrepreneurship as a process. *Journal of Management Studies*, 50(8): 1481-1512.
- McMullen, J. S., & Shepherd, D. A. 2006. Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur. *Academy of Management Review*, 31(1): 132-152.
- Menon, A. 2018. Bringing cognition into strategic interactions: Strategic mental models and open questions. *Strategic Management Journal*, 39(1): 168-192.
- Milanov, H., & Fernhaber, S. A. 2009. The impact of early imprinting on the evolution of new venture networks. *Journal of Business Venturing*, 24(1): 46-61.
- Miller, K. D., & Tsang, E. W. 2011. Testing management theories: critical realist philosophy and research methods. *Strategic Management Journal*, 32(2): 139-158.
- Milliken, F. J. 1987. Three Types of Perceived Uncertainty About the Environment: State, Effect, and Response Uncertainty. *Academy of Management Review*, 12(1): 133-143.
- Mintzberg, H., Raisinghani, D., & Theoret, A. 1976. The structure of "unstructured" decision processes. *Administrative Science Quarterly*, 21(2): 246-275.
- Mousavi, S., & Garrison, J. 2003. Toward a transactional theory of decision making: creative rationality as functional coordination in context. *Journal of Economic Methodology*, 10(2): 131-156.
- Mullins, J. W., & Forlani, D. 2005. Missing the boat or sinking the boat: a study of new venture decision making. *Journal of Business Venturing*, 20(1): 47-69.
- Murray, F., & Tripsas, M. 2004. The exploratory processes of entrepreneurial firms: The role of purposeful experimentation. *Advances in Strategic Management*, 21: 45-76.
- Naman, J. L., & Slevin, D. P. 1993. Entrepreneurship and the concept of fit: A model and empirical tests. *Strategic Management Journal*, 14(2): 137-153.
- Nash, S. 2003. On pragmatic philosophy and Knightian uncertainty. *Review of Social Economy*, 61(2): 251-272.
- Nash, S., & Rybak, L. 2010. On Logical Difficulties, Philosophy, and the TCE Explanation of the Firm. *Review of Social Economy*, 68(3): 339-363.
- Navarro, D. J., & Perfors, A. F. 2011. Hypothesis generation, sparse categories, and the positive test strategy. *Psychological Review*, 118(1): 120.
- Nickerson, J., & Argyres, N. 2018. Strategizing before strategic decision making. *Strategy Science*, 3(4): 592-605.
- Nicolini, D., Mengis, J., & Swan, J. 2012. Understanding the role of objects in cross-disciplinary collaboration. *Organization Science*, 23(3): 612-629.
- Nisbett, R. E., & Ross, L. 1980. *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.
- O'Hagan, A., Buck, C. E., Daneshkhah, A., Eiser, J. R., Garthwaite, P. H., Jenkinson, D. J., Oakley, J. E., & Rakow, T. 2006. *Uncertain judgements: eliciting experts' probabilities*. John Wiley & Sons.
- Oaksford, M., & Chater, N. 2007. *Bayesian rationality: The probabilistic approach to human reasoning*. Oxford University Press.
- Osterwalder, A., & Pigneur, Y. 2010. *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons.
- Ott, T. E., & Eisenhardt, K. M. 2020. Decision Weaving: Forming Novel, Complex Strategy in Entrepreneurial Settings. *Strategic Management Journal*, 41(12): 2275-2314.
- Ott, T. E., Eisenhardt, K. M., & Bingham, C. B. 2017. Strategy formation in entrepreneurial settings: Past insights and future directions. *Strategic Entrepreneurship Journal*, 11(3): 306-325.

- Packard, M. D., & Burnham, T. A. 2021. Do we understand each other? Toward a simulated empathy theory for entrepreneurship. *Journal of Business Venturing*, 36(1): 106076.
- Packard, M. D., & Clark, B. B. 2020a. Mitigating versus Managing Epistemic and Aleatory Uncertainty. *Academy of Management Review*, 45(4): 872-876.
- Packard, M. D., & Clark, B. B. 2020b. On the mitigability of uncertainty and the choice between predictive and non-predictive strategy. *Academy of Management Review*, 45(4): 766-786.
- Packard, M. D., Clark, B. B., & Klein, P. G. 2017. Uncertainty types and transitions in the entrepreneurial process. *Organization Science*, 28(5): 840-856.
- Peirce, C. S. 1931-1958. *Collected Works: Science and philosophy and Reviews, correspondence, and bibliography*. Belknap Press of Harvard University Press.
- Pindyck, R. S. 1993. Investments of uncertain cost. *Journal of Financial Economics*, 34(1): 53-76.
- Popper, K. R. 1972. *Objective knowledge*. Oxford University Press Oxford.
- Puranam, P., Stieglitz, N., Osman, M., & Pillutla, M. M. 2015. Modelling bounded rationality in organizations: Progress and prospects. *Academy of Management Annals*, 9(1): 337-392.
- Putnam, H. 1995. *Words and life*. Harvard University Press.
- Rajan, R. G., & Zingales, L. 2001. The firm as a dedicated hierarchy: A theory of the origins and growth of firms. *Quarterly Journal of Economics*, 116(3): 805-851.
- Ramoglou, S., Gartner, W. B., & Tsang, E. W. 2020. "Who is an entrepreneur?" is (still) the wrong question. *Journal of Business Venturing Insights*, 13: e00168.
- Ramoglou, S., & Tsang, E. W. 2016. A realist perspective of entrepreneurship: Opportunities as propensities. *Academy of Management Review*, 41(3): 410-434.
- Ramoglou, S., & Tsang, E. W. 2018. Opportunities lie in the demand side: transcending the discovery-creation debate. *Academy of Management Review*, 43(4): 815-818.
- Rapp, D. J., & Olbrich, M. 2020. On predictive entrepreneurial action in uncertain, ill-structured conditions. *Review of Managerial Science*: 1-19.
- Ries, E. 2011. *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Currency.
- Rindova, V., & Courtney, H. 2020. To shape or adapt: Knowledge problems, epistemologies and strategic postures under Knightian uncertainty. *Academy of Management Review*, forthcoming.
- Rothschild, E. 2013. *Economic sentiments*. Harvard University Press.
- Rubleske, J., & Berente, N. 2017. A pragmatist perspective on entrepreneurial opportunities. *International Journal of Innovation Science*, 9(2): 121-136.
- Sarasvathy, S. 2001. Causation and Effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. *Academy of Management Review*, 26(2): 243-263.
- Savage, L. L. 1954. *The foundations of statistics*. New York: Wiley.
- Sen, A. 1982. Rights and agency. *Philosophy & Public Affairs*: 3-39.
- Shane, S. A., & Venkataraman, S. 2000. The promise of entrepreneurship as a field of research. *Academy of Management Review*, 25(1): 217-226.
- Shepherd, D. A. 2015. Party On! A call for entrepreneurship research that is more interactive, activity based, cognitively hot, compassionate, and prosocial. *Journal of Business Venturing*, 30(4): 489-507.
- Shepherd, D. A., & Gruber, M. 2021. The lean startup framework: Closing the academic-practitioner divide. *Entrepreneurship Theory and Practice*, 45(5): 967-998.
- Shepherd, D. A., Haynie, J. M., & McMullen, J. S. 2012. Confirmatory search as a useful heuristic? Testing the veracity of entrepreneurial conjectures. *Journal of Business Venturing*, 27(6): 637-651.
- Shepherd, D. A., McMullen, J. S., & Jennings, P. D. 2007. The formation of opportunity beliefs: Overcoming ignorance and reducing doubt. *Strategic Entrepreneurship Journal*, 1(1-2): 75-95.
- Shepherd, D. A., & Zacharakis, A. 2002. Venture capitalists' expertise - A call for research into decision aids and cognitive feedback. *Journal of Business Venturing*, 17(1): 1-20.
- Shook, J. R. 2003. Entrepreneurship and values in a democratic and pragmatic economics: commentary on 'A transactional view of entrepreneurship'. *Journal of Economic Methodology*, 10(2): 181-190.
- Shrestha, Y. R., He, V. F., Puranam, P., & von Krogh, G. 2021. Algorithm supported induction for building theory: How can we use prediction models to theorize? *Organization Science*, 32(3): 856-880.
- Simon, H. A. 1996. *Models of my life*. MIT press.

- Smith, J. E. 1978. *Purpose and thought: The meaning of pragmatism*. Yale University Press New Haven.
- Steyaert, C. 2007. 'Entrepreneurship' as a conceptual attractor? A review of process theories in 20 years of entrepreneurship studies. *Entrepreneurship and regional development*, 19(6): 453-477.
- Thiel, P. A., & Masters, B. 2014. *Zero to one: Notes on startups, or how to build the future*. Currency.
- Thomas, R. P., Dougherty, M. R., Sprenger, A. M., & Harbison, J. 2008. Diagnostic hypothesis generation and human judgment. *Psychological Review*, 115(1): 155.
- Thomke, S., & Manzi, J. 2014. The Discipline of Business Experimentation. *Harvard Business Review*, 92(12): 70-79.
- Thorndike, E. L. 1962. *Psychology and the Science of Education: Selected Writings*. Bureau of Publications, Teachers College, Columbia University.
- Tidhar, R., & Eisenhardt, K. M. 2020. Get rich or die trying... Finding revenue model fit using machine learning and multiple cases. *Strategic Management Journal*, 41(7): 1245-1273.
- Todd, P. M., & Gigerenzer, G. E. 2012. *Ecological rationality: Intelligence in the world*. Oxford University Press.
- Tomlinson, S. 1997. Edward Lee Thorndike and John Dewey on the science of education. *Oxford Review of Education*, 23(3): 365-383.
- Townsend, D. M., Hunt, R. A., McMullen, J. S., & Sarasvathy, S. D. 2018. Uncertainty, knowledge problems, and entrepreneurial action. *Academy of Management Annals*, 12(2): 659-687.
- Van den Steen, E. 2005. Organizational beliefs and managerial vision. *Journal of Law, Economics, and Organization*, 21(1): 256-283.
- Van den Steen, E. 2010. Interpersonal Authority in a Theory of the Firm. *American Economic Review*, 100(1): 466-490.
- Van den Steen, E. 2017. Strategy and the strategist: How it matters who develops the strategy. *Management Science*, 64(10): 4533-4551.
- Van Voorhis, C. W., & Morgan, B. L. 2007. Understanding power and rules of thumb for determining sample sizes. *Tutorials in quantitative methods for psychology*, 3(2): 43-50.
- Varian, H. R. 2014. Big data: New tricks for econometrics. *Journal of Economic Perspectives*, 28(2): 3-28.
- Volz, K. G., & Gigerenzer, G. 2012. Cognitive processes in decisions under risk are not the same as in decisions under uncertainty. *Frontiers in Neuroscience*, 6(105): 1-6.
- Walker, W. E., Harremoës, P., Rotmans, J., Van Der Sluijs, J. P., Van Asselt, M. B., Janssen, P., & Krayen von Krauss, M. P. 2003. Defining uncertainty: a conceptual basis for uncertainty management in model-based decision support. *Integrated Assessment*, 4(1): 5-17.
- Watson, T. J. 2013. Entrepreneurial action and the Euro-American social science tradition: pragmatism, realism and looking beyond 'the entrepreneur'. *Entrepreneurship & Regional Development*, 25(1-2): 16-33.
- Williams, D. W., & Wood, M. S. 2015. Rule-based reasoning for understanding opportunity evaluation. *Academy of Management Perspectives*, 29(2): 218-236.
- Wilson, A. B. 2016. *Peirce's Empiricism: Its Roots and Its Originality*. Lexington Books.
- Wood, M. S., & McKelvie, A. 2015. Opportunity evaluation as future focused cognition: Identifying conceptual themes and empirical trends. *International Journal of Management Reviews*, 17(2): 256-277.
- Wood, M. S., McKelvie, A., & Haynie, J. M. 2014. Making it personal: Opportunity individuation and the shaping of opportunity beliefs. *Journal of Business Venturing*, 29(2): 252-272.
- Wood, M. S., & McKinley, W. 2010. The production of entrepreneurial opportunity: a constructivist perspective. *Strategic Entrepreneurship Journal*, 4(1): 66-84.
- Zott, C., & Amit, R. 2008. The fit between product market strategy and business model: Implications for firm performance. *Strategic Management Journal*, 29(1): 1-26.
- Zuckerman, M., Knee, C. R., Hodgins, H. S., & Miyake, K. 1995. Hypothesis confirmation: The joint effect of positive test strategy and acquiescence response set. *Journal of Personality and Social Psychology*, 68(1): 52.
- Zuzul, T., & Tripsas, M. 2020. Start-up inertia versus flexibility: The role of founder identity in a nascent industry. *Administrative Science Quarterly*, 65(2): 395-433.

Table 1: Distinctiveness of scientific from causal and effectual perspectives of entrepreneurship

	Causal	Scientific	Effectual
Main problem faced by entrepreneur	Discovery of opportunity	Uncertain value of belief	Contingency of resources
View of opportunity	Objective	Tentative	Subjective
How to deal with uncertainty	Reduce uncertainty	Exploit and then reduce uncertainty	Exploit uncertainty
Organizational focus	Opportunity	Belief	Resources
Main cognitive task	Alertness to opportunities	Fitting of belief to the market	Creativity of resource configuration
Relationship between resources and business idea	Entrepreneur searches for the resources required to realize opportunity	Entrepreneur sees resources and ends as mutually contingent	Entrepreneur comes up with possible ends considering available resources
Value of resources	Objective	Belief-specific	Subjective
Entrepreneurial actions	Find valuable opportunity, then exploit it	Belief formation, testing, responding	Explore affordances of available means, deploy control mechanisms

Table 2: Belief formation, testing, and response

Action	Doubt	Inferential problem	Heuristics to overcome doubts and inferential problems
<p><i>Belief formation</i></p> <p>Generate opportunity belief</p>	<p><i>Product-market fit:</i></p> <p>Doubt about product-market fit</p>	<p>Endogenous uncertainty: underfitting of opportunity belief in its environment</p>	<ul style="list-style-type: none"> - Elicit novel belief via suggestive question: “What important truth do few people agree with you on?” Try to defend the novel belief by specifying why you are right and other people wrong about the belief - Conduct belief-building qualitative, empathetic interviews on underlying needs, pain points and problems in the target market - Specify (1) assumptions about unmet needs in the market and (2) required product features and their feasibility to meet these needs - Specify what has to be true for the belief to work: “Given the idea, I assume that ...” - Compose business model canvas or business plan to keep assumptions on market needs and product features in sight, assess their consistency and avoid blind spots - Specify value proposition: (1) the market targeted, (2) the problems or unmet needs that participants in this market face, (3) the belief, composed of assumptions on market needs and product features
<p><i>Belief testing</i></p> <p>Test the belief and analyze feedback</p>	<p><i>Feedback ambiguity:</i></p> <p>Doubt about validity of feedback</p>	<p>False positives or false negatives in feedback</p>	<ul style="list-style-type: none"> - Experiment: A/B tests to identify causal feature-demand relationship, rank product features, disentangle inter-feature correlations - Start with least costly and most informative experiments, on key assumptions - Create artifact of belief, such as prototype, minimum viable product or pitch deck; refer to analogous offering - Analyze feedback from key clients and independent parties; focus on feedback with high effect size - Consider entrepreneurs’ own tendency to seek verification; and lack of imagination and acquiescence tendency by third party evaluators - Analyze unit economics, such as customer lifetime value - customer acquisition costs - Stage investment into belief - Sample size with enough power: the larger the number of cues to be tested, the larger the required sample - Consider connection between Type 1 and 2 errors: Define approval threshold for belief to be retained (e.g., min. 70%), and refusal threshold for belief to be rejected or revised (e.g., max. 40% approval rate)
<p><i>Responding</i></p> <p>Halt, keep, or update belief</p>	<p><i>Response error:</i></p> <p>Doubt about total error of revised belief</p>	<p>Bias-variance tradeoff tied to over- and underfitting in the response</p>	<ul style="list-style-type: none"> - Partition sample: replicate testing on different client cohorts, compare unit economics across cohorts, deploy machine learning to minimize total error in the response - Introduce bias, by deploying frugal heuristics: To discriminate between alternatives, take the best, take the first successful, equal allotment, focus on non-compensatory features. To determine extent of belief updating, update towards analogical successful offering, satisfice, update up to affordable loss, combine these heuristics

Figure 1: Entrepreneurship as belief formation, testing, and response process

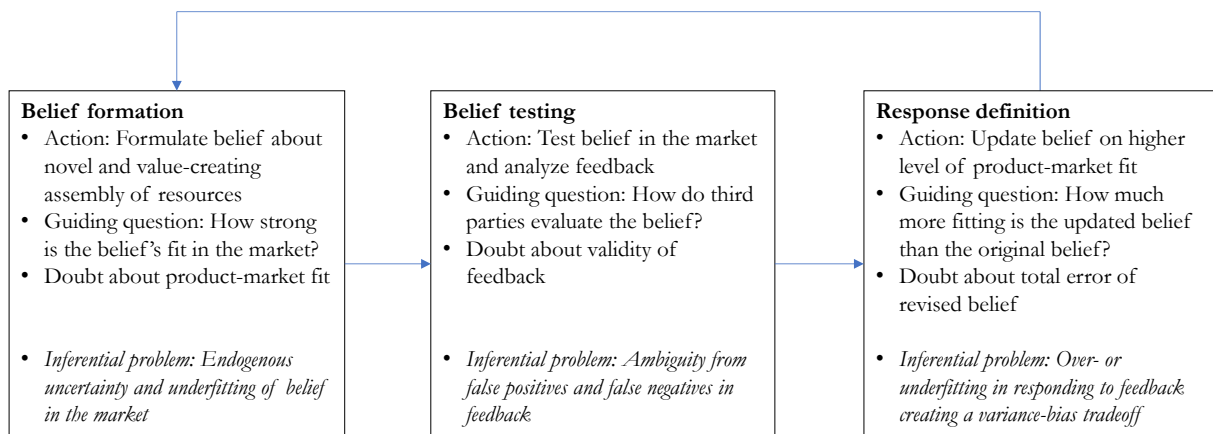
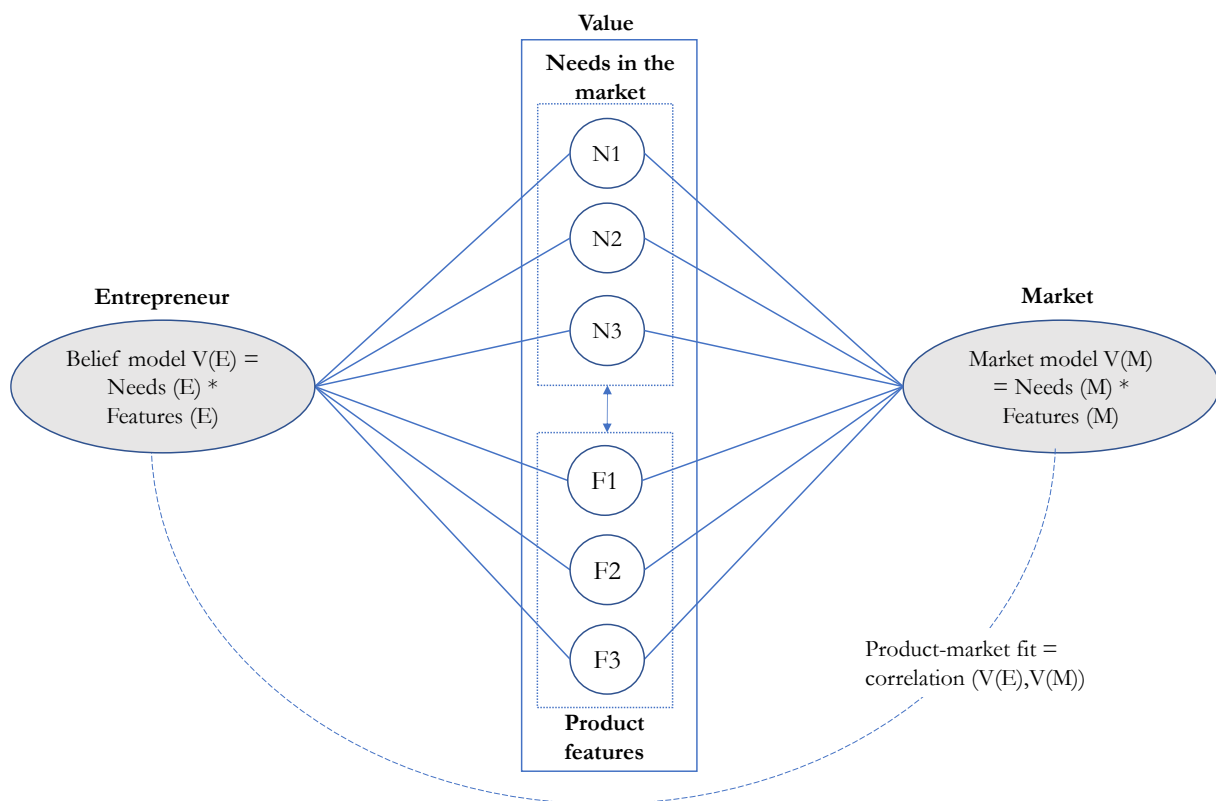
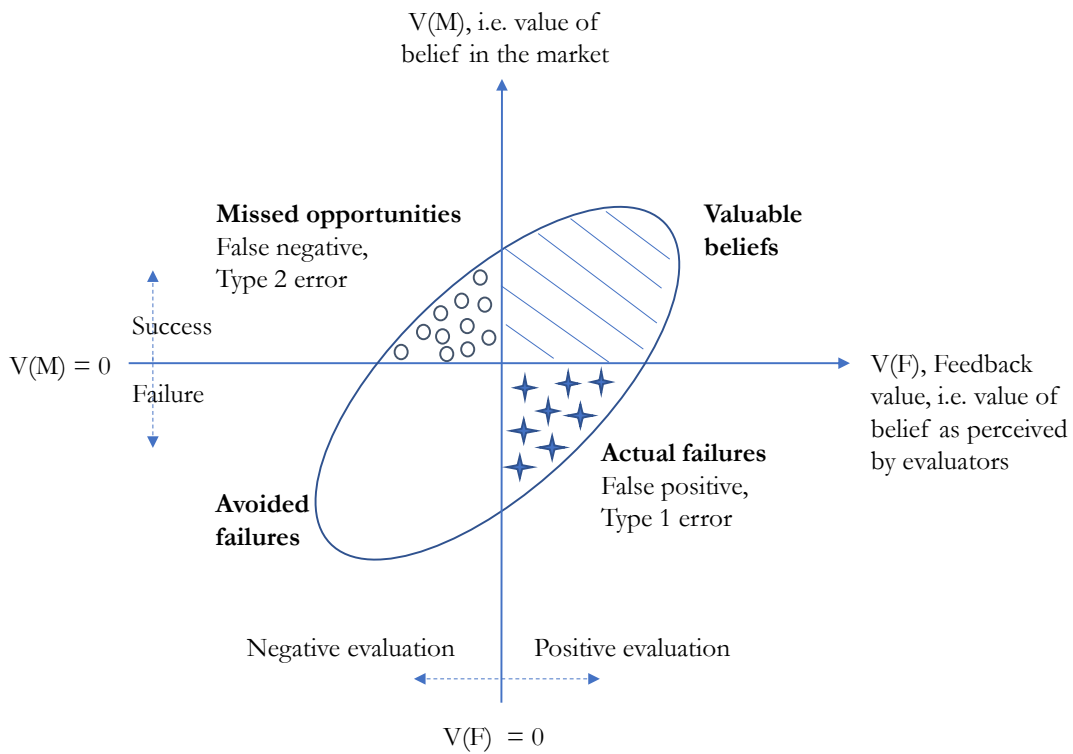


Figure 2: Belief formation and product-market fit



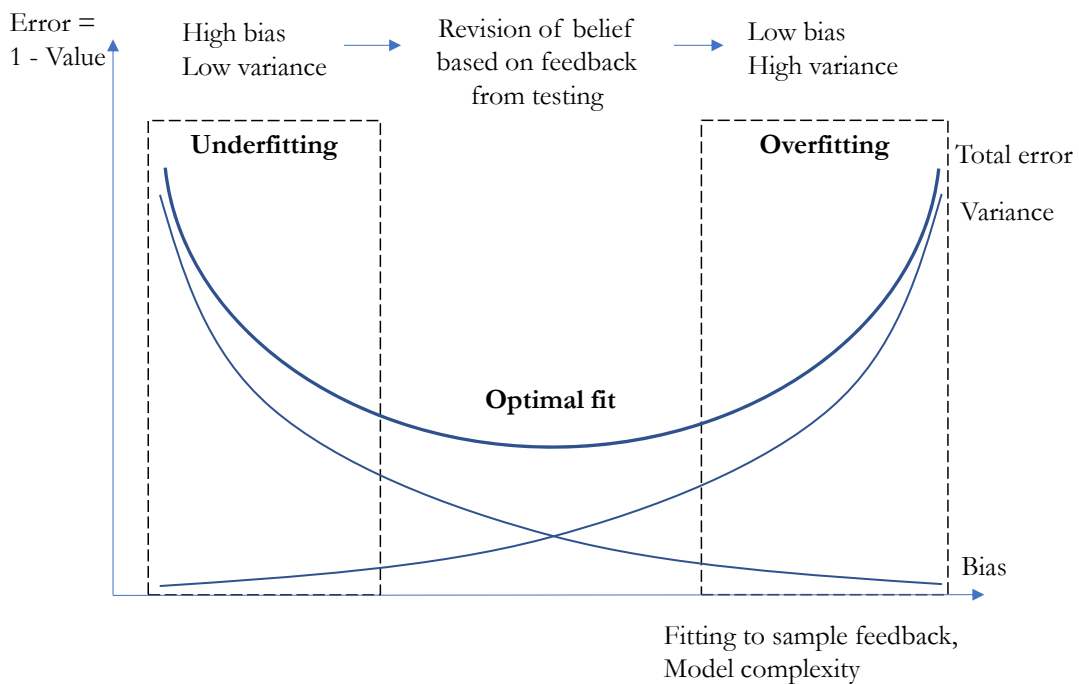
Error terms, inter-needs and inter-feature correlations are left out of the illustration for clarity of exposition.

Figure 3: Belief testing and feedback ambiguity



The size of the ellipse denotes how strongly the feedback value $V(F)$ matches the value of the belief in the market $V(M)$. In case $V(F)$ perfectly matches $V(M)$, the ellipse is the 45-degree line. $V(F) = 0$ and $V(M) = 0$ can be thought of as the minimum required returns to retain a belief, and is set to 0 in Figure 3.

Figure 4: Responding and total error of the response



Thomas Zellweger (thomas.zellweger@unisg.ch) is a Professor of Management at the University of St. Gallen. His research focuses on the strategic management and governance of private firms, and entrepreneurship.

Todd Zenger (todd.zenger@utah.edu) is the N. Eldon Tanner Professor of Strategy and Strategic Leadership at the Eccles School of Business at the University of Utah. His research focuses on corporate strategy, organization design and entrepreneurship. He is incoming Editor-in-Chief at *Strategy Science*.