

PREDICTION- AND CONTROL-BASED STRATEGIES IN ENTREPRENEURSHIP: THE ROLE OF INFORMATION

GRACIELA KUECHLE,^{1,2*} BEATRICE BOULU-RESHEF,^{2,3,4}
and SEAN D. CARR²

¹Faculty of International Business, Heilbronn University, Heilbronn, Germany

²Darden School of Business, University of Virginia, Charlottesville, Virginia, U.S.A.

³Department of Economics, University of Virginia, Charlottesville, Virginia, U.S.A.

⁴Université Paris 1 Panthéon-Sorbonne, Centre d'Economie de la Sorbonne, Paris, France

Research summary: Prediction- and control-based strategies are the two main hypotheses of how entrepreneurs deal with uncertainty in theories of entrepreneurship. Prediction-based strategies focus on estimating unknowns via sampling methods, whereas control-based strategies focus on shaping unknowns via proactive behavior. These strategies may lead to different propensities to undertake uncertain prospects, as they differ in terms of cognition and involvement. In an experimental test, we study the conditions under which prediction- and control-based strategies lead subjects to accept bets in ambiguous environments. Individuals who use control methods to mitigate uncertainty are more likely to accept the bet after a favorable outcome compared to those who use predictive methods. These results revert in the presence of unfavorable outcomes. We discuss the implications for entrepreneurship theory and practice.

Managerial summary: Entrepreneurs often adopt prediction- and control-based strategies in order to reduce uncertainty. Prediction-based strategies focus on gathering information to estimate future outcomes, whereas control-based strategies concentrate on taking actions to create a more favorable environment for the venture. Results from an experimental test show that these strategies can affect behavior differently. In particular, when the decision maker receives favorable information, control-based strategies are more likely to lead to the acceptance of an uncertain prospect than prediction-based strategies. This effect reverts when the decision maker receives unfavorable information. Our findings are valuable for entrepreneurs, investors, and policy makers. Understanding the distinctive impact of strategy on behavior may help entrepreneurs and investors calibrate the potential of a venture, thereby avoiding the misallocation of valuable resources. Copyright © 2016 Strategic Management Society.

INTRODUCTION

Entrepreneurial action is fraught with uncertainties. Whether entrepreneurs intend to introduce a new

product, enter into a new market, or create a new firm, they must conceive modes of action to get information that will help them deal with unknowns, such as consumer demand, competitors' strategies, and the support of potential stakeholders (Knight, 1921). Such uncertainties are detrimental to action, as they pose doubts about the environment in which the entrepreneur acts, the influence of external factors on the developing venture, and the consequences of

Keywords: entrepreneurship; uncertainty; effectuation; experimental economics; theories of entrepreneurship

*Correspondence to: Graciela Kuechle, Heilbronn University, Max-Planck-Str. 39, 74081 Heilbronn, Germany. E-mail: graciela.kuechle@hs-heilbronn.de

any response by the entrepreneur (Arrow, 1974; McKelvie, Haynie, and Gustavsson, 2009; Milliken, 1987). Therefore, it is not surprising that to shore up the fate of their emerging ventures, entrepreneurs resort to strategies to mitigate uncertainty (Alvarez and Barney, 2005).

According to the entrepreneurship literature, information acquisition methods to reduce uncertainty can be classified in two broad categories—those that concentrate on predicting the environment and those that focus on controlling it (Knight, 1921; Mintzberg and Waters, 1985; Sarasvathy, 2001; Wiltbank *et al.*, 2006). Predictive strategies seek the optimal course of action—e.g., the type of product to be introduced, the time of entry—based on a predetermined specification of the possible states of the world, an estimation of their likelihoods, and forecasted values for any relevant parameters (Ansoff, 1979; Porter, 1980). Control-based strategies, eschew prediction and concentrate on obtaining the commitment of stakeholders who provide resources in exchange for co-participation in the transformation of the project (Sarasvathy, 2001).

Consider the case of an entrepreneur who has adopted a prediction-based strategy. Assume that she hires a consultant to estimate the demand for her product, predict market trends, and track competitors to position the venture. Now consider an entrepreneur who uses a control-based approach and assume that instead of predicting crucial variables, she focuses on creating a favorable environment for the venture by keeping options open and cooperating with committed partners. Suppose now that things go well for both entrepreneurs. The first one discovers that there is a considerable proportion of customers who are interested in buying her product. The second one forges an alliance with a committed partner that will enable the scalability of her business. Who is, *ceteris paribus*, more likely to launch the venture? Consider now the case in which the strategies adopted by these entrepreneurs yield a negative outcome. Who is more likely to postpone or give up the entrepreneurial project? Extant research does not address this question, to our knowledge.

Both prediction- and control-based approaches to entrepreneurial action aim to reduce uncertainty. Yet they presuppose different cognitive models of the situation and different degrees of involvement by the entrepreneur. With regard to cognition, predictive strategies may be interpreted as producing reliable information about current market trends, whereas control-based strategies may be seen as firsthand

evidence of the chances of transforming customers' preferences. As far as involvement is concerned, predictive strategies are passive in nature, and their outcomes are relatively independent of the behavior of the entrepreneur. Control-based strategies, in contrast, presuppose an entrepreneur's active involvement and yield results that heavily depend on the entrepreneur's efforts. For these reasons, we expect the outcomes of these strategies to elicit different feelings of confidence and, therefore, to have different effects on the willingness to engage in entrepreneurial action (Heath and Tversky, 1991; Loewenstein, 2004; Leary, 2007; Patzelt and Shepherd, 2011).

Our goal in this paper is to investigate the impact of prediction- and control-based strategies on the decision to undertake uncertain prospects and the extent to which this relationship is affected by the nature of the information received by the individual. We report results from two extra-laboratory experiments (as defined by Charness, Gneezy, and Kuhn, 2013) in which subjects face a bet on an uncertain prospect after having received information in ways that resemble predictive- and control-based strategies.

The choice of an experimental method for this research is based on three considerations. First, it allows us to control for confounding factors affecting the choice of strategy to reduce uncertainty. Second, it measures the impact of the decision-making heuristics relative to a neutral benchmark, an effect that cannot be captured by other empirical methods (Acs *et al.*, 2010; Hagel and Roth, 1995; Camerer and Loewenstein, 2004). Third, it isolates the role of information updating from other contextual factors. Nevertheless, we acknowledge that the study of real-world entrepreneurial settings is indispensable to secure the external validity of any research focused on entrepreneurial action. As a first step in this direction, we provide results of a second experiment in which subjects face a hypothetical decision to launch a venture. The results are consistent with those of the abstract formulation.

Our findings show that prediction- and control-based strategies affect behavior in ambiguous environments differently. In particular, we find that control-based procedures are more likely to induce the acceptance of uncertain bets in the presence of favorable outcomes compared to prediction-based strategies, and they are less likely to induce that behavior in the presence of negative outcomes.

These results have potential implications for the concretion of entrepreneurial undertakings and the allocation of financial resources. Consider, for

instance, the case of incubators and other institutions that provide support to entrepreneurs. They invest considerably large amounts of resources and have an enormous influence on the approach followed by the entrepreneurs to set up their ventures. Insights as to how strategies that focus on prediction versus strategies that focus on control affect their decisions could be of great value for them. The same holds for entrepreneurs, angel investors, and other providers of capital. Understanding the distinctive impact of strategy upon behavior may help entrepreneurs and investors calibrate the potential of the venture avoiding over-, under- or mis-investment.

THEORETICAL BACKGROUND AND EMPIRICAL EVIDENCE

Decision making under uncertainty and ambiguity

Uncertainty, understood as a lack of knowledge about the outcome of some future event, is ubiquitous (Arrow, 1974). Knight (1921) distinguished between measurable uncertainty, or risk and immeasurable uncertainty. Whereas risk can, in principle, be reduced through *a priori* calculation or statistical estimation, uncertainty can be dealt with only through the exercise of judgment and the formation of beliefs. Keynes (1921) distinguished between the likelihood placed on one's judgment and the weight or body of evidence supporting the assessed likelihood. He was skeptical as to whether a single probability number could express both dimensions: 'If two probabilities are equal in degree, ought we, in choosing a course of action, to prefer that one which is based on a greater body of knowledge?' (Keynes, 1921: 313).

Proponents of the subjective probability approach bypassed these concerns by assuming that decision makers can assign well-behaved numerical probabilities to virtually any event. Probabilities are revealed by the odds at which a person is exactly indifferent between betting for and against a given event (de Finetti, 1937; Savage, 1954). For instance, according to the axioms of subjective expected utility, a decision maker should be indifferent between a 50:50 chance of winning a prize on the toss of a coin and a subjectively assessed 50:50 chance of winning the same prize if an event occurs for which there are no objectively known probabilities.

Starting with Ellsberg (1961), much empirical evidence has shown that ignorance of probabilities has behavioral consequences (see Camerer and Weber

(1992) for a comprehensive review of the literature). Ellsberg (1961) was the first to investigate betting behavior in situations in which probabilities were unknown. One of his experimental designs consisted of two urns, each containing 100 balls of two possible colors, black and red. In the first urn, the proportion of red and black balls was unknown, whereas in the second there were 50 red balls and 50 black balls. People who were offered gambles regarding the color of a ball drawn at random were indifferent between betting on red and betting on black regardless of the urn. Yet, when asked whether they preferred to bet on a red ball being drawn from the first or the second urn, most people preferred the second urn instead of showing indifference. The same preference was observed in the case of the black ball. The probabilities revealed by these choices contradict standard subjective expected utility theory and indicate a preference for the urn with known composition (Ellsberg, 1961).

To explain these results, Ellsberg introduced the concept of ambiguity of information as 'a quality depending on the amount, type, reliability and 'unanimity' of information, and giving rise to one's degree of 'confidence' in an estimate of relative likelihoods.' (Ellsberg, 1961: 657) Subsequent studies confirmed the relevance of the quality of the sources from which the information stems (Einhorn and Hogarth, 1985, 1986).

Heath and Tversky (1991) extended the focus of ambiguity aversion by considering clear events such as games of chance and vague events characteristic of real-world situations. They found that individuals preferred vague or ambiguous bets over nonambiguous bets in contexts in which they considered themselves knowledgeable. They argued that this pattern may originate not only in enhanced confidence emanating from previous experiences in familiar domains, but also in psychic payoffs resulting from self-evaluation (Heath and Tversky, 1991). Knowledgeable individuals may be motivated to take uncertain prospects in their domain of expertise because their success is usually ascribed to good judgment and their failure to bad luck. Novices, however, may be less keen on betting because they have a hard time taking credit for their success and fully bear the blame for failure.

To explain these facts, Heath and Tversky (1991) postulated the so-called competence hypothesis according to which, feelings of competence emanating from the relative knowledge held by the individual may determine preferences for given

sources of ambiguity. They argued that ignoring important information is upsetting and precludes the acceptance of bets, especially if this ignorance is asymmetric.

Fox and Tversky (1995) went one step further by considering comparative versus non-comparative evaluations. They found empirical support for the comparative ignorance hypothesis that states that ambiguity aversion is produced by a comparison with a less ambiguous event or with more knowledgeable individuals. According to Fox and Tversky (1995), a preference for a particular source of ambiguity is elicited only if the individual becomes aware of his/her ignorance. Their results were compatible with previous experiments by Curley, Yates, and Abrams (1986) based on Ellsberg's design—although subjects were not more averse to ambiguity when the contents of the urn were revealed afterward they were significantly more averse to ambiguous events when the outcome of the gamble they had chosen was revealed in front other subjects.

In sum, ambiguity is a situation in which the decision maker ignores both the outcomes and the probability distribution of a given event, information that could be known and may already be known by other people (Camerer and Weber, 1992; Frisch and Baron, 1988). Knightian uncertainty, however, is a situation in which the missing information is unavailable because the future is yet to be created. Therefore, there is no procedure that can reduce the doubts about the possible courses of actions, the possible states of the world, and the nature of their outcomes (Knight, 1921). In this article, we will use the terms ambiguity and uncertainty interchangeably.

Based on the reviewed literature and following Frisch and Baron (1988), we summarize the reasons for ambiguity avoidance as follows: (1) in the presence of ambiguity other individuals—possibly competitors—may have more information and therefore an advantage; (2) in the long run, a series of identical ambiguous bets is more risky than a comparable series of nonambiguous bets; (3) there is the possibility of waiting for more information, especially if one does not have access to large samples; (4) issues of blame, responsibility, and regret are more salient than in nonambiguous situations.

Uncertainty and entrepreneurial behavior

Uncertainty is an essential feature of entrepreneurship. Knight (1921) argued that it constitutes the ultimate

source of profit, and he ascribed it to the inherent lack of knowledge about phenomena governed by human action when decision instances are novel and unique. Entrepreneurial action is embedded in ambiguous contexts, lacks a well-defined structure, and is plagued with constraints and path dependencies.

Undoubtedly, individuals have evolved means to deal with uncertainty, either through intuition or judgment (Knight, 1921). For instance, entrepreneurs have been defined as individuals who specialize in taking judgmental decisions about the coordination of scarce resources (Casson, 1982; McMullen and Shepherd, 2006). Nevertheless, theoretical considerations and empirical evidence unequivocally show that uncertainty hinders entrepreneurial action (Arrow, 1974; McMullen and Shepherd, 2006).

McKelvie *et al.* (2009) provide evidence in this respect. Following Milliken's (1987) conceptualization of uncertainty in organization theory, they distinguish between state, effect, and response uncertainty. State uncertainty characterizes a decision in which the individual lacks knowledge of the environment in which the venture is about to be created. Effect uncertainty occurs when the decision maker ignores the repercussions of the actions available to other economic agents, such as customers and competitors. Response uncertainty happens when the decision maker has doubts about possible responses and their repercussions (Milliken, 1987).

The individuals studied by McKelvie *et al.* (2009) showed overall aversion to uncertainty and expressed particular concern about the ambiguity surrounding the impact of their own actions, their ability to keep up with technological change, and the corresponding reactions of competitors. In particular, they were unwilling to undertake hypothetical ventures if they perceived a lack of control over the outcomes in their sphere of influence (McKelvie *et al.*, 2009).

McMullen and Shepherd (2006) define uncertainty in entrepreneurial settings in terms of what it does more than in terms of what it is. According to them, uncertainty is a form of doubt that: (1) produces hesitancy; (2) promotes indecision; and (3) encourages procrastination (McMullen and Shepherd, 2006). They argue that this effect is due to cognitive as well as to motivational aspects operating in the two stages of the process leading to entrepreneurial action. During the so-called 'attention stage,' domain-specific knowledge and personal motivations underlie the assessment of the existence of a third-person opportunity, whereas in the 'evaluation stage,' cognitive processes influence the assessment of

feasibility of this third-person opportunity, and motivational elements affect its desirability.

Strategies used by entrepreneurs to mitigate uncertainty

In the management literature, mainstream strategies for entrepreneurial action in business environments can be classified into two broad groups: those that focus on predicting the environment and those that focus on adapting to it (Brews and Hunt, 1999). Extreme predictive approaches focus on gathering information to optimally position the organization (Ansoff, 1979) whereas purely adaptive approaches concentrate on attaining flexibility to enable rapid change in the face of changing conditions (Hough and White, 2003; Mintzberg, 1994; Mosakowski, 1997; Simon, 1973).

As Wiltbank *et al.* (2006) show, these canonical types plus others that combine prediction and adaptation to different degrees (e.g., competitive analysis, real options, and fast decision making, to name a few) share the view that the environment in which the organization thrives is considerably exogenous and that uncertainty is a given. Opposed to this ontological position, approaches based on social constructivism portray the environment as malleable and endogenous (McMullen and Shepherd, 2006; Wiltbank *et al.*, 2006). According to this view, entrepreneurial opportunities are enacted (Mintzberg, 1994; Sarasvathy, 2001). Cognitive and motivational elements still play a role, but the crucial construct is the perceived behavioral control of the individual (McMullen and Shepherd, 2006). Consistent with this view, Wiltbank *et al.* (2006) distinguish between visionary and transformative approaches to uncertainty. Visionary approaches engage in construction by ‘...imagining future possibilities and proactively bringing them to fruition’ (Wiltbank *et al.*, 2006: 990). Transformative approaches, however, are open to future developments. Among them, we find effectuation (Sarasvathy, 2001), which is characterized by: (1) means-driven rather than goal-oriented action; (2) affordable loss instead of expected return; and (3) the leveraging rather than avoidance of contingencies (Wiltbank *et al.*, 2006).

In the realm of entrepreneurship, predictive strategies correspond to an estimation of parameters using sampling methods, whereas effectual strategies correspond to taking actions in order to control and transform the environment with available means (Dew *et al.*, 2009). In this article, we compare

prediction-based strategies against control-based strategies of a transformative kind as defined in Wiltbank *et al.* (2006). It is worth clarifying that we do not focus on effectuation, which is a much broader concept, and, therefore, provide no overarching assessment of effectual strategies.

The role of information

In situations characterized by limited information, individuals rely on cognitive cues or criteria to facilitate decisions (Brunswick, 1956; Kahnemann and Tversky, 1979; Rosch, 1975). Encouraging market research may prompt an entry decision, and adverse evidence on the demand side may postpone it. The signing of a sales agreement with an important customer may trigger the decision to launch a product, whereas the exit of an important stakeholder may lead to a redefinition of the product or further search for a suitable partner. These considerations lead us to hypothesize as follows.

Hypothesis 1a: The more favorable the outcome elicited by control-based strategies, the higher the propensity to accept an uncertain prospect.

Hypothesis 1b: The more favorable the outcome elicited by prediction-based strategies, the higher the propensity to accept an uncertain prospect.

Achieving a goal associated with a motivation elicits affective reactions (DeCharms, 1968; Frisch and Baron, 1988; Loewenstein, 2004; Leary, 2007; White, 1959). The motivation of the decision maker is to reduce uncertainty. Yet the extent to which the strategy used to mitigate uncertainty will be successful is an open matter. Forecasts produced by predictive strategies may predict strong popularity or the opposite among consumers. Control-oriented strategies, however, may attempt to secure promising alliances with potential partners or may lead to a lack of support among contacted customers. The entrepreneur will need to decide whether to start a venture after assessing the outcomes of these strategies and under the influence of the emotions elicited by the updated information (Patzelt and Shepherd, 2011; Shepherd, 2003).

The outcomes of predictive strategies are, in principle, independent of the behavior and characteristics of entrepreneurs, whereas the

outcomes of control-based strategies are heavily dependent on their human, financial, and social capital. Furthermore, predictive strategies are passive in nature, as they merely take stock of the main characteristics of the environment. Control-based strategies, however, require involvement and, therefore, active behavior directed toward shaping the environment. Committed entrepreneurs are likely to experience feelings of self-fulfillment in the presence of successful outcomes and disappointment in the presence of failure (DeCharms, 1968; Leary, 2007; Patzelt and Shepherd, 2011; Shepherd, 2003; White, 1959). Based on the previous analysis, we expect subjects who adopt control-based strategies to display stronger reactions to both failures and successes than subjects who pursue predictive strategies.

Finally, if individuals are more concerned with their chances of controlling the environment relative to the possibility of predicting it, as shown by McKelvie *et al.* (2009), we should expect them to react more strongly to the outcomes of control-based strategies than to the information generated by predictive approaches. For all these reasons, we hypothesize as follows:

Hypothesis 2a: Favorable outcomes of control-based strategies will make individuals more likely to accept an uncertain prospect compared to equally positive outcomes of prediction-based strategies.

Hypothesis 2b: Unfavorable outcomes of control-based strategies will make individuals less likely to accept an uncertain prospect compared to equally adverse outcomes of prediction-based strategies.

METHODOLOGY

Experimental design

To gain knowledge of how prediction- and control-based strategies affect behavior in the presence of information, we performed two experiments: a context-free information experiment and an entrepreneurial information experiment. The context-free experiment is based on Ellsberg's (1961) design. The entrepreneurial information experiment serves as a robustness check of the treatment effects that are identified in the context-free information experiment.

Following Ellsberg's (1961) experimental design and inspired by Sarasvathy's (2001) thought experiment to clarify effectuation, we model an uncertain scenario as a bet on an urn of unknown composition. The participants are first informed about the existence of an urn containing N marbles of two colors (red and green) in unknown proportions and the posterior decision of whether or not to accept a bet on drawing a green marble from the urn. The subject wins the bet if the marble extracted is green and loses otherwise. The total amount of marbles, N , is equal to 10 in one treatment and five in the other for reasons that will become clear in the next paragraph.

After the introduction of the bet and before making the decision, the subjects are provided with a procedure to update their information about the urn. In the prediction treatment, the subjects observe a sample of five marbles that are randomly extracted from the urn (they are told that the sampled marbles will be reinserted before the draw, in case they accept the bet). In the control treatment, the subjects insert five marbles into the urn. Prediction is operationalized by means of a sampling method, as it enables the subjects to predict the contents of the urn, and control is operationalized by letting the subjects insert marbles, as it allows them to control or manipulate the contents of the urn. In the control treatment, the urn initially has five marbles so that after insertion, the bet will be placed on an urn with 10 marbles. Subjects do not actually sample from the urn, neither do they physically insert marbles. But they are shown pictures (see Figure 1) of both procedures to help them conceive the two information acquisition procedures.

To account for the fact that sampling and control can lead to both favorable and unfavorable outcomes, we allow subjects to sample and insert one of the six possible combinations of red and green marbles into the urn (five green, zero red (5G0R); four green, one red (4G1R); three green, two red (3G2R); two green, three red (2G3R); one green, four red (1G4R), and zero green, five red (0G5R)). To control for ordering effects, we included pictures of all possible combinations in which two colors appear, i.e., 4G1R, 1R4G, 3G2R, 2R3G, 2G3R, 3R2G, and 1G4R, 4R1G (trivially 5G0R=0R5G and 5R0G=0G5R).

Sarasvathy's (2001) thought experiment suggests that effectuation is about changing the odds in one's favor:

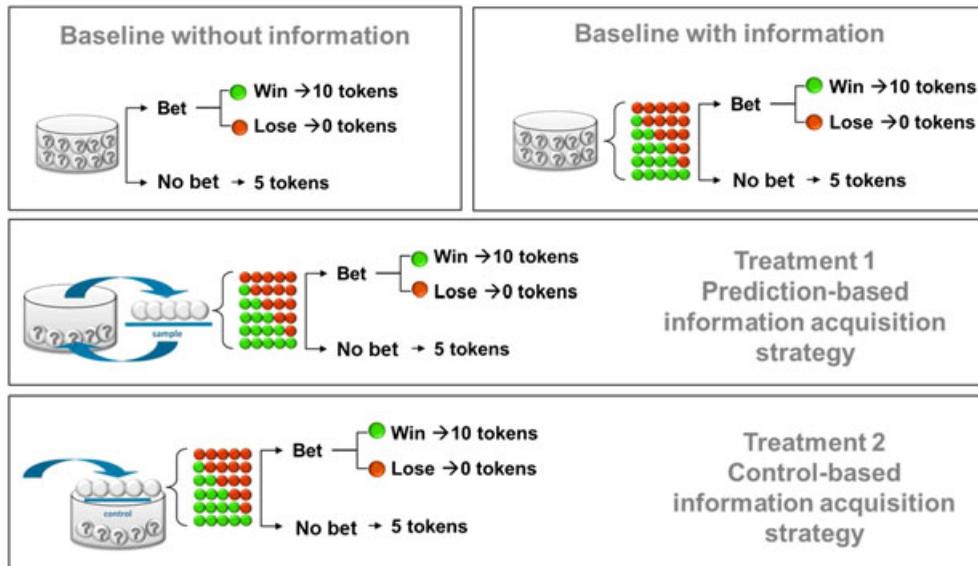


Figure 1. Sketch of the research design

‘Whatever the initial distribution of balls in the urn, I will continue to acquire red balls and put them into the urn. I will look for other people who own red balls and induce them to become partners and put their balls in the urn. As time goes by, there will be so many red balls in the urn that almost every draw will obtain one. On the other hand, if I and my acquaintances have only green balls, we will put them into the urn, and when there are enough, we will create a new game where green balls win.’ (Sarasvathy, 2001: 252)

It is natural to assume that entrepreneurs will always intend to create a favorable environment for their ventures. Yet it stands to reason that they will not always succeed. To account for this fact and to be able to compare prediction and control under all possible combinations of green and red marbles, subjects insert all six possible color combinations.

This is a between-subject experiment. Each subject is assigned to only one treatment (prediction, control, or the baseline) and is confronted with only one of the six possible color arrangements of the marbles—sampled, inserted, or given—in the case of the baseline. Subjects ignore that there is an alternative method to the one they have been assigned.¹ After either sampling or inserting the marbles, they decide whether to accept the bet.

¹ This eliminates the metacognitive aspects highlighted in Haynie et al. (2010).

As shown in Figure 1, the subjects are endowed with five tokens. If they accept the bet and the marble is green, they win five tokens, and if the marble is red, they lose their original endowment of five tokens. Accepting the bet means they will finish with either 10 or zero tokens. We calibrated our results using two baseline treatments—one that does not contain any information feature and one that contains information but does not involve sampling. Furthermore, we conducted an entrepreneurial information experiment in which participants faced a similar trade-off. The only difference is that the uncertain prospect is formulated in an entrepreneurial context. The wording of the experiments is available in the Appendix. Table 1 summarizes the features of the two experiments.

Bayesian updating as a benchmark

For the purpose of this experiment, we consider Bayesian updating as a benchmark. A Bayesian decision maker starts with a prior distribution and updates it after receiving information (DeGroot, 1989). For simplicity, we assume that subjects expect equal amounts of green (g) and red (r) marbles. This assumption is without loss of generality because we will use it in the analysis of both treatments. The random variable, X, takes the value '1' if the marble is green and '0' otherwise and has a Bernoulli distribution. Prior to any information, the expected value and variance, when facing a bet on drawing

Table 1. Experiments and treatments

	Baseline (without information)	Baseline (with information)	Control	Prediction
Context-free information experiment	<p>The urn contains 10 marbles of two colors, red and green, in proportions that are unknown to you.</p>  <p>To reduce uncertainty, the program will make visible to you five marbles.</p>  <p>Would you like to bet on the urn?</p>	<p>To reduce uncertainty, you can control the color of five marbles by inserting them into the urn before the bet</p> <p>Here you insert two green marbles and 3 green marbles.</p>  <p>Five marbles are known to be green.</p>	<p>To reduce uncertainty, you will be given the opportunity to observe five marbles that will be randomly extracted from the urn by the computer. After you observe the sample, the five extracted marbles will be returned to the urn.</p> <p>Here the sample contains one red marble and five red marbles.</p> 	
Entrepre-neurial information-related experiment	<p>You believe the product has great potential, yet success of the project is highly uncertain due to its novelty among customers.</p> <p>Which action will you take?</p> <p>There are 10 potential customers in your region and you know that four are willing to buy it and one is not.</p> <p>You do not know anything about the other customers.</p> <p>Which action will you take?</p>	<p>After changing the probabilities by inserting these marbles, would you like to bet on the urn?</p> <p>To mitigate this uncertainty, you talk with potential customers you know, present your product, assess their feedback, and work on enlisting their support to create his new market.</p>	<p>After receiving this information, would you like to bet on the urn?</p> <p>To mitigate this uncertainty, you ask a consultancy to do market research so they can predict where the market is heading and forecast customers' willingness to buy your product.</p>	
			<p>Out of the 10 customers in your region, you spoke to five, and four liked your product and have committed to buying it and one did not like your product and has not committed to buying it.</p>	<p>The market researcher looks at a sample of the population of customers and predicts that out of the 10 customers in your region, one is not likely to buy your product and four are.</p>

one green ball ($n=1$), are $E(X) = \frac{g}{g+r} = 0.5$ and $Var(X) = \frac{g}{g+r} \frac{r}{g+r} = 0.25$.

In the prediction treatment, the subject observes a sample of size $n=5$ with g green marbles and r red marbles ($0 \leq g \leq 5$ and $0 \leq r \leq 5$). Since the sampling procedure is done without replacement, the prior distribution is the hypergeometric distribution with expected value $E(X) = n \frac{g}{g+r}$ and variance $Var(X) = n \frac{gr}{(g+r)^2} \frac{N-n}{N-1}$ (DeGroot, 1989), where N is the total amount of marbles in the urn.

The posterior distribution is a negative hypergeometric or beta-binomial distribution with parameters $\alpha = g+1$ and $\beta = r+1$ (DeGroot, 1989). The expected value of X is $E(X) = n \frac{\alpha}{\alpha+\beta}$ and the variance is $Var(X) = \frac{n\alpha\beta(n+\alpha+\beta)}{(\alpha+\beta)^2(\alpha+\beta+1)}$ (Tripathi, Gupta, and Gurland, 1994). If the subject observes a sample with g green marbles, the expected value of X before the bet will be $E(X) = \frac{g+1}{g+r+2}$ (since $n=1$). The expected proportion of green marbles is revised downward after observing samples with two or less green marbles and upward otherwise. The variance is always reduced after sampling, but the reduction depends on the composition of the sample (for detailed information, see Table A5 in the Appendix).

In the control treatment, subjects insert five marbles into an urn already containing five marbles of two possible colors (green and red) in unknown proportions. In this situation, the decision maker could think that if he/she accepts the bet, he/she will face one of two possible urns. One urn contains the five known marbles and the other the five unknown marbles. There are different options open to the decision maker. He/she could believe that the inserted marbles were randomly sampled from an urn that is similar to the one he/she does not get to see. In that case, there would be no difference between prediction and control. But she could think that there is no relationship between the two virtual 'urns.' In this case, his/her update will be more conservative than the one a Bayesian decision maker would have performed after sampling. This means that if he/she inserts three or more marbles, he/she will be less optimistic than he/she would have been had he/she sampled them. Similarly, a Bayesian decision maker who inserts two or fewer marbles will be less pessimistic than a Bayesian decision maker who samples the same amount of green marbles. In other words, subjects in the control treatment should be closer to the baseline treatment with no information. This will be called the expected value effect.

Another feature of the control treatment is that the variance will be larger than in the prediction treatment. This means that decision makers in this treatment should be, *ceteris paribus*, less willing to bet regardless of the colors of the five marbles the subject has seen. This will be referred to as the variance effect. As an example, the last two columns of Table A5 present the expected value and variance of X for a subject who believes that the marble to be drawn has equal chances of coming from the unknown urn and the known urn.

Subjects who insert three or more green marbles will be less likely to accept the bet than subjects who sampled the same amount of marbles due to the combined effect of a smaller upward adjustment in the expected value of green marbles and a higher variance. But, subjects who insert three or more red marbles may be more likely to bet compared to sampling if the expected value effect is larger than the variance effect. If, however, the variance effect is larger than the expected value effect, then it is not clear if the propensity to bet will differ between these two treatments. These considerations mean that the benchmark of Bayesian decision making will lead subjects in the presence of good news to be less willing to bet in the control treatment compared to the prediction treatment. In the presence of adverse news, the subject will be more likely to accept the bet or the final effect may be ambiguous.

DATA COLLECTION

The subjects for the experiments were recruited through the Amazon Mechanical Turk online labor market. The sample was restricted to U.S. citizens. Each subject automatically received \$0.10 for participating in the context-free experiment and \$0.20 for participating in the entrepreneurial information experiment. The difference in base scheme was calculated to compensate the participants for their time spent on the task, as in online labor markets, participants evaluate jobs based on their hourly rate. Thus, as participating in the entrepreneurial information took twice as much time, the participation reward was doubled to maintain a similar wage per hour and to avoid attracting participants of different types. In addition to the participation reward, subjects also earned \$0.05, \$0.10, or \$0.15, depending on their decision and the outcome of their decision. All participants received

bonuses, but the amount of the bonus varied. The experiment was conducted with a total of 2,409 subjects. The summary data is available in the Appendix (A1). In total, 46 participants had taken the survey more than once—on average, they had taken it 2.49 times. All occurrences of these duplicates were removed. Forty-four participants did not finish the experiment, and their data entries were removed from the analysis.

As explained in the method section, the experiment is a between-subject design i.e., subjects made only one decision, and they saw only one information condition. The treatment (i.e., sampling or changing the composition of the urn) is the independent variable; the dependent variable is the subjects' propensity to accept the uncertain prospect. As explained earlier, we hypothesize that subjects in the control treatment will be more likely to accept the bet when the odds are favorable; conversely, they will be less likely to accept the bet than the subjects in the prediction treatment when the odds are unfavorable.

RESULTS

The effects of the treatments are summarized in Table 2. Table 3 reports information about all treatments, all information conditions, the ordering of the information, and the proportion of subjects who accepted the bet. The statistical tests are provided in Table 3. The overall results are depicted in Figure 2, and the effects of information ordering are depicted in Figure 3.

Overall, there is no major difference between the context-free information experiments and the entrepreneurial information experiments, as shown in Table 3. This enables us to say that it is the content of the information and not the context what drives the results.

The results in Table 3, which are based on a z-test and report the significance of the results, show that the effect of inserting a large number of green marbles is associated with a higher likelihood to accept the bet in the control treatment compared to the prediction treatment. In addition, the effect of inserting a large number of red marbles is associated with a lower likelihood to make the bet in the control treatment compared to the prediction treatment.

Note that the results of the baseline without information show that in the absence of information, 65 percent of the subjects accept the bet in both the

context-free experiment and in the entrepreneurial information experiment. Also, the ordering of the information has no effect in the context-free information experiments, but it affects the results in the entrepreneurial information experiments, as shown in Figure 3.

DISCUSSION

We set out to investigate the potential impact of methods to reduce uncertainty on the propensity to accept an uncertain prospect. First, we hypothesized that the subjects would be more willing to accept the bet the higher the proportion of green marbles either inserted or sampled. Second, we hypothesized that the subjects who inserted the marbles would be more likely to accept the bet after a favorable outcome (i.e., three or more green marbles) than the subjects who observed an equally favorable sample from the urn. Third, we hypothesized that the subjects who inserted the marbles would be less likely to accept the bet after an unfavorable outcome (i.e., three or more red marbles) compared to the subjects who observed an equally unfavorable sample from the urn.

Overall, the subjects in our study behave in accordance with the predictions of our research hypotheses. According to this evidence, we reject the null hypothesis of Bayesian updating. As explained before, a Bayesian decision maker should either underreact in the control treatment or find no difference between the treatments—provided the amount of green marbles in the sample coincide with the amount of green marbles inserted.

Explanations for our results are based on the cognitive aspects and the varying degrees of personal involvement that are implied by prediction and control strategies. The results show that the subjects did not view predictive strategies as more reliable than control strategies. Had they seen them as more reliable, we would have observed a higher proportion of betting behavior after favorable sampling and a lower proportion after unfavorable sampling. One explanation is that the subjects may feel more confident after being able to insert marbles that increase their odds and less confident after inserting marbles that decrease their odds.

Our research strategy and focus differs from the extant literature on this topic in several respects (Dew *et al.*, 2009; McKelvie *et al.*, 2009; Wiltbank *et al.*, 2009). First, our dependent variable is the

Table 2. Summary results

Treatment	Decision	No info	Information conditions													
			5G	4G1R	4G1R	1R4G	3G2R	3G2R	3G2R	2R3G	2G3R	2G3R	3R2G	1G4R	1G4R	4R1G
Context-free information experiments																
Baseline	Bet	35	40	71	35	36	58	23	35	40	18	22	46	19	27	23
	Do not bet	19	4	18	9	9	27	11	16	39	18	21	32	14	18	12
	% bet	0.65	0.91	0.80	0.80	0.80	0.68	0.68	0.69	0.51	0.50	0.51	0.59	0.58	0.60	0.66
Control	Bet	33	73	37	36	66	32	34	33	33	17	16	30	13	17	25
	Do not bet	3	11	5	6	29	15	14	43	21	22	22	66	33	33	33
	% bet	0.92	0.87	0.88	0.86	0.69	0.68	0.71	0.43	0.45	0.42	0.31	0.28	0.34	0.43	
Prediction	Bet	37	72	37	35	66	39	27	36	36	20	16	35	21	14	21
	Do not bet	11	16	9	7	32	18	14	32	32	17	15	39	20	19	16
	% bet	0.77	0.82	0.80	0.83	0.67	0.68	0.66	0.53	0.54	0.52	0.47	0.51	0.42	0.57	
Entrepreneurial information experiments																
Baseline	Bet	33	41	59	27	32	55	25	30	47	23	24	31	18	13	26
	Do not bet	18	7	12	6	6	11	5	6	21	13	8	27	19	8	28
	% bet	0.65	0.85	0.83	0.82	0.84	0.83	0.83	0.83	0.69	0.64	0.75	0.53	0.49	0.62	0.48
Control	Bet	42	53	26	27	52	23	29	25	25	16	9	24	11	13	21
	Do not bet	5	8	3	5	13	8	5	30	9	21	21	41	22	19	37
	% bet	0.89	0.87	0.90	0.84	0.80	0.74	0.85	0.45	0.64	0.30	0.30	0.37	0.33	0.41	0.36
Prediction	Bet	32	43	18	25	33	14	19	19	41	22	19	30	18	12	36
	Do not bet	13	16	9	7	13	7	6	6	16	6	10	31	12	19	16
	% bet	0.71	0.73	0.67	0.78	0.72	0.67	0.76	0.72	0.72	0.79	0.66	0.49	0.60	0.39	0.69

Table 3. Statistical tests

Information	%			P-value		
	Control	Prediction	Baseline with information	Control vs. prediction	Control vs. baseline with information	Prediction vs. baseline with information
5G0R	0.92	0.77	0.91	0.03**	0.44	0.03**
N	36	48	44			
4G1R	0.87	0.82	0.80	0.08*	0.03**	0.31
N	222	176	178			
3G2R	0.69	0.67	0.68	0.33	0.42	0.42
N	190	196	170			
2G3R	0.43	0.53	0.51	0.04*	0.08*	0.36
N	152	136	158			
1G4R	0.31	0.47	0.59	0.00***	0.00***	0.02**
N	192	148	156			
0G5R	0.43	0.57	0.66	0.09*	0.02**	0.21
N	58	37	35			

*** Significance at the 0.01 level, ** Significance at the 0.05 level, * Significance at the 0.10 level. All tests are one tailed.

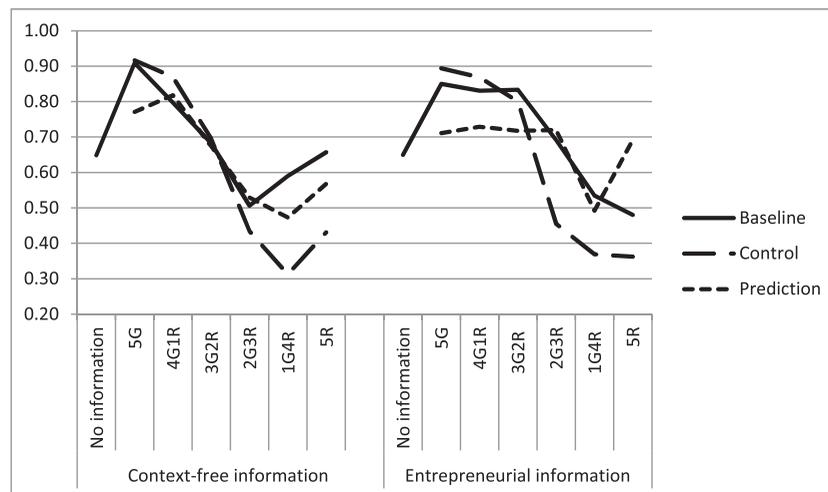


Figure 2. Percentage of risk-taking behavior by treatment and by information condition

propensity to undertake an uncertain prospect—and not performance (Wiltbank *et al.*, 2009) or the use of cognitive frames (Dew *et al.*, 2009). Second, we conduct an experiment with pay-for-performance incentives instead of using a judgment-based research tool as in McKelvie *et al.* (2009). Furthermore, we investigate the effects of information updating—and not the impact of uncertainty (McKelvie *et al.*, 2009).

As for the contribution to the literature, our research suggests ways to reconcile the apparent tension between the findings in McKelvie *et al.* (2009) and Dew *et al.* (2009). According to McKelvie

et al. (2009), doubts about the possibility of controlling one's own responses is the strongest deterrent to entrepreneurial action. Yet according to the literature on effectuation, entrepreneurs prefer to take action in the face of unknown outcomes (Sarasvathy, 2001; Dew *et al.*, 2009). This apparent contradiction may be resolved by distinguishing between *ex ante* and *ex post* evaluations. *Ex ante*, subjects may be reluctant to undertake uncertain prospects if they are ignorant about the extent to which they can control the future. Yet in line with our results, the experience of being able to

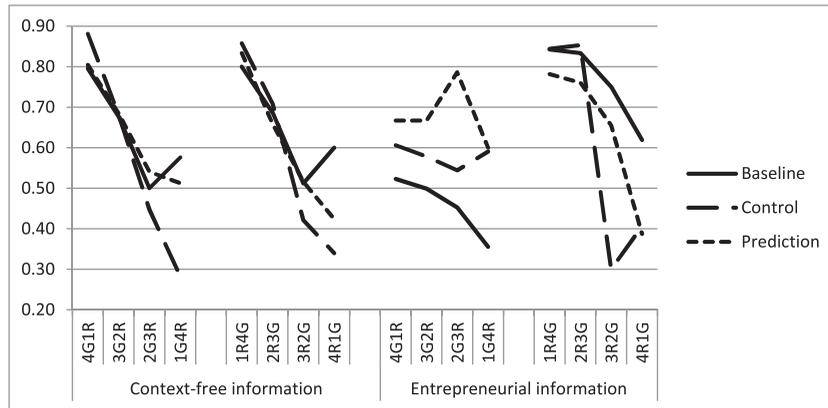


Figure 3. Effect of the ordering of information by treatment and by information condition

successfully control the odds may lead *ex post* to a higher propensity to bear uncertainty.

As for limitations, we acknowledge that betting on urns is a reduced representation of the decision problems that entrepreneurs face (Einhorn and Hogarth, 1986; Heath and Tversky, 1991). First, gambling devices involve a well-structured state space (Einhorn and Hogarth, 1986), elements that in real life are difficult to identify. Second, real-life settings are plagued with constraints and path dependencies that betting decisions lack. Third, in real settings there is a future that does not exist in experiments. Fourth, gambling metaphors abstract from the context in which the decision is made (Einhorn and Hogarth, 1986; Heath and Tversky, 1991).

Nevertheless, we argue that the analytical model of the urn provides a valid and insightful frame to gain knowledge of the cognitive mechanisms involved in entrepreneurial actions. First, in real-world settings, the relationship between strategy and choice, let alone the effect of information updating, will be confounded by both contextual and individual factors that are difficult to control for. For instance, entrepreneurs may have a predisposition to choose predictive or control-based strategies because of their personal traits or previous life experiences. A research design that fails to randomly assign strategies to subjects will face the problem of confounding variables (Pearl, 2009). Our research design is free of this bias and enables us to identify treatment effects. Second, to isolate the impact of information, it is necessary to compare equally favorable and unfavorable outcomes in each treatment, a task that only experimental manipulation can achieve (Acs *et al.*, 2010; Hagel and Roth, 1995). Third, abstract gambles contain essential elements of much larger problems

(Kahnemann and Tversky, 2000), even when in real settings they may be counterbalanced by contextual factors.

We acknowledge that we can only induce a weak sense of control over outcomes in the lab. In real settings, personal involvement will be substantially stronger, thereby amplifying the incidence of our findings. Consider for instance, entrepreneurial decisions embedded in the context of occupational choice. Feelings of confidence and self-fulfillment after having managed to shape the odds of the venture in one's favor and the possible disappointment in the opposite situation will elicit stronger responses due to their financial and professional implications (Shepherd, 2003). We consider this aspect to be a strength of our design since our goal was to find an effect with a minimal manipulation of the independent variable.

Entrepreneurial action—and the process of venture creation more generally—involves not only the acquisition of resources, but also the handling of information. In this light, our research is seminal and suggests avenues for future research. Further experiments should investigate the cognitive, motivational, and emotional channels through which information and outcomes may affect entrepreneurial action—both in experimental and real-world settings, as it is well known that entrepreneurs need confidence to launch their ventures (Cassar, 2010; Hayward *et al.*, 2010). Our findings also suggest that confidence may depend in part on an information acquisition strategy.

Understanding the potential impact of methods to reduce uncertainty has potential implications for the practice of entrepreneurship. For instance, considerable amounts of private and public resources are devoted every year to supporting the creation of

new ventures. An improved knowledge of the determinants of entrepreneurial action may contribute to a more efficient allocation of these resources. In this respect, Murnieks *et al.* (2011) find that similarities between decision-making processes of entrepreneurs and venture capitalists bias the evaluation of investment opportunities. In other words, investors are more likely to invest in ventures whose founders adopt similar decision heuristics. In this respect, our research indicates that both entrepreneurs and investors may over- or underreact, potentially amplifying the effects of information acquisition methods. In particular, our findings suggest that the use of control-based strategies may lead individuals to recognize that potentially there are opportunity costs associated with investments when the odds are not good.

CONCLUSION

Decisions about entrepreneurial action are strongly influenced by uncertainty (Busenitz and Barney, 1997; McKelvie *et al.*, 2009; McMullen and Shepherd, 2006). Potential entrepreneurs have expressed reluctance to start a new venture in scenarios in which they felt uncertain about the options at their disposal, their ability to achieve their goals and the responses of their competitors (McKelvie *et al.*, 2009).

Two main strategies to reduce uncertainty stand out in entrepreneurship research—namely prediction- and control-based strategies. Predictive strategies focus on gathering information to estimate unknowns, whereas control-based strategies aim to shape the environment through proactive behavior. Entrepreneurs will have to decide how to act on the evidence provided by their information-updating method to reduce uncertainty. This evidence may, in principle, be favorable or unfavorable to the prospective venture. Since prediction and control differ as to how they process information and on the amount of involvement required, we hypothesized that they may lead to different propensities to undertake an uncertain project depending on the nature of the information received by the entrepreneur.

Our results are consistent with our research hypotheses and suggest that control-based strategies are more likely to lead to the acceptance of uncertainty than prediction-based strategies in the presence

of successful outcomes, and less likely in the presence of unfavorable outcomes. Its limitations notwithstanding, these findings contribute to both theory and practice. On the one hand, our findings help understand how entrepreneurs deal with information. On the other hand, they inform entrepreneurs, investors and policy makers about the possible consequences of their strategies to reduce uncertainty.

ACKNOWLEDGEMENTS

The authors thank Saras Sarasvathy and three anonymous referees for their valuable comments, which helped improve the manuscript. The usual disclaimer applies. The financial support of the Batten Institute for Entrepreneurship and Innovation at the University of Virginia is gratefully acknowledged.

REFERENCES

- Acs Z, Audretsch D, Desai S, Welpel I. 2010. On experiments in entrepreneurship research. *Journal of Economic Behavior & Organization* **76**(1): 1–2.
- Alvarez S, Barney JB. 2005. How do entrepreneurs organize firms under conditions of uncertainty? *Journal of Management* **31**(5): 776–793.
- Ansoff HI. 1979. *Strategic Management*. Wiley: New York.
- Arrow KJ. 1974. Limited knowledge and economic analysis. *American Economic Review* **64**: 1–10.
- Brews PJ, Hunt MR. 1999. Learning to plan and planning to learn: resolving the planning school/learning school debate. *Strategic Management Journal* **20**(10): 889–913.
- Brunswick E. 1956. *Perceptions and the Representative Design of Experiments*. University of California Press: Berkeley, CA.
- Busenitz L, Barney J. 1997. Differences between entrepreneurs and managers in large organizations: biases and heuristics in strategic decision making. *Journal of Business Venturing* **12**: 9–30.
- Camerer CF, Loewenstein G. 2004. Behavioral economics: past, present and future. In *Advances in Behavioral Economics*, Camerer CF, Loewenstein G, Rabin M (eds). Princeton University Press: Princeton, NJ.
- Camerer CF, Weber M. 1992. Recent developments in modeling preferences. *Journal of Risk and Uncertainty* **5**(4): 325–370.
- Cassar G. 2010. Are individuals entering self-employment overly optimistic? An empirical test of plans and projections on nascent entrepreneur expectations. *Strategic Management Journal* **31**(8): 822–840.
- Casson M. 1982. *The Entrepreneur: An Economic Theory*. Barnes & Noble Books: Totowa, NJ.

- Charness G, Gneezy U, Kuhn M. 2013. Experimental methods: extra-laboratory experiments extending the reach of experimental economics. *Journal of Economic Behavior & Organization* **91**: 93–100.
- Curley SE, Yates JF, Abrams RA. 1986. Psychological sources of ambiguity avoidance. *Organizational Behavior and Human Decision Processes* **38**: 230–256.
- DeCharms RC. 1968. *Personal Causation: The Internal Affective Determinants of Behavior*. Academic Press: New York.
- de Finetti B. 1937. La prevision: ses lois logiques, ses sources subjectives. *Annales de l'Institut Henri Poincare* **7**: 1–68.
- DeGroot MH. 1989. *Probability and Statistics* (2nd edn). Addison-Wesley: Reading, MA.
- Dew N, Read S, Sarasvathy S, Wiltbank R. 2009. Effectual versus predictive logics in entrepreneurial decision making: differences between experts and novices. *Journal of Business Venturing* **24**: 287–309.
- Einhorn HJ, Hogarth RM. 1985. Ambiguity and uncertainty in probabilistic inference. *Psychological Review* **92**: 433–446.
- Einhorn HJ, Hogarth RM. 1986. Decision making under ambiguity. *Journal of Business* **59**: S225–S250.
- Ellsberg D. 1961. Risk, ambiguity and the Savage axioms. *Quarterly Journal of Economics* **75**: 643–669.
- Fox CR, Tversky A. 1995. Ambiguity aversion and comparative ignorance. *Quarterly Journal of Economics* **110**(3): 585–603.
- Frisch D, Baron J. 1988. Ambiguity and rationality. *Journal of Behavioral Decision Making* **1**: 149–157.
- Hagel JH, Roth AE. 1995. *The Handbook of Experimental Economics*. Princeton University Press: Princeton, NJ.
- Haynie MJ, Shepherd D, Mosakowski E, Earley CP. 2010. A situated metacognitive model of entrepreneurial mindset. *Journal of Business Venturing* **25**: 217–229.
- Hayward MLA, Forster WR, Sarasvathy SD, Fredrickson BL. 2010. Beyond hubris: how highly confident entrepreneurs rebound to venture again. *Journal of Business Venturing* **25**(6): 569–578.
- Heath C, Tversky A. 1991. Preference and belief: ambiguity and competence in choice under uncertainty. *Journal of Risk and Uncertainty* **4**: 5–28.
- Hough JR, White MA. 2003. Environmental dynamism and strategic decision making rationality: an examination at the decision level. *Strategic Management Journal* **24**(5): 481–489.
- Kahnemann D, Tversky A. 1979. Prospect theory: an analysis of decision under risk. *Econometrica* **47**(2): 263–291.
- Kahnemann D, Tversky A. 2000. *Choice, Values and Frames*. Cambridge University Press: Cambridge, U.K.
- Keynes JM. 1921. *A Treatise on Probability*. McMillan & Co.: London, U.K.
- Knight FH. 1921. *Risk, Uncertainty and Profit*. Houghton Mifflin: New York.
- Leary MR. 2007. Motivational and emotional aspects of the self. *Annual Review of Psychology* **58**: 317–344.
- Loewenstein G. 2004. Out of control: visceral influences on behavior. In *Advances in Behavioral Economics*, Camerer CF, Loewenstein G, Rabin M (eds). Princeton University Press: Princeton, NJ.
- McKelvie A, Haynie JM, Gustavsson V. 2009. Unpacking the uncertainty construct: implications for entrepreneurial action. *Journal of Business Venturing* **26**: 273–292.
- McMullen JS, Shepherd DA. 2006. Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur. *Academy of Management Review* **31**(1): 132–152.
- Milliken FJ. 1987. The three types of perceived uncertainty about the environment: state, effect, and response uncertainty. *Academy of Management Review* **12**(1): 133–143.
- Mintzberg H. 1994. *The Rise and Fall of Strategic Planning: Reconceiving Roles for Planning, Plans, Planners*. Free Press: New York.
- Mintzberg H, Waters JA. 1985. Of strategies, deliberate and emergent. *Strategic Management Journal* **6**(3): 257–272.
- Mosakowski E. 1997. Strategy making under causal ambiguity: conceptual issues and empirical evidence. *Organization Science* **8**(4): 414–442.
- Murnieks CY, Haynie MJ, Wiltbank RE, Harting T. 2011. 'I like how you think:' similarity as an interaction bias in the investor-entrepreneur dyad. *Journal of Management Studies* **33**: 119–135.
- Patzelt H, Shepherd DA. 2011. Negative emotions of an entrepreneurial career: self-employment and regulatory coping behaviors. *Journal of Business Venturing* **26**(2): 226–238.
- Pearl J. 2009. *Causality: Models, Reasoning, and Inference* (2nd edn). Cambridge University Press: New York.
- Porter ME. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. Free Press: New York.
- Rosch E. 1975. Cognitive representation of semantic categories. *Journal of Experimental Psychology* **104**(3): 192–233.
- Sarasvathy SD. 2001. Causation and effectuation: toward a theoretical shift from economic inevitability to entrepreneurial contingency. *Academy of Management Review* **26**(2): 243–263.
- Savage LJ. 1954. *The Foundations of Statistics*. John Wiley & Sons: New York.
- Shepherd DA. 2003. Learning from business failure: propositions of grief recovery for the self-employed. *Academy of Management Review* **28**(2): 318–328.
- Simon HA. 1973. The structure of ill-structured problems. *Artificial Intelligence* **4**: 181–201.
- Tripathi RC, Gupta RC, Gurland J. 1994. Estimation of the parameters in the beta binomial model. *Annals of the Institute of Statistical Mathematics* **46**(2): 317–331.
- White RW. 1959. Motivation reconsidered: the concept of competence. *Psychological Review* **66**: 297–333.
- Wiltbank R, Dew N, Read S, Sarasvathy SD. 2006. What to do next? The case for non-predictive strategy. *Strategic Management Journal* **27**(10): 981–998.

Wiltbank R, Read S, Dew N, Sarasvathy SD. 2009. Prediction and control under uncertainty: outcomes in angel investing. *Journal of Business Venturing* 24: 116–133.

APPENDIX

A1. Wording of the experiments: context-free information experiment

Page 1

So that we can compensate you, please enter your Amazon worker ID code below.

Please create a five-digit survey code. Write it here and in the HIT.

Page 2

Welcome to this experiment in decision making, which has been developed and financed by researchers from a large public university.

- It will take approximately two minutes to complete.
- You will receive 10 cents for your participation.
- Depending on your decision and luck, you may earn bonuses of 5, 10, or 15 more cents.
- In the experiment, 1 token is worth 1 cent. All numbers below refer to your earnings beyond your participation reward.

Good luck!

Page 3

You will be asked whether you want to place a bet on the color of the marble that will be extracted from an urn. You are endowed with 10 tokens. Your decision will affect your earnings in the following way.

- If you bet and the extracted marble is green, then you win 5 tokens.
- If you bet and the extracted marble is red, then you lose 5 tokens.
- If you don't bet, then you keep your endowment.

The program chooses a color according to the proportion of green and red marbles in the urn.

The urn contains 10 marbles of two colors, red and green, in proportions that are unknown to you.



[Baseline (without information)]

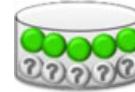
Would you like to bet on the urn?

[Baseline (with information)]

To reduce uncertainty, the program will make visible to you five marbles.

On a new page

Five marbles are known to be green.



Would you like to bet on the urn?

[Control]

To reduce uncertainty, you can control the color of five marbles by inserting them into the urn before the bet.



On a new page

Here you insert five green marbles.



After changing the probabilities by inserting these marbles, would you like to bet on the urn?

[Prediction]

To reduce uncertainty, you will be given the opportunity to observe five marbles that will be randomly extracted from the urn by the computer. After you observe the sample, the five extracted marbles will be returned to the urn.



On a new page

Here the sample contains one red marble and four green marbles.



After receiving this information, would you like to bet on the urn?

[If did not bet]

You did not bet, you will receive your bonus of 10 cents based on your decision.

[If bet and won]

Great, you won: you got a green marble! Thank you for your participation!

You will receive your bonus based on your decision and the outcome.

[If bet and lost]

Too bad, you lost: you got a red marble! Thank you for your participation!

You will receive your bonus based on your decision.

A2. Wording of the experiments: entrepreneurial information experiment

Page 1

So that we can compensate you, please enter your Amazon worker ID code below.

Please create a five-digit survey code. Write it here and in the HIT.

Page 2

Welcome to this experiment in decision making, which has been developed and financed by researchers from a large public university.

It will take approximately four minutes to complete.

- You will receive 20 cents for your participation.
- Depending on your decision and luck, you may earn bonuses of 5, 10, or 15 more cents.
- All numbers hereafter refer to your earnings beyond your participation reward.

Good luck!

Page 3

You will be presented with an entrepreneurial decision. Please use your imagination to put yourself in the context of this hypothetical situation and answer the questions as if you were the person in the position. Your decision will affect your earnings in the following way:

- If you don't launch the venture, then you win 10 cents.
- If you launch the venture and it is successful, then you win 15 cents.
- If you launch the venture and it is unsuccessful, then you win 5 cents.
- The computer will generate the outcome based on the information.

The program chooses the outcome according to the information in decision opportunity.

Page 4

You have developed a novel product with the potential to create a new market. You have successfully tested a prototype within your circle of acquaintances and consider it time to decide whether to launch the product. You have the resources and infrastructure to test its performance in the marketplace.

- If successful, you will be able attract further financial resources to escalate the venture.
- If unsuccessful, you will deplete your current savings.

You believe the product has great potential, yet success of the project is highly uncertain due to its novelty among customers.

[Baseline (without information)]

Which action will you take?

[Baseline (with information)]

There are 10 potential customers in your region and you know that four are willing to buy it and one is not. You do not know anything about the other customers.

Which action will you take?

[Control]

To mitigate this uncertainty, you talk with potential customers you know, present your product, assess their feedback and work on enlisting their support to create this new market.

Out of the 10 customers in your region, you spoke to five and four liked your product and have committed to buying it and one did not like your product and has not committed to buying it.

Which action will you take?

[Prediction]

To mitigate this uncertainty, you ask a consultancy to do market research so they can predict where the market is heading and forecast customers' willingness to buy your product.

The market researcher looks at a sample of the population of customers and predicts that out of the 10 customers in your region, one is not likely to buy your product and four are.

Which action will you take?

Page 5

[If launched and successful]

You launched your product and it got successful!

Thank you for your participation!

You will receive your bonus of 15 cents based on your decision and the outcome.

[If launched and unsuccessful]

You launched your product and it did not get successful.

Thank you for your participation! You will receive your bonus of 5 cents based on your decision and the outcome.

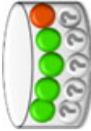
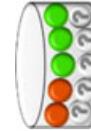
[If did not launch the product]

You did not launch your product.

Thank you for your participation!

You will receive your bonus of 10 cents based on your decision.

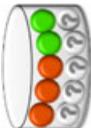
A3. Explanation of all the conditions: context-free information experiment

Information condition	Number of green marbles	Number of red marbles	Position of the marbles	Baseline	Control	Prediction
No information	0	0	N/A			
5G	5	0	N/A			
4G1R	4	1	Green/Red			
1R4G	4	1	Red/Green			
3G2R	3	2	Green/Red			
2R3G	3	2	Red/Green			
2G3R	2	3	Green/Red			

(Continues)

A3. (Continued)

(Continued)

Information condition	Number of green marbles	Number of red marbles	Position of the marbles	Baseline	Control	Prediction
3R2G	2	3	Red/Green			
1G4R	1	4	Green/Red			
4R1G	1	4	Red/Green			
5R	0	5	N/A			

A4. Explanation of all the conditions: entrepreneurial information experiment

Information condition	Number of customers interested	Number of customers not interested	Position of the customers	Baseline	Control	Prediction
No information	0	0	N/A	[No text]		
5G	5	0	N/A	'5 are willing to buy it'	'5 liked your product and have committed to buying it'	'5 are likely to buy your product'
4G1R	4	1	Interested/ Not interested	'4 are willing to buy it and 1 is not'	'4 liked your product and have committed to buying it and 1 did not like your product and has not committed to buying it'	'4 are likely to buy your product and 1 is not'
1R4G	4	1	Not interested/ Interested	'1 is not willing to buy it and 4 are not'	'1 did not like your product and has not committed to buying it and 4 liked your product and have committed to buying it'	'1 is not likely to buy your product and 4 are'
3G2R	3	2	Interested/ Not interested	'3 are willing to buy it and 2 are not'	'3 liked your product and have committed to buying it and 2 did not like your product and have not committed to buying it'	'3 are likely to buy your product and 2 are not'
2R3G	3	2	Not interested/ Interested	'2 are not willing to buy it and 3 are'	'2 did not like your product and have not committed to buying it and 3 liked your product and have committed to buying it'	'2 are not likely to buy your product and 3 are'
2G3R	2	3	Interested/ Not interested	'2 are willing to buy it and 3 are not'	'2 liked your product and have committed to buying it and 3 did not like your product and have not committed to buying it'	'2 are likely to buy your product and 3 are not'
3R2G	2	3	Not interested/ Interested	'3 are not willing to buy it and 2 are'	'3 did not like your product and have not committed to buying it and 2 liked your product and have committed to buying it'	'3 are not likely to buy your product and 2 are'

A4. (Continued)

Information condition	Number of customers interested	Number of customers not interested	Position of the customers	Baseline	Control	Prediction
1G4R	1	4	Interested/ Not interested	'1 is willing to buy it and 4 are not'	product and have committed to buying it '1 liked your product and has committed to buying it and 4 did not like your product and have not committed to buying it'	'1 is likely to buy your product and 4 are not'
4R1G	1	4	Not interested/ Interested	'4 are not willing to buy it and 1 is''	'4 did not like your product and have not committed to buying it and 1 liked your product and has committed to buying it'	'4 are not likely to buy your product and 1 is'
5R	0	5	N/A	'5 are not willing to buy it'	'5 did not like your product and have not committed to buying it'	'5 are not likely to buy your product'

A5. Bayesian updating

Amount of marbles		Prediction		Control	
G	R	E(X)	Var(X)	E(X)	Var(X)
0	5	0.14	0.12	0.32	0.19
1	4	0.29	0.20	0.39	0.23
2	3	0.43	0.24	0.46	0.25
3	2	0.57	0.24	0.54	0.25
4	1	0.71	0.20	0.61	0.23
5	0	0.86	0.12	0.68	0.19