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The Evolutionary Explanation of What? A Closer Look at Adaptationist Explanations of Risk Preferences

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Abstract: The paper examines evolutionary explanations of risk preferences. First, the paper argues that evolutionary psychology is ill-suited for explaining prospect theory risk preferences since the empirical evidence does not support the universality of the fourfold pattern of risk preferences postulated by prospect theory. Second, the paper argues that explaining prospect theory risk preferences by means of risk-sensitive foraging models is incomplete since this approach does not offer a rationale for the observed diversity in human decision making involving monetary gambles. Finally, the paper suggests adopting a wider perspective on evolutionary approaches to human behaviour that also takes into account the role of cultural processes in shaping risk preferences.

Keywords: risk preferences, prospect theory, evolutionary psychology, human behavioural ecology, cultural evolution.

JEL Classification: D01, D91, Z10

I. INTRODUCTION

In common parlance risk refers to the possibility of harm, injury or loss. Among decision theorists and economists, however, risk is associated with a different concept. Rather than identifying risk with the possibility of harm, risk refers to uncertainty or, more precisely, the dispersion of outcomes in a probability distribution. As such, risk is typically associated with statistical concepts such as the variance of a probability distribution. Formally, an agent is said to be risk-averse if and only if

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she prefers x for certain to a lottery with expected monetary value x. An agent is said to be risk seeking if and only if she prefers a lottery with expected monetary value x to x for certain. While it is rather intuitive that human beings are averse to risk when interpreted as the possibility of harm, it is an open question of whether—and if so, why—human beings are averse to risk when interpreted as the dispersion of outcomes.[1]

Okasha (2007) offers an adaptationist explanation of risk aversion that invokes results from theoretical biology; these results demonstrate that natural selection is sensitive to both the mean and the variance of the offspring distribution when organisms evolve in stochastic environments. In particular, given two traits with the same mean offspring number, it can be shown that under certain environmental conditions natural selection favours the trait with the lower variance in reproductive success. Okasha's account has been criticised on the grounds that it misconstrues its explanandum. Rather than explaining that human beings are risk-averse, Schulz (2008) argues that explaining human attitudes towards risk requires the explanation of both risk-averse and risk-seeking behaviours.

Prospect theory is generally considered to be the most influential descriptive account of decision making under risk in psychology and behavioural economics (Tversky and Kahneman 1992). The theory stipulates that for events with moderate to high probability agents are risk-averse in the gains domain and risk-seeking in the loss domain. For gains and losses with low probability, however, the pattern is reversed. This postulated attitude towards risk is referred to as the fourfold pattern of risk preferences.[2]

In line with Schulz's requirement that an adequate evolutionary explanation of risk preferences has to account for both risk-averse and risk-seeking behaviour in human agents, a number of evolutionary explanations of the risk preferences postulated by prospect theory have been proposed (Aktipis and Kurzban 2004; Brennan and Lo 2011; McDermott et al. 2008; Mishra and Fiddick 2012; Mallpress et al. 2015). Mallpress et al. (2015), for instance, provide an adaptive rationale for the fourfold pattern of risk preferences by identifying conditions under

[1] For a more detailed treatment of these two different concepts of risk (i.e., risk as the possibility of harm and risk as dispersion), see Friedman et al. (2014).

[2] More precisely, the focus here is on what is referred to as cumulative prospect theory (Tversky and Kahneman 1992).

which these risk preferences maximize the reproductive value of a decision maker. Mallpress et al. demonstrate that prospect theory risk preferences can arise when environmental conditions change stochastically over time, thereby affecting the reserve energy level of a decision maker, and the pattern of change shows auto-correlation.[3]

In order to further the philosophical debate on the evolution of human attitudes towards risk, I will take a closer look at evolutionary explanations of prospect theory risk preferences. I will make three points. First, I will argue that evolutionary psychology is ill-suited for explaining prospect theory risk preferences since the empirical evidence does not support the universality of the fourfold pattern of risk preferences. Second, I will argue that explaining prospect theory risk preferences by means of risk-sensitive foraging models is incomplete since this approach does not offer a rationale for the observed diversity in human decision making involving monetary gambles. And third, I will suggest adopting a wider perspective on evolutionary approaches to human behaviour that also takes into account the role of cultural processes in shaping risk preferences.

The structure of the paper is as follows. Section 2 introduces basic ideas from evolutionary psychology as well as some criticisms raised against this evolutionary approach to human behaviour. Section 3 revisits the evidence for the risk preferences postulated by prospect theory. Section 4 turns to the application of human behavioural ecology to the study of prospect theory risk preferences. Section 5 offers some suggestive remarks on what the literature on cultural evolution can contribute to our understanding of human attitudes towards risk. Section 6 concludes with some general thoughts on the prospect of explaining risk preferences evolutionarily.

II. EVOLUTIONARY PSYCHOLOGY AND RISK PREFERENCES

Evolutionary psychology studies how organisms adapt behaviourally to their environment. The focus of evolutionary psychology has traditionally been on universal adaptations, that is, aspects of the human genome that became fixated in the population by natural

[3] In a discrete model environmental states are said to be positively auto-correlated if the occurrence of a given environmental state at time t increases the probability of the same state occurring at time t + 1. In such a setting knowledge about a current environmental state provides information about the likely environmental conditions in the near future.

selection before our species spread across the world about 50,000 years ago and that have not changed systematically since (Tooby and Cosmides 1990). For instance, evolutionary psychologists have proposed two central hypotheses regarding sex differences in human mating preferences. It has been argued that men have an evolved preference for mating with young women while women have an evolved preference for mating with high-status men (e.g., Buss 1992; Ellis 1992).

Aktipis and Kurzban (2004) suggest that evolutionary psychology can provide evolutionary explanations of human preferences, including human attitudes towards risk. They write:

> Economists can (and do) claim that individuals get utility from these activities, leaving the question of the origin of tastes and preferences to the other behavioral sciences [...]. Evolutionary psychology provides answers—or at least a way to generate possible answers—about these origins tastes and preferences that enabled us to better solve adaptive problems were selected for during human evolutionary history (Aktipis and Kurzban 2004, 137).

Similarly, McDermott et al. (2008) motivate their evolutionary account of prospect theory preferences by reference to work in evolutionary psychology. More specifically, they argue that the human cognitive architecture evolved to solve particular adaptive problems related to finding sufficient food resources required for survival persists and is currently utilized in other survival-related decisions.

In order to establish my critique of the use of evolutionary psychology for the explanation of prospect theory risk preferences, I will begin with a criticism of evolutionary psychology originally due to Buller (2005). Buller questions whether the mating preferences postulated and subsequently explained by evolutionary psychologists constitute a trait that is universally shared by human beings. He develops his objection by first setting a standard that mating preferences have to satisfy in order to be considered as universal. Buller writes:

> to say that those preferences are "universal" means that they are observable *in all cultures, all historical periods, all economic or political systems, all social classes, all religious groups, all "races" or ethnicities, and all relevant ages of the life cycle* (2005, 210, italics in original).

In a second step, Buller argues that evolutionary psychologists have failed to provide evidence that the mating preferences inferred by evolutionary psychologists are universal among humans given this standard. In particular, he argues that mating preferences tend to vary with age and social class. As such, evolutionary psychologists have misconstrued the explanandum of their account of mating preferences.[4]

From the perspective of this paper, the second step of Buller's objection is of less relevance since it is specific to the subject of human mating preferences. The first step, however, raises a more general issue that also applies to evolutionary explanations of human attitudes towards risk based on ideas from evolutionary psychology. In order to assess whether prospect theory risk preferences fall into the category of universal preferences that shape human nature, a notion of universality has to be adopted that allows for empirical data to have a say on the subject matter. Obviously, such an account of universality should not be overly restrictive in order to provide a convincing critique of evolutionary psychology. Here, I will adopt the requirement that our best available evidence has to support the idea that a majority of agents adopts the fourfold pattern of risk preferences when making decisions under risk.

The insistence that a particular preference is shared by the majority of agents introduces some arbitrariness into the discussion. In particular, one might wonder what makes the 50% threshold philosophically relevant. This requirement, however, sits well with recent characterizations of the subject matter of evolutionary psychology arguing that evolutionary psychology aims to explain traits that are present in most humans (Machery 2008). Based on Machery's conception, the focus of evolutionary psychology is on the similarities between humans rather than on human differences. This step does not deny that evolutionary biology can explain polymorphisms found in the human population, such as the differences in blood types. Furthermore, this view does not ignore that some evolutionary psychologists have recently turned to providing selective accounts for individual

[4] Buller's critique has faced a number of objections. For instance, Delton et al. (2006) argue that Buller wrongly assumes that the mating preferences postulated by evolutionary psychology are to be identical across different stages of the life cycle. That being said, Buller's argument offers a good starting point for assessing the application of evolutionary psychology to the explanation of human attitudes towards risk.

differences (Buss and Hawley 2010) but delegates the explanation of these phenomena to other evolutionary approaches.

My reading of the notion of universal preference is also rather modest in a different sense. I do not ascribe a particular reading to the notion of preference but only tacitly assume a notion of preference that is compatible with stochastic choice models in economics.[5] Doing so, however, requires a notion of preference that allows for the possibility that agents can make errors in their choice behaviour. That is, even though an agent can have preferences satisfying various axioms of rational choice theory, she can wrongly express these preferences in a choice situation. While this restriction does not impact the course of this paper, it is worth noting that this constraint rules out revealed preference theory as a matter of logic. According to revealed preference theory, preference is reducible to (hypothetical) choice. That is, a preference ordering over a set of alternatives is just a summary of an agent's choices between them. One consequence of this reading is that agents cannot, by definition, make mistakes when expressing their true preferences.

III. EVIDENCE AND PROSPECT THEORY

A comprehensive review of the literature and a recent experimental study on the evidential basis of prospect theory has been provided by Harrison and Swarthout (2016). My presentation of Harrison and Swarthout's work follows the summary of Harrison and Ross (2017). Harrison and Swarthout argue that virtually no previous studies have estimated a model of prospect theory in which all experimental tasks involved real payoffs, and that those studies that were satisfactory from a methodological perspective found little evidence in support of the theory. Based on their experimental data, Harrison and Swarthout conclude that human decision making under risk is heterogeneous and almost all of the experimental subjects apply rank-dependent utility theory rather than prospect theory or, to a lesser extent, expected utility theory rather than prospect theory. Rank-dependent utility theory proposed by Quiggin (1982) extends orthodox expected utility theory by allowing for decision weights on lottery outcomes. As such, rank-dependent utility theory transforms probabilities into decision weights similar to prospect theory. In contrast to prospect theory, however,

[5] A number of stochastic choice models have been proposed in the decision-theoretic literature. For an overview, see Suppes et al. (1989) and Wilcox (2008).

rank-dependent utility theory does not invoke the concept of a reference point based on which gains and losses are to be evaluated. Similar to prospect theory, rank-dependent utility theory is designed to make sense of the fact that agents both purchase lottery tickets and insure against losses. Harrison and Swarthout's data suggest that most of the apparently loss-averse choice behaviour results from probability weighting rather than from direct disutility experienced when an outcome is framed against a reference point. That is, their experimental subjects behave as if they evaluate the net payment rather than the gross loss when one is presented to them and then apply probability weighting consistent with rank-dependent utility theory.

Prospect theory is widely seen as the most promising descriptive account of decision making under risk. In the light of the existing literature as well as some recent experimental work, however, the laboratory evidence is not as solid as previously assumed. According to Harrison and Swarthout's experimental study, the most empirically adequate hypothesis about human choice under risk is that it is heterogeneous and that in cases where agents do not follow expected utility theory, choice behaviour is better characterized by rank-dependent utility theory than prospect theory. I conclude that a majority of agents in these experiments appear to follow decision making models different from prospect theory. As such, the empirical evidence does not support the idea that humans universally share the fourfold pattern of risk preferences. This suggests that evolutionary psychology—understood as an evolutionary account of universal human traits—is not the right theoretical framework to produce an evolutionary explanation of the fourfold pattern of risk preferences.

This conclusion sounds familiar from the perspective of earlier philosophical critiques of evolutionary approaches to human behaviour. In the context of sociobiology, Gould and Lewontin (1979) as well as Kitcher (1985) have identified a flawed form of scientific reasoning that combines an overly liberal form of evolutionary thinking with loose experimental testing. More specifically, they argue that sociobiologists have been culpable of providing spurious confirmation to the existence of traits whose empirical basis is rather weak. While I have not taken issue with evolutionary models giving rise to prospect theory preferences, such as Mallpress et al. (2015), I have also diagnosed a lack of empirical support for the preferences explained by these models.

One might object to my critique that observing choice behaviour, which seems to follow diverse models of decision making under risk, is not sufficient to rule out the universality of prospect theory risk preferences. Indeed, Cosmides and Tooby (1997) stress that cultural diversity is compatible with the existence of a set of universal cognitive adaptations. For instance, they argue that humans share a preference for sweet foods but that the expression of this preference has changed significantly since the Pleistocene. Modern humans have a large number of different food options compared to their hunter-gatherer ancestors and as a result their preference for sweet foods manifests itself in different ways (e.g., in the consumption of fast food). Returning to the evolution of risk preferences, however, it is unclear whether a similar argument can be made. Taking the analogy with the universality of the preference for sweet food seriously, would require that the fourfold pattern of risk preference constitutes the universal human attitude towards risk while choice behaviour that is more aptly characterized as following expected utility theory or rank-dependent utility theory corresponds to the different manifestations of this preference in contemporary society. Since it is difficult to make sense of risk preferences that follow a rank-dependent utility model as a manifestation of the risk preferences postulated by prospect theory, the analogy between the universality of food and risk preferences breaks down.

IV. RISK-SENSITIVE FORAGING MEETS PROSPECT THEORY

Evolutionary psychology traditionally focuses on universal features of human psychology in its explanations. In contrast to evolutionary psychology, human behavioural ecology aims to provide adaptationist accounts of the observed differences in human behaviour. Laland and Brown write:

> The principal goal of human behavioural ecology is to account for the variation in human behaviour by asking whether models of optimality and fitness-maximisation provide good explanations for the differences found between individuals. An overriding assumption is that human beings exhibit an extraordinary flexibility of behaviour, allowing them to behave in an adaptive manner in all kinds of environments (2002, 112).

Similarly, Smith et al. characterise the explanatory strategy employed by human behavioural ecologists as follows:

> [Human behavioural ecology] applies the theoretical perspective of animal behavioral ecology to human populations, examining the degree to which behavior is adaptively adjusted to environmental (including social) conditions, emphasizing conditional strategies of the form "in situation X, maximize fitness payoffs by doing α, in situation Y, do β" (2001, 128).

Evolutionary psychologists stress that the environment of contemporary human beings differs substantively from the selective environment faced by our ancestors, which is typically understood as the Pleistocene environment inhabited by our hunter-gatherer ancestors. As a result, evolutionary psychologists postulate an adaptive lag between the environment during which complex human behavioural traits have been shaped by natural selection and the present-day environment inhabited by modern human beings. Human behavioural ecologists, on the other hand, downplay the significance of this adaptive lag. From their perspective, evolutionary psychologists underestimate the amount of currently adaptive behaviour found in the human population.[6]

Human behavioural ecologists regularly employ risk-sensitive foraging theory in their models. Risk-sensitive foraging theory provides an account of how animals should choose between stochastic foraging options in order to maximize reproductive success (Caraco 1980; Stephens 1981; McNamara and Houston 1992). A particular risk-sensitive foraging model that has been invoked in evolutionary explanations of prospect theory risk preferences is the daily energy budget rule due to Stephens (1981). This decision rule aims to explain the behaviour of small birds foraging during the winter months.

The problem faced by these birds is that they need to acquire enough energy during the day in order to survive the following night. Suppose the foraging bird has two foraging options that have the same expected energy gain but differ in variance. Stephens shows that the foraging bird should choose the more variable foraging option if the daily energy budget is negative, that is, if the expected energy gains are insufficient to meet the energy requirements, and the less variable option if the daily energy budget is positive.

A number of researchers in the social sciences have made use of results from risk-sensitive foraging theory in order to offer an

[6] For a more comprehensive treatment of the differences between evolutionary psychology and human behavioural ecology, see Laland and Brown (2002).

evolutionary rationale for prospect theory. For instance, Aktipis and Kurzban (2004) argue that the asymmetry between losses and gains postulated by prospect theory is underwritten by risk-sensitive foraging theory since marginal energy losses are more fitness relevant than marginal fitness gains. While energy losses can sometimes lead to death, energy gains will merely extend the life span of a forager. Furthermore, they assert that the curvature of the value function in prospect theory is underwritten by risk-sensitive foraging theory. In Stephens's model, energetic gains have diminishing marginal returns in fitness due to the workings of the threshold value that energy reserves have to exceed by nightfall in order to avoid starvation overnight. That is, a given amount of energy will matter more to a bird that is close to starvation than a well-fed specimen. Aktipis and Kurzban suggest that this biological mechanism supports the risk aversion for gains postulated by prospect theory. McDermott et al. (2008) go one step further and explicitly identify the energy threshold value in the daily energy budget rule with the reference point in prospect theory. They assert that risk seeking is optimal from an evolutionary perspective in the domain of losses, where a forager expects an energetic shortfall compared to the energy threshold value that guarantees overnight survival. Further, they assert that risk aversion is optimal in the domain of gains. That is, being risk averse maximizes the probability of surviving to the next day when the forager expects to exceed the energy threshold in Stephens's model.

Houston et al. (2014) critically analyze the relationship between risk-sensitive foraging theory and prospect theory. They highlight that the formal connection between risk-sensitive foraging theory and prospect theory established by McDermott et al. (2008) is only valid under rather restrictive assumptions, such as the forager having no choice between foraging options, there is no benefit of building up excess reserves above the critical energy threshold for overnight survival and there are no upper or lower boundaries on energy reserves. Furthermore, Houston et al. argue that the threshold value in the daily energy budget rule cannot be identified with the reference point in prospect theory as suggested by McDermott et al.

Setting these criticisms aside, I will develop a further critique of the use of risk-sensitive foraging models for explaining prospect theory risk preferences. A recent evolutionary model of prospect theory preferences drawing on insights from behavioural ecology is provided by Mallpress et al. (2015). In line with risk-sensitive foraging theory, the model assumes that nature selects for strategies that maximize the reproductive value of a forager. In the model, reproductive value crucially depends on the energy reserves of an agent. In particular, it is assumed that a forager can only reproduce if the organism builds up sufficient energy reserves. If the forager's energy reserves reach (or overshoot) a given threshold, the forager reproduces and gains a fixed fitness payoff in terms of reproductive units but also loses a particular amount of energetic reserves. The forager then continues at this new energy reserve level and can reproduce again if it acquires a sufficient amount of energy reserves until it dies (i.e. its energy reserve level reaches zero). The energy reserves of the forager are affected by the state of the environment. In some environmental states the energy reserves increase while in others the reserves decrease. It is assumed that environmental states change stochastically over time and the pattern of change shows auto-correlation.

Given these assumptions about the environment and the reproductive mechanism of a forager, Mallpress et al. investigate the fitness impact of a hypothetical gamble that involves choosing between the deterministic background rate of energetic gain in a given environment and a stochastic option of energy acquisition. They demonstrate that the fourfold pattern of risk preferences over changes in energy reserves enhances fitness in a variety of stochastic environments showing intermediate degrees of auto-correlation. However, the fourfold pattern ceases to be optimal and universal risk aversion is selected for when the mean change in energy reserves across the possible environmental states is positive.

Mallpress et al. demonstrate that under certain environmental conditions the fourfold pattern of prospect theory with regard to energy reserves is selected for. How does this explain prospect theory preferences over monetary lotteries shown in some experimental studies? An explanatory strategy invoked by Okasha (2007) is to postulate a currency shift from offspring numbers to money in his adaptationist explanation of risk aversion. The justification of such a move is typically that offspring numbers in biological models share a number of money-like features. In a similar vein, a currency shift from energy to money can be postulated. Of course, the deterministic link between energy reserves and reproduction assumed in Mallpress et al. does not hold when energy reserves are substituted by monetary wealth and the model is applied to contemporary western societies. Humans typically do not reproduce once their bank account surpasses a certain threshold value.[7] But suppose one accepts that there is a close link between money and energy. What are the implications of this explanatory strategy?

According to Smith et al., human behavioural ecologists identify conditional strategies of the form "in environment X, do α" and "in environment Y, do β" (2001, 112). Mallpress et al. show that prospect theory preferences over energy gambles (denoted as action α) result from an environment (denoted as environment X) in which the mean change in energy reserves across environmental states is (approximately) zero. In contrast, risk averse behaviour over energy gambles (denoted as β) in both the gains and loss domain is selected for in a situation in which the mean change in energy reserves is positive (denoted as Y). By applying the currency shift from energy to money, situation X translates into an environment X* in which the mean change in monetary wealth across states of the world is zero while situation Y translates into an environment Y* in which the mean change in wealth is positive. Similarly, prospect theory preferences over energy gambles α translate into prospect theory preferences over monetary gambles α* while risk aversion with regard to energy gambles β translates into risk aversion with regard to monetary lotteries β*. In situation X* prospect theory preferences over money α* are fitness enhancing, while in situation Y* risk averse preferences over money β* are selected for.

In combination with the currency shift from energy to money, the evolutionary model of Mallpress et al. then establishes explanations of the form "If situation X* holds, then risk preferences α* are optimal". In order to assess whether this conditional can account for human risk-taking behaviour observed in experimental monetary gambles, the assumptions embodied in the antecedent condition X* have to be checked. That is, one has to assess the degree of auto-correlation between choices and the extent to which current options allow to make inferences regarding the availability of future options.

Mallpress et al. are frank in admitting that the conditions of their evolutionary model are typically not met by the experimental set-ups in

[7] Grüne-Yanoff (2011) raises a similar point in his discussion of the use of evolutionary game theory in the social sciences. He argues that while animals largely exist on the subsistence level, humans mostly do not. As a consequence, it is much less clear what the implications of the compliance with conventions or norms are for survival and reproduction in humans compared to the implications for survival and reproduction in non-human animals.

studies of human decision making. So, how does the model explain human risk-taking behaviour? Mallpress et al. suggest that in studies on human decision making, "people may be acting on the basis of evolved predispositions that are adapted to natural environments with a richer temporal structure" (2015, 369).

If our attitudes towards risk are adapted to an environment that has a richer temporal structure than the present one (e.g., by environmental change showing a certain degree of auto-correlation), then the view of Mallpress et al. stands in conflict with the methodological assumption of human behavioural ecology that humans act optimally in their present environment. Their position here shares similarities with mainstream evolutionary psychology, which postulates that complex human behavioural traits are adapted to an ancestral environment that differs significantly from the present one. Following this line of reasoning, Mallpress et al. seem to have two options. The first option adapts the view of evolutionary psychology that there is an ancestral environment, typically seen as the Pleistocene environment inhabited by our hunter-gatherer ancestors that shaped human attitudes towards risk. Mallpress et al. would have then to make the case that this environment had a particular stochastic structure, say, show a certain degree of auto-correlation, in order to make the case for the evolution of the fourfold pattern of risk preferences. Mallpress et al. gesture at this option by pointing out that most environments, including those in which our human ancestors evolved, show some degree of auto-correlation. This option, however, runs into the difficulty that the evidence speaks against the universality of the fourfold pattern of risk preferences as discussed in section 3.

The second option allows for a variety of different ancestral environmental conditions some of which favoured the evolution of prospect theory risk preferences while others selected for risk aversion. While this option allows for a plethora of evolved human attitudes towards risk, it does not offer a rationale for the observed diversity in human decision making involving monetary gambles. For instance, one might ask: Under which condition should we expect to see experimental subjects show the fourfold pattern of risk preferences? And, under which conditions do experimental subjects show risk aversion? A natural answer to these questions would be to refer to the conditions described by situations X* and Y*, respectively. However, Mallpress et al. make it clear that this is not their explanatory strategy when they point out that conditions such as X* and Y* are typically not met in experimental tests of human decision making under risk. This leaves the problem of identifying the conditions under which different evolved risk-taking behaviour is to be observed in monetary gambles unaddressed. Phrased differently, it is left unclear what triggers an evolved predisposition towards risk-taking. Without this further detail, however, it is difficult to see whether Mallpress et al. are on the right track with their proposed model. I therefore suggest that the evolutionary model of Mallpress et al. offers only an incomplete account of human attitudes towards risk. A further explanatory step is needed that bridges the gap between the evolution of risk attitudes in ancestral environments and the risk-taking behaviour in experimental studies of decision making involving monetary lotteries.

VI. RISK AND CULTURAL EVOLUTION

While my previous remarks have been mainly critical in character, this does not imply that I reject evolutionary thinking about risk preferences tout court. In this section, I would like to widen the scope and discuss some evolutionary approaches to human behaviour by drawing on ideas from cultural evolution. Doing so goes along with a shift of gear. Rather than assessing particular evolutionary models of risk preferences in detail, I will offer some suggestive remarks on what the literature on cultural evolution can contribute to our understanding of human attitudes towards risk.

Cultural evolution refers to the change in socially transmitted beliefs, customs, skills, preferences and languages. A number of theories of cultural evolution have been proposed in biology and the social sciences. Richerson and Boyd (2005), for instance, develop formal evolutionary models to explain how human populations have changed over time under the influence of various forms of learning. By augmenting standard evolutionary models of population change with social learning processes such as imitation and teaching, they exploit the fact that learning allows human populations to change very quickly and to adapt to their environment without the workings of natural selection. The question of whether these learning processes are similar to those at play in biological evolution is only of secondary importance in Richerson and Boyd's work. As such, their work differs from what Lewens (2015) calls the ‘selectionist approach’ to cultural evolution, which maintains that cultural items such as ideas, tools and practices compete in a Darwinian struggle for survival. Proponents of the selectionist approach, such as Mesoudi (2011), suggest that cultural change can be described as a Darwinian evolutionary process that is similar in key respects to biological evolution.

A variety of non-genetic transmission processes can shape human preferences. Religious attitudes and political preferences, for instance, are typically learned from the parents while clothing preferences are strongly influenced by one's peers. Furthermore, non-peers and non-parents, such as teachers and grandparents, can shape our attitudes and preferences (Cavalli-Sforza and Feldman 1981). Independent of whether these transmission mechanisms can be understood in Darwinian terms, there exist good reasons to reflect on the role of these learning processes when accounting for the evolution of risk preferences. Dohmen et al. (2012), for instance, provide evidence for both the transmission of risk attitudes from parents to children and the influence of other role models in the environment on child risk attitudes. In addition, Dohmen et al. make the case that the transmission of risk attitudes from parents to children cannot be reduced to solely genetic factors but require also some form of socialization. For example, they observe that children reproduce the specific variation in attitudes across contexts observed in the parents and argue that this phenomenon is hard to explain with genetics and indicates that socialization is a rather fine-tuned process. As a consequence, ignoring non-genetic transmission processes may result in leaving out some potentially important preference forming mechanisms.

Cultural evolution theorists, however, have not studied the evolution of risk preferences in detail. A notable exception is Stern (2010), who studies the evolution of risk preferences by means of a biological model that includes both a genetic inheritance mechanism and a non-genetic form of inheritance of a parent's experience. He interprets this non-genetic transmission mechanism by reference to the inheritance of property and acquired knowledge commonly found in the human population. Taking into account forms of 'cultural inheritance', such as property and acquired knowledge, can only be seen as a first step towards a more comprehensive treatment of the coevolution of genes and culture that lead to the presently observed human attitudes towards risk.

VI. CONCLUSION

While any final verdict on evolutionary explanations of risk preferences would be premature, some general comments on the prospects and challenges of such explanations are in order. The previous discussion has focused on the fourfold pattern of risk preferences postulated by prospect theory as the explanandum of an evolutionary explanation. While this step was motivated by the prominent status of prospect theory as a descriptive account of decision making under risk, doing so led to a rather sceptical conclusion with regard to the possibility of explaining these preferences by means of evolutionary psychology understood as an evolutionary account of universal human traits. Matters would be different, however, if a feature of human decision making is selected as the target of an evolutionary explanation that has better empirical support than the fourfold pattern of risk preferences.

Returning to Harrison and Swarthout's study, a concave utility function is estimated for both expected utility theory as well as rank-dependent utility theory that emerges as the best performing non-expected utility theory. This suggests that a concave utility function, representing diminishing marginal returns of wealth, constitutes a more promising candidate for a universal feature of human preferences. As such, a concave utility function is a more suitable phenomenon to be explained by mainstream evolutionary psychology. Assuming a currency shift between monetary wealth and food, there is a plausible biological rationale for a concave utility function since reproductive output frequently scales concavely with food intake, that is, additional food leads to additional offspring but it does so with diminishing returns. Indeed, fitness functions of this kind are regularly invoked in risk-sensitive foraging theory (Houston and McNamara 1999).

Of course, having established a concave utility function does not by itself specify how agents make decisions under risk. For instance, it remains to be answered whether or not agents assign particular weights to the probabilities in their decision making process as suggested by rank-dependent utility theory. Phrased differently, the additional question arises of whether agents apply expected utility theory or some form of non-expected utility theory. Another lesson to draw from Harrison and Swarthout's study is that human decision making under risk is heterogeneous. While most of their experimental subjects apply rank-dependent utility theory, a smaller group makes decisions in line with expected utility theory. An adequate explanation of human risk attitudes has to provide a rationale for the apparent diversity in probability weighting. It cannot be presumed that a single decision theoretic procedure has become fixed in the human population.

While human behavioural ecology rightly stresses the diversity of human behaviour, it typically focuses on the ecological conditions giving rise to diverse behavioural patterns. As a consequence, similar behavioural patterns should be observed in similar environments. With regard to human decision making under risk, however, this is not necessarily the case. In particular, it is unclear whether experimental subjects showing diverse decision making under risk can be said to operate under different local ecological conditions. Theories of cultural evolution offer a further perspective on how evolutionary thinking can contribute to our understanding of risk preferences. It remains to be seen whether taking into account non-genetic transmission processes discussed by cultural evolutionist can offer an adequate explanation of the diversity in human decision making under risk.

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