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Focusing and Framing of Risky Alternatives*

Markus Dertwinkel-Kalt[1,†] Tobias Wenzel[2,‡]

[1]University of Cologne

[2]University of Bath

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Abstract

This paper develops a theory of focusing and framing in an intertemporal context with risky choices. We provide a selection criterion between existing theories of focusing by allowing a decision maker to choose her frame such that her attention is either drawn to salient events associated with an option or to the expected utilities an option yields in different time periods. Our key assumption is that a decision maker can choose her frame in a self-serving manner. We predict that the selected frame induces overoptimistic actions in the sense that subjects underrate downside risk but overrate upside risk and accordingly reveal overoptimistic choices. Hence, our theory can explain phenomena such as excessive harmful consumption (smoking, unhealthy diet) and risky investments (entrepreneurship, lotteries, gambling) in one coherent framework. Notably, overoptimistic actions are not universal, but have plausible limits. We characterize under which situations overoptimistic actions are most likely to occur and under which circumstances choices should be rational or even pessimistic.

JEL Classification: D03, D11, D90

Keywords: Focusing, Salience, Framing, Overoptimism.

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†Email: mdertwin@uni-koeln.de

‡Email: t.wenzel@bath.ac.uk.

1 Introduction

Attentional focusing affects choices in many contexts. According to Kahneman (2011, p. 324), "our mind has a useful capability to focus on whatever is odd, different or unusual." Recently, this mechanism has been formally modeled, thereby explaining a broad variety of choice puzzles described in the empirical and experimental behavioral economics literature. At its core, attentional focusing assumes that aspects of an alternative which are especially salient are overweighted, whereas less prominent, but possibly important aspects are underweighted. This distortion gives rise to an alternative's *focus-weighted utility*, and decision makers select among the alternatives to maximize their focus-weighted utility rather than their actual net present value.

Attentional focusing has been investigated in two seminal contributions by Kőszegi and Szeidl (2013, henceforth: KS) and Bordalo *et al.* (2012, henceforth: BGS).[1] Either of these models introduces a specific approach toward the framing of decision situations and proposes a frame in which decision makers evaluate the available options.[2] Each frame induces distortions of attention and therefore biased decisions if decision makers focus on features that are rendered especially salient in the respective frame. The main difference between the two approaches lies in whether attributes decision makers may focus on are defined on a state basis in a time period (BGS) or on the expected utility of an option in a time period (KS). Then, according to each of the frames, attention is guided toward those attributes in which the range of choice is broader, that is, in which the available options differ a great deal. Those attributes which gather much attention are overweighted insofar as the decision weights on these attributes are enhanced while less salient attributes are rather neglected. But the way the attributes are specified is crucial for the models' implications so that predictions of the two approaches may be very different. The aim of the present paper is to bring together these two approaches. Note that we do not provide a novel frame, but instead propose a selection criterion between these two existing frames.

To do so we present a theory of intertemporal decision making in a risky environment

[1]In both approaches attention is stimulus-driven, that is, automatically directed toward certain outstanding choice features. A different class of models assumes that attention is goal-directed, that is, a scarce resource which is allocated to attributes ex ante, either in an efficient way or guided through priors (Schwartzstein, 2014; Gabaix, 2014; Woodford, 2012). Lieder *et al.* (2016) have linked these two strands of research by providing a microfoundation of salience. Accordingly, an over-representation of extreme events in decision making as suggested by KS and BGS may simply reflect the rational use of limited cognitive resources. An approach to limited attention that is very different to these approaches is undertaken by Masatlioglu *et al.* (2012) who assume that an agent chooses the optimal option from her consideration set, which does not include all alternatives due to attention limitations. They analyze under which conditions choices provide information on whether an option was included in the consideration set or not.

[2]Notably, *framing* in general captures two different notions: the way alternatives are presented and arranged (*visual frame*), and the way in which the alternatives are mentally represented by the decision maker (*mental frame*). The models we bring together belong to the second category, providing approaches how a decision maker can frame outcomes. Recent studies by Leland and Schneider (2016) and Dertwinkel-Kalt and Köster (2015) have explained how the visual frame may impact on the mental frame. They obtain variants of the approach by BGS that account, for instance, for puzzles of choice under risk that mainly occur under specific visual representations of a decision situation (such as violations of first-order stochastic dominance).

that encompasses both previous approaches. We incorporate the core assumption that a decision maker adopts the frame that yields a higher focus-weighted utility, that is, for a given decision situation the decision maker can decide in which frame information is perceived.[3] Such a self-serving interpretation of information is consistent with psychological insights (e.g., Falk and Zimmermann, 2016; Dawson *et al.*, 2002; Balcetis and Dunning, 2006). Therefore, in our model, a decision maker is hypothesized to choose both (1) an alternative, and (2) the frame in which she evaluates the respective alternative in order to maximize her focus-weighted utility. Our equilibrium notion requires the consistent choice of alternative *and* frame.

We derive our main results by comparing behavior in two different classes of decision situations. In one class people trade immediate benefits against future downside risks, and in the second class they trade immediate costs against future upside risks. This classification comprises many relevant decision situations. Among others, the first class contains decisions of harmful consumption: an unhealthy eating habit may provide immediate pleasure, but may also cause future costs in the sense that it may trigger diabetes or increases the risk of heart attacks. The second class typically contains investment decisions such as the decision of whether or not to start an own business. Becoming an entrepreneur involves an immediate investment and the chances of rewards in the future.

As the key result, our model yields predictions concerning *overoptimistic actions* while neither BGS nor KS can, taken by itself, explain overoptimistic actions in situations with future downside risk *and* with future upside risk in one coherent framework. Each of these two models accounts for such overoptimistic behavior only in one class of situations, but predicts the opposite in the other one. That is, in their models, some actions could be regarded as overoptimistic and some as overly pessimistic. The notion of overoptimism only enters through our selection criterion. We can rationalize overoptimistic behavior in the sense that decision makers underrate downside risks but overrate upside risks. Consider the first scenario as an example of harmful consumption: Harmful consumption like smoking gives an immediate pleasure, but may cause serious diseases like lung cancer which may be realized in any future period with a small probability. An individual framing the decision in terms of events as suggested by Bordalo *et al.* (2012) overrates the incidence of getting lung cancer due to its severe negative outcome and therefore abstains from smoking. As this adverse outcome is unlikely, however, the expected smoking-induced harm in each future period in time is rather small compared to the large immediate pleasure derived from smoking. Thus, an individual frames the decision via expected utilities in time periods as suggested by KS, thereby underrating the importance of the dispersed future risks and overrating the immediate benefits of smoking. As a consequence, she opts for the latter frame and smokes, even if it might be rational to abstain.

The same individual's attitude toward risk is fundamentally different in a decision situation with future upside risk. Suppose the agent decides whether to launch a new

[3]This assumption stands in contrast to alternative approaches (e.g., Piccione and Spiegler, 2012) that treat the framing of options as a choice variable for the firm offering the alternatives.

business. For this, an initial investment is required and future rewards are highly uncertain. Entrepreneurship offers the chance of a very high income, but, on average, it is not profitable (Hamilton, 2000). Expected payoffs in each period may be rather small, but since the entrepreneurship offers the chance of a high reward, this is especially salient. Thus, the agent decides in favor of the representation via events and thereby overrates her winning chances. This can explain excessive entrepreneurship. Taken together, our model can explain overoptimistic actions in situations with future downside risk *and* with future upside risk in one unified framework—which existing contributions cannot.

In addition, we obtain more general insights into a decision maker's frame and consumption choices. The more asymmetric an investment option is (that is, an option which yields large potential payoffs in exchange for immediate costs), the more likely the decision maker is to adopt the frame proposed by BGS and to overrate potential future rewards. The more asymmetric a consumption option is (that is, an option which yields an immediate benefit in exchange for potential large future costs) the more likely the decision maker is to evaluate the respective option in the frame proposed by KS.

It is important to notice that our model does not predict such overoptimism per se, but has plausible limitations. For example, a risk-averse agent will always prefer safe options (ensuring safe and positive outcomes in all time periods) over symmetric mean preserving spreads. Hence, our model does not contradict risk-averse or match risk-seeking behavior in general.

We proceed by presenting our model in Section 2 and deriving our main results on overoptimistic actions in Section 3. In Section 4, we relate our findings to the asymmetry of choice options and derive the limits of overoptimism in our framework. In Section 5 we discuss the related literature. We conclude in Section 6.

2 Two Types of Focusing

This section presents a theory of intertemporal decision making in a risky environment in which the decision maker chooses—beside a neutral frame—between one of two frames as proposed by KS and BGS. Thus, we do not provide a new frame in which the decision maker evaluates her choices, but rather a unified framework that encompasses both approaches and a criterion that selects between the two frames.

2.1 The Model

We consider choices by a decision maker in a period 0 from a choice set C. Each of the options yields (risky) outcomes in each of the following T periods. The decision maker evaluates the options according to a frame which may yield a valuation that differs from the net present value.

More specifically, the decision problem consists of the following elements:

(1) *a choice set* $C := \{c^i | 1 \leq i \leq I\}$ *with* I *choice options* $c^i = \left(c^i_\tau\right)_{\tau \in \mathcal{T}}$*, where* $1 \leq i \leq I$*, and*

(2) *a time horizon* $\mathcal{T}$*,*

(3) *probability spaces* $(S_\tau, \mathcal{F}_\tau, p_\tau)$ *for all periods* $\tau \in \mathcal{T}$*,*

(4) *a set of frames* X*.*

For $0 < T \in \mathbb{N}$, define the *time-horizon* $\mathcal{T} := \{0, 1, \ldots, T\}$ as the set of periods under consideration. In each time period τ there is a set of states of the world S_τ. For each $\tau \in \mathcal{T}$ and some $I \in \mathbb{N}$ there is a real-valued random variable c_τ^i with finite support for all $1 \leq i \leq I$. Denote S_τ the sample space (also called the *state space* or the *set of (personal) events in period* τ) which is generated by the random variables $\{c_\tau^i | 1 \leq i \leq I\}$ and denote $\mathcal{F}_\tau$ the corresponding canonical σ-algebra.[4,5] We consider a probability space $(S_\tau, \mathcal{F}_\tau, p_\tau)$ for some probability measure p_τ, which assigns each *state of the world* $s \in S_\tau$ its objective probability $p_{\tau,s} := p_\tau(s)$, such that $\sum_{s \in S_\tau} p_{\tau,s} = 1$ holds. Each state $s \in S_\tau$ can be written as a vector which assigns each alternative $c^i \in C$ an outcome $c_{\tau,s}^i := c_\tau^i(s)$, that is, $s = (c_{\tau,s}^i)_{c^i \in C}$. We refer to $c_{\tau,s}^i$ as the *consumption level* which choice c^i provides in period τ and state s.[6]

A decision maker knows the probability distributions p_τ and has to choose in period 0 one option from the choice set C before uncertainty is resolved and states for all periods are realized.[7]

A consumption level $c_{\tau,s}^i$ provides a utility to the decision maker, which is given by an *instantaneous consumption utility function* $u : \mathbb{R} \to \mathbb{R}$ which is constant over time and strictly monotonically increasing. We set $u(0) = 0$. We assume that the decision maker discounts utilities at period τ via a discounting function $\delta(\tau)$. For instance, in the case of exponential discounting (Samuelson, 1937), $\delta(\tau) = \delta^\tau$ holds. In line with KS, we impose additive separability between utilities in time periods throughout the paper.

Finally, a decision situation is always represented in some *frame* $x \in X$, where X denotes the set of available frames. A frame (or, synonymously, *focus type*) denotes a decision maker's mental representation of a decision situation. In the following, we will—beside a neutral frame where evaluations match expected utility—analyze two specific frames proposed in the behavioral literature, which direct the decision maker's attention toward different aspects of the available choice options.

[4]In many applications, the state space is defined over all periods $0, 1, \ldots, T$. Here, we define a separate state space for each point in time to keep the model tractable. Our assumption of separate state spaces for each point in time fits our assumption that decision makers consider outcomes at points in time separately.

[5]In line with the literature (e.g., Bordalo *et al.*, 2012) we assume that the state space is exogenous and well-defined by the available choice options such that each state can be identified with a feasible payoff-combination of the available options.

[6]The random variable c_τ^i could represent a risky asset or lottery, or an immaterial consequence such as a health impact. If an agent, for instance, decides to smoke a cigarette in period t, her respective option c^i may involve the negative health impact c_τ^i for $\tau > 0$. Thus, by consuming a cigarette at t, she has to decide for the entire bundle c^i which also comprises future negative health impacts c_τ^i for $\tau > 0$.

[7]For our model, it is irrelevant whether the states are realized simultaneously or sequentially as the only decision is made ex ante, before any uncertainty is resolved.

Neutral frame (N): Net present value. *A decision maker opting for a neutral frame (without attention distortions) evaluates an option* $c^i = (c_0^i, \ldots, c_T^i) \in C$ *based on its net present value, that is,*

$$U(c^i|N) := U(c^i) = \sum_{\tau=0}^{T} \delta(\tau) E(u(c_\tau^i)). \tag{N}$$

with

$$E(u(c_\tau^i)) = \sum_{s \in S_\tau} p_{\tau,s} u(c_{\tau,s}^i).$$

However, a decision maker may not necessarily evaluate options according to net present value, but may rather evaluate the options unconsciously according to attention-biased frames. As each frame induces the decision maker to focus on certain aspects, we call the distorted utilities that we define in the following approaches *focus-weighted utilities*. In our theory, as is detailed below, we endogenize a decision maker's representation of a choice problem by assuming that she can choose her frame. To proceed, we first need the notion of a *focusing function*.

Definition 1 *A focusing function is a continuous function* $g : \mathbb{R}_{\geq 0} \to \mathbb{R}_{>0}$.

In the two approaches which we present in the following, the focusing function assigns each state (time period) a weight, the so-called *focus weight*, which is a function of the range of attainable utilities in the specific state (time period). Range refers to the difference between the maximally and the minimally achievable utilities in the respective state (time period). The larger the focus weight on a state (point in time), the more *salient* is the state (point in time). We adopt the assumption by KS, according to which the focusing function is strictly monotonically increasing, that is, a decision maker puts a higher focus weight on a state (time period) the larger the range of attainable utilities in this state (period).[8]

Assumption 1 *The focusing function* g *is strictly monotonically increasing.*

In the following we present two different frames according to which decision situations can be evaluated. While, in principle, one can think of many different frames, here we focus on two frames proposed in the recent literature (BGS, KS).

Frame (E) according to KS: Focus on expected utilities in time periods. *Frame (E) guides the decision maker's attention toward different periods in time, so that she attaches focus weight*

$$g_\tau := g\left(\max_{c^i \in C} \delta(\tau) E(u(c_\tau^i)) - \min_{c^i \in C} \delta(\tau) E(u(c_\tau^i))\right) \tag{E1}$$

[8] The assumption of a strictly monotonically increasing focusing function is also shared by the continuous approach presented in the appendix of Bordalo *et al.* (2016) and discussed in more detail in Dertwinkel-Kalt and Köster (2017a).

on the expected utility she derives from option c^i in period τ. Define the normalization factor

$$g_E := \frac{1}{T+1}\sum_{\tau=0}^{T} g_\tau.$$

The focus-weighted utility of a decision maker who frames a decision situation via expected outcomes in time periods is then defined as

$$U(c^i|E) := \sum_{\tau=0}^{T}\delta(\tau)\,\frac{g_\tau}{g_E}\,E(u(c^i_\tau)). \tag{E}$$
$$= \sum_{\tau=0}^{T}\delta(\tau)\,\frac{g_\tau}{g_E}\sum_{s\in S_\tau} p_{\tau,s}u(c^i_{\tau,s})$$

This implies that with a focus on time periods, the focus weight depends, as in KS, on the (discounted) range of utilities a decision maker may receive in a given period. Formally, the argument of the focusing function g equals the range of attainable expected utilities possible to be received by a decision maker in a certain time period. Since g is strictly increasing, time periods with a larger range of possible expected utilities among the options receive more weight in the decision process than periods where the options under consideration deliver more balanced expected utilities. All focus weights are divided by their average. This allows for comparability with the focus-weighted utilities derived from the following, alternative approach.[9]

Frame (S) according to BGS: Focus on states. *Frame (S) induces the decision maker to focus on salient states, so that she misinterprets the probability with which a state s occurs according to a focus weight assigned by some given focusing function g. Her subjective probability that state s occurs in period τ equals*

$$\tilde{p}_{\tau,s} := \frac{g_{\tau,s}}{g_{\tau,S}}\,p_{\tau,s},$$

where the focus weight $g_{\tau,s}$ is defined as

$$g_{\tau,s} := g\left(\max_{c^i\in C}\delta(\tau)u(c^i_{\tau,s}) - \min_{c^i\in C}\delta(\tau)u(c^i_{\tau,s})\right) \tag{S1}$$

and the normalization factor

$$g_{\tau,S} := \sum_{s\in S_\tau} p_{\tau,s}g_{\tau,s}$$

[9] This normalization has been chosen as it is analogous to the one chosen in the following approach, which is also shared by Bordalo *et al.* (2012). It ensures that in a choice set consisting of non-risky constant income streams (which give the same certain payoff in every period) any option's focus-weighted utility in any of the frames matches its net-present value. Intuitively, if the outcomes of an option are safe and identical in all periods, focusing on expected utilities at points in time or focusing on risky states should not affect the option's evaluation.

ensures that $\sum_{s \in S_\tau} \tilde{p}_{\tau,s} = 1$.[10] *Denote* $\tilde{c}^i_\tau$ *as the random variable which realizes* $c^i_{\tau,s}$ *with probability* $\tilde{p}_s$. *Accordingly, the focus-weighted utility is defined as*

$$U(c^i|S) := U(\tilde{c}^i) = \sum_{\tau=0}^{T} \delta(\tau) E(u(\tilde{c}^i_\tau)) \tag{S}$$

$$= \sum_{\tau=0}^{T} \delta(\tau) \sum_{s \in S_\tau} \frac{g_{\tau,s}}{g_{\tau,S}} \, p_{\tau,s} \, u(c^i_{\tau,s}).$$

In contrast to frame (E), this frame guides the decision maker's focus toward states, such that the focus weights $g_{\tau,s}$ are defined on the set of states. Weights are not attached to the expected utility of an option in a given period, but rather to states s within a given period that are more salient by offering a larger range of utilities across the different options. *Assumption* 1 then implies that a state receives relatively more weight in the decision process if the range of possible utilities across the options differs more.

This frame implies that, as in Bordalo *et al.* (2012), a state s where the options' payoffs are very different receives a relatively large weight in the decision process, that is, the subjective probability $\tilde{p}_{\tau,s}$ exceeds the objective one. That is, states with a possibly extreme outcome (yielding either an extremely positive or an extremely negative utility) receive a relatively large weight in the decision process, even if the expected utilities across the options do not differ much at that period in time and if the probability of the extreme event is rather small. In contrast, states in which all options' payoffs are relatively balanced receive less focus weight.

2.2 Solution Concept

We ask which decision situations are evaluated in which frame. Therefore, we apply the following equilibrium concept.

Definition 2 *For* $c^i \in C$ *and* $x \in X$ *we denote* (c^i, x) *a self-serving equilibrium (SSE) if*

$$U(c^i|x) \geq U(c^j|y)$$

for all $c^j \in C$ *and all* $y \in X$.

A self-serving equilibrium is defined as the optimal combination of a consumption choice and a frame. Thus, the decision maker optimizes over both the consumption choice and the frame. This implies, in particular, that in a self-serving equilibrium consumption choice and frame choice are consistent: given the frame choice, the decision maker has no incentive to switch her consumption choice, and given her consumption choice, the decision maker has no incentive to switch her frame. Note that the timing of choices does not have an effect on the equilibrium: the equilibrium outcome is independent of whether

[10] Note that this normalization is equivalent to Bordalo *et al.* (2012). According to this normalization, low probability states are relatively more distorted than high probability states.

the frame is selected prior to the choice option or vice versa. It should also be noted that frame choice may happen subconsciously. We do not think that subjects willingly and consciously think of options in a way that is too rosy. Instead, subconscious processes may drive an interpretation of the options at hand that stresses upsides or blurs downsides.[11]

In our subsequent analysis we investigate under which circumstances a decision maker behaves in an overoptimistic manner. We say that a decision maker behaves overoptimistic if the following definition is met:

Definition 3 *A SSE* (c^i, x) *is overoptimistic if the following two conditions hold:*

(i) $U(c^i|x) > U(c^i)$ *and*

(ii) there is another option $c^j \neq c^i$ *with* $U(c^j) > U(c^i)$*.*

Our definition of overoptimism requires two conditions to be met. First, the decision maker believes to receive a higher utility than she actually does. Second, there is at least one other option that would yield a higher net present value than the chosen action. If all self-serving equilibria are overoptimistic we also say that the agent engages in *overoptimistic actions*.

2.3 Discussion of the Psychological Foundations

Here, we discuss the two main psychological assumptions underlying our model, attention to salient features and self-servingness in choosing a frame and directing attention. Further constituents of our model are discussed in the original papers by KS and BGS.

Salience. People' s attention is often drawn toward more vivid attributes, which receive a disproportionate weight in the decision process when comparing different options (Taylor and Thompson, 1982). A well-known example comes from Schkade and Kahnemann (1998) who argue that when comparing the quality of life in California and the Midwest, a decision maker attaches a disproportionate weight to climate and weather conditions compared to other attributes where the regions are more similar.

Which features of a given decision situation attract the decision maker's attention depends on the representation of the decision problem. In decision situations under uncertainty, a frame may either direct attention toward salient states associated with an option (for instance, the large gains of winning the jackpot of a lottery) or toward the expected outcome an option yields at a certain point in time (for instance, a lottery's expected payoff). While other frames guiding the decision maker's attention toward different aspects could exist, we restrict our paper to these frames as these have an intuitive appeal and can explain important choice patterns (BGS, KS) that have been empirically (Hastings and

[11] Note that the equilibrium notion is similar to Bracha and Brown (2012) where risk perception is affected by a decision maker's emotional process. In their equilibrium notion, action and risk perception are chosen in a consistent manner.

Shapiro, 2013) and experimentally (Dertwinkel-Kalt *et al.*, 2016, 2017; Frydman and Mormann, 2016) supported.

Variants of the focusing and salience models proposed by KS and BGS can account for a wide range of decision anomalies. Bordalo *et al.* (2013b) explain puzzles of consumer choice such as decoy and compromise effect via salience. Leland and Schneider (2016, 2017) have proposed an axiomatized version of the salience model that explains hyperbolic discounting and present-biased behavior. Also, choice puzzles that most models cannot account for can be reconciled with the salience model. Leland and Schneider (2016) and Dertwinkel-Kalt and Köster (2015) show that violations of first-order stochastic dominance may result from a specific interplay of economic and visual salience. Salience has been also successfully applied to different economic field such as political economy (Nunnari and Zápal, 2017), law and economics (Bordalo *et al.*, 2015), business economics (Dertwinkel-Kalt and Köster, 2017b) and industrial organization (Bordalo *et al.*, 2016; Herweg *et al.*, 2017).

Self-servingness. Self-serving judgments or self-serving assessments of information represent a robust psychological mechanism that can be observed in many circumstances. For example, people's judgment of what is fair is influenced by self-interest (Messick and Sentis, 1979), but also objective information is assessed in self-serving manners (Dawson *et al.*, 2002; Balcetis and Dunning, 2006). Whereas according to BGS and KS attention is fully shaped by the environment, Falk and Zimmermann (2016) find in an experimental study that this is not entirely true, concluding that "subjects can actively manage attention in a self-serving way."

In our model, self-servingness is reflected by positing that a decision maker's assessment of risky situations is influenced by her choice of a frame in order to maximize her focus-weighted utility. As will be seen later, the assumption that the frame is chosen is the key assumption of our model, and helps us to explain why decision makers may assess risk quite differently when faced with large upside or downside risks.

Importantly, while information processing appears to be self-serving, the resulting choices can be self-deceiving or self-destructive in the long run: overweighting favorable and underweighting undesired features can induce choices with severely bad consequences in the long run. Therefore, choices which we call *self-serving* may be self-serving only in the short run while being harmful in the long run.

3 Overoptimistic Actions

Each intertemporal decision trades relative benefits in some time periods for relative costs in other time periods. We distinguish between two major, opposing classes of decision situations: people may either trade *immediate benefits for future costs* or *immediate costs for future expected rewards*.

Any kind of harmful consumption typically belongs to the first class: people smoke, drink alcohol or engage in unhealthy eating habits. In other words, people take risks and potential future costs in terms of bad health to enjoy immediate pleasure. By smoking now, people have a higher risk of getting respiratory diseases or lung cancer. By drinking too much alcohol, people risk getting liver diseases and hepatic cancer, and an unhealthy diet may trigger the development of diabetes. According to our model, this is driven by overoptimism: people adopt frame (E) as proposed by KS which blurs the options' downsides. Below we argue that, according to our model, in those situations decision makers choose frame (E) and thereby direct their attention to the expected utilities in different periods associated with an option. Consequently, they somewhat ignore the downsides as these are blurred over time: the enjoyable immediate effect yields a large positive utility, while the adverse components of the choice are, in each future period, small in terms of expected utilities. As a result, focusing on relatively large expected utilities in different time periods overrates the upsides, but underweights the downsides from present consumption.

Investment decisions belong to the second class: people incur immediate costs to gain benefits in the future. A prime example is entrepreneurship where a decision maker invests in a new business, and the chances of success are highly uncertain. Existing research suggests that people are too optimistic when becoming an entrepreneur (Camerer and Lovallo, 1999; Koellinger *et al.*, 2007). Failure rates are high and, on average, it is not profitable to become an entrepreneur (Hamilton, 2000; Moskovitz and Vissing-Jorgensen, 2002). Our model can explain this overoptimistic, probably excessive, entrepreneurial activity. When deciding to invest, people choose frame (S), as proposed by BGS, and direct their attention on the chance of becoming "the next google" while neglecting that on average it is far more likely that the new business will result in failure.

A similar example is the phenomenon that so many people engage in games of chance, which often have a significant negative expected return. In Germany alone, 25.5 million people participated in gambling in 2011, while 11.6 million took part in the weekly Saturday lotto. Especially lotto subscriptions are widespread, according to which agents make a certain payment in order to participate in each weekly lotto over a longer period. However, only 48% of the stakes are on average returned to the gamblers (Beckert and Lutter, 2007). Our model yields an intuitive reason for engaging in unprofitable gambling: people choose to focus on the winning states (by adopting frame (S)) and therefore overrate their chances of winning.

Specification. In the following, we consider binary decisions as such a simplified setup suffices to generate our model's main insights.[12] We also abstract from any time discounting and set $\delta(\tau) = 1$, but our results are fully transferable to setups in which future (per-

[12] We are mainly interested in analyzing whether people engage in a certain behavior, and not to which degree they engage in such actions. Hence, we consider a setup with a binary decision. Moreover, arbitrary consideration sets yield vast state spaces and, therefore, cannot be analyzed in general.

ceived) utilities are discounted (for a discussion of the role of discounting see Section 6).[13]

We consider the choice between a risky option c^u and a safe option c^c (which we interpret as *abstaining from the risky option*) in a period t. The safe option realizes a payoff c^c_τ at each point in time τ. We set the payoff of the safe option to $c^c_\tau = 0$ for all τ. The uncertain option c^u involves for each period a random variable c^u_τ that either gives outcome $c^u_{\tau,1}$ or $c^u_{\tau,2}$. Therefore, S_τ consists of two states, indexed by 1 and 2, for all $\tau > 0$.

3.1 Harmful Consumption (or Future Downside Risk)

We start with a situation where a decision maker trades off immediate (safe) benefits against future downside risks. These situations can be represented by choices from a choice set $C = \{c^c, c^u\}$, where c^c represents the safe option of abstaining from harmful consumption, while c^u is the potentially harmful activity that imposes a risk upon the decision maker.

We model the risky option of harmful consumption as follows. Let $F := u(c^u_0) > 0$ denote the immediate safe net present value of the risky option to be obtained in period 0. Since immediate gratification is assumed to come at the cost of future risk, c^u_τ for $\tau > 0$ may yield two different outcomes. Therefore, for all periods $\tau > 0$ we distinguish between two states. Either, the risky option yields the same outcome as the safe option (s_1), or it yields an adverse outcome (s_2) such that $-L := u(c^u_{\tau,2}) < 0$. For instance, in the smoking example, state 1 represents the outcome that the smoker is not diagnosed with lung cancer, and state 2 represents the outcome where she is. We assume that the probability space is identical over all $\tau > 0$.[14] Let $p := p_{\tau,2}$ denote the probability of state 2 at each $\tau > 0$. We denote the expected utility that comes with the initial choice of the harmful product in each future period $\tau > 0$ by $f := -E(u(c^u_\tau))$. We consider $L > F > f$. That is, we consider situations where the utility loss ($-L$) in the downside state is relatively large but occurs with a relatively small probability.

We now analyze the choices made by a decision maker whose attention is drawn on states (S) or on expected utilities (E). Note that the assessment of the safe option is independent of the chosen frame since $U(c^c) = U(c^c|S) = U(c^c|E) = 0$.

To start with, suppose that the decision maker evaluates the risky option according to frame (S). We first note that the downside risk of the risky option is the more salient state, and hence, $g_{\tau,2} = g(L) > g_{\tau,1} = g(0)$. This implies that the decision maker tends to

[13] In that case, however, without knowledge of the exact shape of the focusing function, our formulas would be cluttered as the focusing function would have to be evaluated at many points.

[14] Then, it is implied that c^u_τ for $\tau \in \mathcal{T}$ are independently and identically distributed (*iid*) which is a strong assumption that might be too strict in many applications. While independence of $\{c^u_\tau | \tau \in \mathcal{T}\}$ is a formal component of our model, we relax this assumption in Appendix A and show that our main results also carry over to correlated random variables. For instance, in the smoking example, a more plausible assumption would be that if the decision maker gets lung cancer in some period t, then this negative health impact is also present in all periods $\tau > 0$.

overweight the downside risk compared to a rational decision maker. That is:

$$
\begin{aligned}
U(c^u|S) = &\ F - T\left(Lp\,\frac{g(L)}{pg(L)+(1-p)g(0)}\right) \\
< &\ F - TLp = \ U(c^u).
\end{aligned}
$$

Due to the higher focus weight on the downside the decision maker attaches less focus-weighted utility than a rational decision maker to the risky option. In other words, focus-weighted utility falls short of consumption utility, and an agent of focus type (S) is less likely to take the risk than a rational agent.

Next, consider the case where the decision maker evaluates the options in frame (E). In that case, the decision maker evaluates the options according to the expected utility provided in each period. The focus-weighted utility experienced by the decision maker with frame (E) is given by

$$
U(c^u|E) = \frac{T+1}{g(F)+Tg(f)}\left(g(F)F - Tg(f)f\right). \tag{1}
$$

With $F > f$ it follows that $g(F) > g(f)$, and an agent puts more weight on the concentrated upside of the risky option (the immediate benefit in period 0) than on the dispersed downsides.[15] Since the agent puts too much weight on the immediate gratification compared to the downside, the focus-weighted utility exceeds net present value, $U(c^u|E) > U(c^u)$. Therefore, a decision maker tends more toward the risky option.

Indeed, with focus (E) an agent chooses the risky option as long as $U(c^u|E) > 0$, which holds if and only if

$$
\frac{g(F)}{g(f)} > \frac{Tf}{F}. \tag{HC}
$$

If the focusing function is sufficiently steep, that is, the fraction $g(F)/g(f)$ is sufficiently large, then the agent will choose c^u over c^c. However, the risky option represents the suboptimal choice, $U(c^u) < U(c^c)$, as long as the dispersed risks outweigh the immediate benefits, $F < Tf$. Thus, if the focusing effect is strong enough, an agent will be overoptimistic concerning her consumption decision's future costs.

Since $U(c^u|E) > U(c^u) > U(c^u|S)$, the focus-weighted utility is higher when the decision maker is of focus type (E). By focusing on the case where a rational decision maker would not choose the risky option (i.e., $F < Tf$), we summarize our preceding discussion:

Proposition 1 *Suppose $L > F > f$ and $F < Tf$. If and only if Condition* (HC) *holds, the unique SSE, (c^u, E), is overoptimistic.*

The proposition provides conditions as to when and why a decision maker may decide to engage in risky options with large downside risks, even when it is not rational to do so. By choosing to focus on aggregate outcomes at each point in time, she avoids explicitly

[15] If $f > F$, then both types of local thinking predict an overweighting of the downsides, such that in equilibrium the individual will never engage in harmful consumption.

thinking of the downside state of the risky option. Therefore, the overoptimistic decision maker is less concerned regarding the potential downsides than is rational and is more likely to choose the risky option.[16]

Furthermore, if there is an ex ante positive risk that the adverse outcome is realized in each period $\tau > 0$ (independent from the decision maker's consumption decision), our qualitative predictions are not affected. Then, three states are feasible, in which consumption and no consumption yield both utility 0 (state 1), both utility $-L$ (state 2), or exclusively consumption induces the adverse outcome, while no consumption does not (state 3). Here, frame (S) renders state 3 salient, while frame (E) allows the decision maker to focus on the immediate benefit derived from smoking. Therefore, a sufficiently strong focusing bias induces the decision maker to behave optimistically, to choose frame (E) and underrate consumption risks.

We can shed more light on the intuition behind Proposition 1 by comparing options that yield identical net present value, but differ in how the costs are distributed over periods:

Prediction 1 *Consider two options c_1^u and c_2^u which yield identical net present value $U(c_1^u) = U(c_2^u)$ and the same benefit $F > 0$ in period zero. Furthermore, suppose that the costs associated with c_2^u are spread over a larger number of periods, $T' > T$. That is, c_1^u yields outcome $-L$ with probability p in all T periods, while c_2^u yields outcomes $-L_\tau$ with probabilities p_τ in all periods $1 \leq \tau \leq T'$. Suppose $p_\tau L_\tau < f := pL$ for all τ and $L > F > f$. Then, if a decision maker chooses c_1^u from $\{c_1^u, c^c\}$, she chooses also c_2^u from $\{c_2^u, c^c\}$.*

The intuition behind this finding is the following. As a decision maker choosing the risky option evaluates it in frame (E), she chooses the risky option all the more if the negative consequences are spread over more periods, and this holds independent of the distribution of the negative consequences. This is because costs attract less attention if they are dispersed over more periods. This finding contrasts with Prediction 2 in the next section, where the risky option will be evaluated in frame (S).

3.2 Taking Bets (or Future Upside Risk)

Now consider the opposite case where the risky option includes a (non-stochastic) immediate investment cost and the returns are random and dispersed over all future periods.

As before, we set the utility from the safe option (i.e., not becoming an entrepreneur) to $c_\tau^c = 0$ for all τ. The risky option (becoming an entrepreneur) involves an investment $-H := u(c_0^u)$ in period 0, and gives rise to a future stochastic payoff. The state space is assumed to be constant across periods in time and to comprise exactly two states. We

[16] A series of recent studies supports our prediction of overoptimistic smokers according to which smokers underestimate the own risks associated with smoking (Weinstein *et al.*, 2004; Windschitl, 2002; Williams and Clarke, 1997; Slovic, 1998; Waltenbaugh and Zagummy, 2004; Costa-Font and Rovira, 2005; Masiero *et al.*, 2015). Interestingly and in line with our predictions, these studies do not find that smokers necessarily underestimate the other smokers' risks of smoking, that is, rosy beliefs are only in place if the own welfare might be affected.

define state 1 as the loss state, in which the lottery pays 0 (the new business is a failure and the initial investment is lost), and we define state 2 to be the winning state (*becoming the next google*) yielding utility G with probability q. The expected utility from the risky option in future period τ is then $h := E(u(c^u_\tau))$ for all $\tau > 0$.[17] We consider $G > H > h$ such that the upside of the risky option, G, is very prominent, but occurs with a relatively small probability.

In principle, our arguments from above are turned upside down if we consider future upside risks instead of a future downside risk. Suppose the decision maker uses frame (E). Since $g(h) < g(H)$, this implies that the one-time investment cost is given more weight relative to the expected future benefits. In a situation where it is rational not to invest in the risky option (i.e., $H > Th$) this also implies that $U(c^u|E) < U(c^c|E) = 0$ holds.

Now suppose that the decision maker's attention is drawn toward potential states of the lottery so that the decision maker uses frame (S). In this case, the winning state, which yields G, is particularly salient. Due to $g(G) > g(0)$, the decision maker has a large focus weight on the upside of the investment lottery. As the lottery's upside is given more weight by the biased decision maker than by a rational decision maker, the focus-weighted utility derived from frame (S) exceeds the net present value. In fact, with a focus on salient states, a decision maker would choose the risky option over the safe option if and only if $U(c^u|S) > U(c^c|S) = 0$, which holds if and only if

$$-H + TG \cdot \frac{qg(G)}{qg(G) + (1-q)g(0)} > 0, \tag{2}$$

or, equivalently,

$$\frac{g(G)}{g(0)} > \frac{H(1-q)}{q\,(TG - H)}. \tag{TB}$$

If the focusing bias is strong enough, that is, the fraction $g(G)/g(0)$ is large enough, then an agent of focus type (S) will choose to invest even if its expected payoff is negative, that is, $H > Th$, and a rational decision maker would behave risk-averse by picking the safe option.

Since $U(c^u|S) > U(c^u) > U(c^u|E)$, in the case of future upside risk, the decision maker will choose frame (S) and thereby obtains a higher focus-weighted utility. However, by doing so, she *decides* to ignore expected outcomes and to focus on beneficial states. Therefore, agents may invest excessively in a new business and are overoptimistic about the likelihood of success.

Proposition 2 *Suppose $G > H > h$ and $H > Th$. If and only if Condition* (TB) *holds, the unique SSE, (c^u, S), is overoptimistic.*

We point out that Proposition 2 holds for small, but not too small values of the winning

[17]Note that this implies that the size of the winning state, measured by G, does not change over time. Whereas this is a restricting assumption in order to simplify the state space, our analysis also holds with respect to different-sized gains. However, more assumptions about the shape of the focusing function would then have to be made.

probability q. For small values of q it is indeed optimal not to invest in the risky option. However, q must not be too small so that the decision maker with focus (S) still finds it worthwhile to invest and Condition (TB) holds.[18]

As in the previous subsection, we can also analyze the decision maker's behavior by comparing options that yield the same net present value, but where the benefits are larger, but less likely:

Prediction 2 *Consider two options c_1^u and c_2^u which yield identical net present value $U(c_1^u) = U(c_2^u)$ and the the same utility $-H < 0$ in period zero. Option c_1^u yields utility G with probability q in periods $1, \ldots, T$, and c_2^u yields utility $G_\tau \geq G$ with probability $q_\tau \leq q$ in periods $1, \ldots, T'$. Then, if a decision maker chooses c_1^u from $\{c_1^u, c^c\}$, she chooses also c_2^u from $\{c_2^u, c^c\}$.*

This finding follows the intuition in Bordalo *et al.* (2012) and their Proposition 1 where a small probability's upward distortion is the larger the smaller the probability and the larger the corresponding outcome is. Accordingly, keeping the net present value constant, an option becomes more attractive if it gives the prospect of less likely, but larger gains. Note that we did not have to specify whether T' is larger than T or not.

3.3 Attention and Overoptimistic Actions.

Our previous results are summarized in the following corollary. As our core predictions are overoptimistic actions, we subsequently discuss the psychological phenomenon of overoptimism.

Corollary 1 *Fix $L > F > f$ and $G > H > h$ as well as $p, q > 0$. Assume that $H > Th$ and $F < Tf$ hold and that conditions (HC) and (TB) hold. Then, an agent engages in overoptimistic actions in each situation and underrates adverse risks, but overrates favorable risks.*

According to our model, people reveal overoptimistic actions. If focusing effects are sufficiently strong, then a decision maker in our model tends to ignore downside risks and engages in risky behavior which a rational agent would abstain from. The very same agent, however, also overrates upside risks and therefore bears unreasonable, immediate investment costs which are unlikely to pay off. The first kind of behavior is explained by KS and the second kind of behavior by BGS. Overoptimistic actions result from our selection criterion between these two frames.

Our results coincide with the robust finding in psychology that people are overly or unrealistically optimistic. For example, empirical studies show that people often tend to be too optimistic about their future prospects, overrate possible positive events and underrate potential negative events (e.g., Weinstein, 1980; Taylor and Brown, 1988; Weinstein,

[18]Entrepreneurial overoptimism is widespread (Cooper *et al.*, 1988). It has also been shown to be significant in closely related situations of economic interest, such as market entry (Camerer and Lovallo, 1999) or investment decisions (Malmendier and Tate, 2005).

1989).[19] In particular, entrepreneurs are often much too optimistic regarding their chances of making a success of their enterprise (Koellinger *et al.*, 2007). Our model produces such overoptimistic behavior.

Note that while all of our separate results directly follow either from BGS or from KS, neither of these decision models can jointly explain overoptimistic actions in situations with future downside risk *and* with future upside risk. Thus, the novelty in our study does not lie in proposing a new way of framing as such, but it provides a selection criterion between these two frames that have been proposed in the literature. In Bordalo *et al.* (2012) a decision maker overvalues states where the options differ more. Therefore, in situations with large upside risk this model predicts that people would excessively decide in favor of the risky option. This coincides with our prediction. However, with large downside risk, Bordalo *et al.* (2012) predict people to overate the salient downside so that these would be less likely to engage in the risky option. This contrasts with our predictions.

The focusing model by Kőszegi and Szeidl (2013) produces the opposite predictions to Bordalo *et al.* (2012). With a focus on expected utilities in different time periods, their main result is a bias toward concentration. This implies that in situations where an agent trades off an immediate benefit against a future downside, concentrated benefits would be overweighted and actions would be more likely to be overoptimistic. In contrast, in the investment situation, the decision maker would overestimate the one-time investment costs and therefore be less likely to choose the risky action.

We can transfer our insights from this section to other domains beside intertemporal decisions. Our results in the subsection *harmful consumption* imply that people take too many risks in several dimensions in order to enjoy a certain large benefit in one dimension, whereas the subsection *taking bets* reveals that people may sacrifice too much in one dimension to achieve unlikely high benefits in another dimension of their choice.

To sum up, our model shows how self-serving interpretations of decision situations can counteract pure attention effects and can therefore be seen as a selection criterion between Bordalo *et al.* (2012) and Kőszegi and Szeidl (2013). In particular, we would argue that both theories can only partially explain observed behavior, but our unified approach with a self-serving focus can explain overoptimistic behavior with both future upside and downside risks in one framework.[20]

4 Overoptimism and its Limitations

This section discusses two issues. First, we generalize the intuitions behind the overoptimism result of the preceding section. Second, we also discuss situations where our model

[19] Psychologists have shown overoptimism to be present in a wide variety of contexts. For an overview see, for instance, Shepperd *et al.* (2013). More generally, people tend to be more overoptimistic if events are perceived as infrequent such as being involved in a car accident (Harris *et al.*, 2008).

[20] Parts of our findings can be also explained by hyperbolic discounting as analyzed in O'Donoghue and Rabin (1999). Crucially, however, our findings do not rely on a particular discounting function: instead, our attention mechanism can even reverse the prediction of present bias, that is, the model can predict future-biased choices if a large reward can be obtained in a later period.

does not predict an overoptimistic assessment of a choice situation.

4.1 Overoptimism and Asymmetry of Options

This subsection provides more intuition on our mechanism of endogenous framing by studying the effects of the asymmetry of options on the focus-weighted utility derived from the options. We will show that more asymmetric upside risks make it more likely that frame (S) is adopted while more asymmetric downside risks make it more likely that frame (E) is selected.

Suppose that a decision maker can choose between a risky option c^u and a safe option c^c yielding a utility of zero in every period $\tau \in \mathcal{T}$. Assume that for periods $\tau \in \mathcal{T}_1$, where $\mathcal{T}_1 \subseteq \mathcal{T}$, the risky option yields a utility gain G_τ with probability p_τ and a loss of $-L_\tau$ with probability $1-p_\tau$ such that $p_\tau G_\tau - (1-p_\tau)L_\tau = z_\tau \in \mathbb{R}$. If option c^u is evaluated in frame $x \in \{S, E\}$, we denote the sum of its focus-weighted utilities over all periods $\mathcal{T} \backslash \mathcal{T}_1$ as $c^u_x \in \mathbb{R}$.

Note that the evaluation of the safe option is independent of the frame and, hence, $U(c^c|S) = U(c^c|E) = U(c^c) = 0$. Given frame (S), c^u yields the focus-weighted utility

$$U(c^u|S) = c^u_S + \sum_{\tau \in \mathcal{T}_1} \frac{p_\tau g(G_\tau)G_\tau - (1-p_\tau)g(L_\tau)L_\tau}{p_\tau g(G_\tau) + (1-p_\tau)g(L_\tau)}. \tag{3}$$

In the following we consider two such risky options (denoted A_1 and A_2) which are defined as follows. First, they are identical with respect to all periods $\tau \in \mathcal{T} \backslash \mathcal{T}_1$. Second, in all periods $\tau \in \mathcal{T}_1$ both options represent *upside risks*, that is, $G^1_\tau, G^2_\tau > L_\tau$ where G^i_τ denotes the gain option A_i provides in period τ. Third, we say that *upside risk A_2 is (weakly) more asymmetric than A_1* if $G^2_\tau \geq G^1_\tau$ in all $\tau \in \mathcal{T}_1$.

Analogously, let A'_1 and A'_2 be two options which differ only with respect to periods $\tau \in \mathcal{T}_1$. In these periods, both options represent *downside risks*, that is, $L^1_\tau, L^2_\tau > G_\tau$ where L^i_τ denotes the loss option A'_i provides in period τ. Furthermore, we say that *downside risk A'_2 is (weakly) more asymmetric than A'_1* if $L^2_\tau \geq L^1_\tau$ in all $\tau \in \mathcal{T}_1$. The following Proposition (proven in the Appendix) evaluates the effect of more asymmetric payoff distributions on the frame choice if a risky option is compared to the safe option c^c.

Proposition 3 (Bias toward Asymmetry for up- and downside risks)

i) Let A_1 and A_2 be two risky options, where upside risk A_2 is more asymmetric than A_1. If (A_1, S) is a SSE in $\{A_1, c^c\}$ then (A_2, S) is a SSE in $\{A_2, c^c\}$.

ii) Let A'_1 and A'_2 be two risky options, where downside risk A'_2 is more asymmetric than A'_1. If (A'_1, E) is a SSE in $\{A'_1, c^c\}$ then (A'_2, E) is a SSE in $\{A'_2, c^c\}$.

Proposition 3 shows that more asymmetric outcome distributions have different effects on the frame choice depending on whether the skew is in the gain or the loss domain.

Part i) shows that a more asymmetric upside risk makes it more likely that a decision maker adopts frame (S). More specifically, if the option A_1 is evaluated in frame (S) and chosen in equilibrium from $\{A_1, c^c\}$, also the more asymmetric upside risk A_2 is chosen from $\{A_2, c^c\}$ in a SSE. This is due to the fact that the more asymmetric an upside risk is, the more favorable it will appear to be if evaluated through frame (S). Put differently, the utility derived from evaluating an upside risk in frame (S) is the higher the more asymmetric the risk is as we show in the proof of the Proposition 3. In contrast, evaluations in frames (E) and (N) are not affected by the asymmetry of the options. Thereby, part i) relates to *skewness preferences* (e.g., Kraus and Litzenberger, 1976; Ebert and Wiesen, 2011) whereby a decision maker prefers upside risks the more positively skewed (or, in our terminology, the more asymmetric) they are. The model by BGS accounts for skewness preferences (see Bordalo *et al.*, 2013a; Dertwinkel-Kalt and Köster, 2017a); likewise, it gives rise to part i) of Proposition 3. Furthermore, part i) extends Kőszegi and Szeidl (2013)'s *bias toward concentration* to the domain of decision making under risk. A bias toward concentration means that a low-probability, large outcome is preferred over a smaller outcome with a higher probability. Correspondingly, part i) and its proof yield that a decision maker gets a higher utility from A_2 (as its gain is larger, though less likely than that of A_1) if frame (S) is adopted.

Conversely, by part ii), the more asymmetric a downside risk is, the more likely it is to be evaluated in frame (E). If there is a SSE (A'_1, E) in $\{A'_1, c^c\}$, also the more negatively skewed option A'_2 is a SSE in $\{A'_2, c^c\}$. Note that this does not imply that a subject is more likely to choose a risky option yielding a loss the more negatively skewed it is. It rather implies that the more asymmetric a downside option is, the less likely a decision maker is to evaluate the option via frame (S) and the more likely she is to adopt frame (E) which blurrs unfavorable consequences. Thereby, part ii) closely relates to the aversion toward negatively skewed options that the model by BGS predicts (see Bordalo *et al.*, 2013a; Dertwinkel-Kalt and Köster, 2017a).

Altogether, Proposition 3 implies a *bias toward asymmetry*. Loosely speaking, the more asymmetric outcome distributions are the more likely it is that in a self-serving equilibrium a decision maker adopts a frame which is different from the neutral one and the more likely it is that a decision maker engages in overoptimistic actions. Whether the bias goes in the direction of *overemphasizing potential gains* (adopting frame (S)) or *blurring negative consequences* (adopting frame (E)) depends on the direction of the asymmetry. Thereby, Proposition 3 generalizes our results from Section 3.

4.2 Limitations of Overoptimism

While people behave overoptimistically and therefore risk-seeking in many situations, optimistic behavior is not universal in our model. In the following, we discuss situations where our model predicts that a decision maker does not make overoptimistic choices. This analysis yields important differences between our model and models of overoptimism such as Mayraz (2011) as those cannot account for the limitations of overoptimism we delineate here (see also Section 5).

We discuss the choice between a safe option c^c and a risky option c^u which represents a *mean preserving symmetric spread* of the safe option. Suppose that the two options yield the same payoffs in all but one period. In that specific period the safe option offers a safe payoff whereas the risky option offers a gamble with a 50% chance of exceeding the payoff of the safe option and a 50% chance of falling short by the same amount. Formally, let $c^u_\tau = c^c_{\tau'}$ for all $\tau, \tau' \in \mathcal{T}\backslash\{\bar{\tau}\}$. At $\tau = \bar{\tau}$, option c^u pays $c^c_{\bar{\tau}} - \alpha$ or $c^c_{\bar{\tau}} + \alpha$ for some $\alpha > 0$, each with a 50% probability. As c^u represents a mean preserving symmetric spread of c^c, both options yield the same expected payoffs. We will show that in this class of decision situations our model's predictions entirely match the predictions made by expected utility theory.

We impose the following assumptions on the agent's utility function. As before, an outcome of zero yields zero utility, and we assume that the utility is strictly monotonically increasing in the outcome. Second, we distinguish whether the agent has a linear utility function and is therefore risk-neutral, or whether her utility function is concave (convex) such that she is risk-averse (risk-seeking).

Expected utility theory. Expected utility theory predicts that the risk-neutral agent is indifferent between the two options, whereas a risk-averse (risk-seeking) agent is predicted to strictly prefer the safe (risky) option.

As we will show in the following, the choices our model predicts are independent of the focus type, and decisions are in line with expected utility maximization. Therefore, as revealed in the present analysis, overoptimism in our model has plausible limitations. Note that in order to compare utilities derived from the alternatives, we can restrict our analysis to the options' payoffs at the specific point in time $\bar{\tau}$ since they yield equal payoffs at all other points in time.

Frame (S). First, we assume that the decision maker uses representation (S). Given that the agent has a linear utility function, the focus weights on both feasible states are identical and equal $g(u(c^c_{\bar{\tau}}) - u(c^c_{\bar{\tau}} - \alpha)) = g(u(c^c_{\bar{\tau}} + \alpha) - u(c^c_{\bar{\tau}}))$. Consequently, both options' focus-weighted utilities match the net present value and the agent is indifferent between both alternatives, that is, $U(c^c) = U(c^c|S) = U(c^u|S)$.

Under risk-aversion, the focus weight on c^u's relative downside is particularly large, $g(u(c^c_{\bar{\tau}}) - u(c^c_{\bar{\tau}} - \alpha)) > g(u(c^c_{\bar{\tau}} + \alpha) - u(c^c_{\bar{\tau}}))$, so that $U(c^u|S) < U(c^c|S)$. This is reversed under risk-seekingness: the focus weight on the relative upside becomes particularly large, such that $U(c^u|S) > U(c^c|S)$. Therefore, given a focus on states, the safe option is preferred by the risk-averse agent, while the risk-seeking agent prefers the risky option. These predictions exactly meet expected utility maximization. Note that the agent, however, overestimates in each case the difference in utility between the two available options. If the risky option yields the higher focus-weighted utility, then its relative upside is overvalued, whereas if the safe option is preferred, then the risky option's relative downside is overvalued.

Frame (E). Second, we analyze utilities if the agent incorporates frame (E). With a linear utility function both alternatives yield the same expected utilities at all points in time. Therefore, the agent is indifferent between both options.

Under risk-aversion, the safe option c^c gives a higher expected utility at $\bar{\tau}$. Provided $T > 0$, both options' focus weights are larger at $\bar{\tau}$ than at all other points, so that the safe option is preferred while the difference in utility between the two options is overrated. The reverse holds if the agent is risk-seeking where the risky option is preferred and the difference in utility between the two options is overrated as $U(c^u|E) - U(c^c|E) > U(c^u) - U(c^c)$. Therefore, our model predicts maximization of expected utilities if options are evaluated in frame (E).

Proposition 4 *Suppose a decision maker chooses between a safe option c^c and a riskier alternative c^u, which is a two-outcome, mean preserving symmetric spread of the safe option in one period. Then, our model makes the following predictions.*

(i) A risk-neutral decision maker is indifferent between both options, that is, $\max_{x\in\{S,E\}}\{U(c^c), U(c^c|x)\} = \max_{x\in\{S,E\}}\{U(c^u), U(c^u|x)\}$ *holds.*

(ii) A risk-averse decision maker strictly prefers the safe option over the risky alternative, that is, $\max_{x\in\{S,E\}}\{U(c^c), U(c^c|x)\} > \max_{x\in\{S,E\}}\{U(c^u), U(c^u|x)\}$.

(iii) A risk-seeking decision maker strictly prefers the risky option over the safe option, that is, $\max_{x\in\{S,E\}}\{U(c^c), U(c^c|x)\} < \max_{x\in\{S,E\}}\{U(c^u), U(c^u|x)\}$.

The preceding proposition shows that for mean-preserving symmetric spreads, the predictions of our model are fully in line with the predictions by rational choice for various typical curvatures of the utility function.

Remark. Note that the preceding analysis carries over to slightly more general cases. First, it holds true if the same symmetric risk was added at more than one point in time (given that the risky option yields at all these points the same expected payoff). Second, it holds true if we add a little symmetric risk to the safe option in period $\bar{\tau}$. In this case, the risky option is riskier as the symmetric spread in period $\bar{\tau}$ is larger for the risky than for the safe option. Then, our model meets predictions by rational choice as a risk averse decision maker will opt for the safer and a risk-seeking decision maker will opt for the riskier option. While the preceding analysis builds on risks that are exactly symmetric, it is not the case that for any risk that is slightly asymmetric choices would be overoptimistic. The more asymmetric, however, a mean preserving spread is, the more likely it is that actions are overoptimistic (see Section 4.1).

To sum up, we have shown that our model does not predict overoptimism in cases in which symmetric risk was added to a safe option. Instead, an agent following our model opts for the safe option if and only if it is preferred by a rational agent. This is one of the most robust settings where expected utility theory is typically assumed to be valid and decision makers typically behave risk-averse (e.g., Kahneman and Tversky, 1979).[21,22]

So far, we have analyzed highly asymmetric risks where one attention-grabbing up- or downside can be realized with a small probability and symmetric risks as represented by mean-preserving symmetric spreads. We will briefly discuss the case of medium probabilities where the up-/downside risk is asymmetric, but not highly asymmetric.

Suppose some asymmetric downside (upside) risk becomes more symmetric in the sense that the downside (upside) probability is increased while the corresponding downside (upside) payoff is decreased in absolute value. Suppose further that the expected value in each period stays constant (i.e., f in formula (HC) stays constant). Note first that the option's evaluation in frame (E) does not change (see Equation (1)). For downside risks, salience of the downside induces the decision maker to adopt frame (E), independent of whether the downside probability is low or medium. Thus, making a downside risk more symmetrical has no effect on the propensity to decide overoptimistically. In contrast, in the spirit of BGS, Proposition 1, making an upside risk more symmetric reduces the distortion of the option's valuation in frame (S) if the focusing bias is sufficiently strong (see (TB)). As in equilibrium for upside risks frame (S) is adopted, making an upside risk more symmetric makes overoptimistic actions that are risk-seeking less likely.

5 Related Literature on Self-Servingness, Overconfidence, and Framing

Our model shares the predictions of other models, in which decision makers cannot only choose an option, but in which they can also decide on their expectations, their beliefs or their framing of a given decision problem. In this section, we will briefly point out differences between our model and these related models.

Mayraz (2011)'s model of wishful thinking assumes that a decision maker's beliefs depend crucially on her interests and how her interests bias the processing of information. A single parameter measures whether a decision maker is optimistic or pessimistic. In the

[21] Risk aversion can be one-to-one identified with preferences for second-order stochastic dominating options, see for example Hadar and Russell (1969). Therefore, in the simplest test for risk-aversion, subjects choose between (1) a monetary lottery with symmetric risk and (2) its expected payoff. Here, (1) is the simplest lottery which is second-order stochastic dominated by (2). For instance, Kahneman (2011) lists this example in order to define risk aversion. Therefore, all studies which test for risk aversion insinuate that the revealed preference approach is valid in such simple setups and that information about one's true utility function can be elicited through this procedure. Our model also predicts that decision makers reveal their true preferences in such setups.

[22] Our results also apply if the agent's attitude toward risk depends on whether the agent faces monetary gains or losses. Kahneman and Tversky (1979) have suggested that an agent is risk-averse in the domain of positive payments and risk-seeking in the domain of negative payments. The preceding proposition generalizes to this case.

case of optimism, the decision maker maximizes a distorted utility function, according to which probability weights are upward distorted for those events which are favorable for the decision maker, while they are downward distorted for unfavorable events. This, however, predicts that overoptimism is, for optimistic individuals, universal. Therefore, this model cannot account for rational, risk-averse behavior as predicted by our model (see Section 4.2).

According to Brunnermeier and Parker (2005), decision makers experience anticipatory utility, such that decision makers may benefit from overoptimistic beliefs as gains in anticipatory utility may outweigh losses resulting from overoptimistic actions. Both Brunnermeier and Parker and our model predict rational decision making only in settings where decision makers choose between a safe option and a mean preserving symmetric spread.

In general, Brunnermeier and Parker predict a preference for risky options with positively skewed distributions as these allow for overoptimistic beliefs concerning highly positive, but unlikely events. Thereby, their model can account for gambling, lottery purchases and related phenomena, which have also been rationalized by our mechanism. A positive skew induces decision makers in our model to choose frame (S) and to thereby overweight unlikely, salient outcomes as these are favorable if the distribution is positive. In contrast to our model, however, a negative skew induces decision makers to be pessimistic in the model by Brunnermeier and Parker.[23] Consequently, the model by Brunnermeier and Parker cannot account for overoptimism with respect to harmful consumption. We predict that decision makers are induced to use frame (E) for decision situations in which the risky option is negatively skewed unless psychological costs of using (E) are particularly high, for instance if the downside state is particularly vivid as in the examples given in the previous section. In addition, empirical findings by Coutts (2015) and Mayraz (2013) are inconsistent with the model by Brunnermeier and Parker as they do find that raising the costs of mistaken beliefs reduces overoptimism.

Bracha and Brown (2012) consider a model where a decision maker's choices are affected by both rational and emotional processes. In their model, the emotional process affects risk perception in an optimistic fashion. The emotional process chooses an optimal risk perception that balances *affective motivation*—the desire to hold a favorable personal risk perception—and a *taste for accuracy*, whereby distortions of objective risks result in mental costs. The rational process then chooses an action given the risk perception. The equilibrium notion is quite similar to our approach in that risk perception and decisions are consistently chosen. As in our approach, their model predicts a tendency to act in an overoptimistic fashion—via endogenous risk perception in their model and frame choice in ours. Bracha and Brown's model allows for a much more flexible distortion of risk perceptions than our model. As the mental cost function is unobservable, a wide range of

[23]Brunnermeier and Parker (2005) discuss negative skews with the example of stocks: "[...] because the payoff of the asset is negatively skewed, agents with optimal expectations would be pessimistic about the payout of the asset and short the asset" (Brunnermeier and Parker, 2005, p. 1103).

overoptimistic risk perceptions can be supported by their model. In contrast, our model bounds the decision maker to choose between two frames, so that it grants the decision maker much less flexibility for distorting perceptions. This difference can best be seen by looking at decision making when facing symmetric spreads. In contrast to our model, their approach does not always predict rational, risk-averse behavior when facing symmetric spreads due to the tendency of the emotional process to perceive risk optimistically (see the discussion in 4.2).[24]

Wu (1999) considers a model where decision makers may feel anxiety because of delayed resolution of uncertainty. If a decision maker dwells on better outcomes in future periods, she has an optimistic attitude and hence overweights positive outcomes. This approach would also predict overoptimistic choices as in our framework, in particular, if the time horizon is long.[25] Unlike our approach, the anxiety model would then also predict too optimistic decisions when a decision maker is facing lotteries with a mean-preserving symmetric spread (see Section 4.2).

Finally, it should also be noted that risk-seeking behavior cannot produce our results as it account for the plausible limitations of overoptimism (Section 4.2). Also the heuristic that probabilities of positive events are over- and probabilities of negative events are underweighted could account for overoptimistic actions, but not for the limitations of such behavior.

6 Discussion and Conclusion

This paper proposes an attention-based theory of framing of intertemporal decision situations. The theory is based on two psychological phenomena: When making decisions, humans tend to overweight salient features. Furthermore, humans tend to interpret information in a self-serving manner leading to our notion of an endogenously determined representation (frame) of a decision situation. By doing so we have combined alternative approaches of existing attention-based theories of decision making (Bordalo *et al.*, 2012; Kőszegi and Szeidl, 2013) into one coherent framework.

As a main prediction we provide a rationale for overoptimistic choices that can often be observed in practice. The model gives an explanation as to how and why decision makers underrate downside risks but overrate upside risk. In a single framework this can explain not only excessive gambling, but also an excessively unhealthy diet. However, we emphasize that our model does not always predict overoptimistic choices. For instance, a risk-averse decision maker will not reveal overoptimistic choices when facing the choice between a safe option and a mean-preserving symmetric spread. Furthermore, actions

[24]Note that in Bracha and Brown (2012) when facing the choice between a safe option and a symmetric spread a decision maker will only chose the safe option when the utility function is sufficiently concave and/or the mental cost function sufficiently steep. Otherwise the decision maker might choose the risky option, and in this case the emotional process will overweight the probability of a positive outcome.

[25]Note that Wu (1999) also considers the case where a decision maker is anxious about negative outcomes and as a result behaves pessimistically.

induced by an adoption of frame (S) are less likely to be overoptimistic if upsides are less salient, for instance if they are more likely to occur, but smaller in size. The more asymmetric a decision situation is, the more likely actions tend to be overoptimistic.

While we have abstracted from the role discounting plays in our main analysis, in general discounting could amplify or mitigate the effects, depending on whether costs or benefits lie in the future. If future consequences are strongly discounted, the focus weight attached to these consequences is also smaller. If an option's attention-grabbing feature lies in the future, discounting mitigates focus effects. Conversely, if the salient choice features are in the present, while the non-attention grabbing features lie in the future, focus effects are larger if discounting plays a role. In general, shifting decision situations and all of their consequences to the future should make decision situations appear to be more balanced so that focus effects should play less of a role and overoptimistic actions should become less likely.

Similarly, we could extend our approach straightforwardly toward non-stationary risk-preferences by using instantaneous utility functions that differ over time. As we consider only static decisions, our analysis holds true if changes in risk preferences are not anticipated. If differing risk preferences are anticipated, focus effects are amplified if the utility function is rather flat in those periods where non-salient consequences occur, and mitigated if the utility function is flat in the periods with attention-grabbing consequences.

While the model's predictions are in line with many observed phenomena, in future work our predictions might be tested more directly. For instance, in a laboratory experiment, a possible test design could be the following. Given a subject's instantaneous utility and discounting functions have been elicited, a subject makes a decision with intertemporal consequences that are spread over various periods. In another treatment, expected utilities are replaced by distributions. If the distributions' upsides are salient, subjects should adopt frame (S) and decide accordingly. If, in contrast, the distributions have salient downsides, frame (E) should be adopted and behavior should not be affected by whether expected utilities or the respective distributions are provided.

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Appendix

A Interdependent States

We previously assumed that state realizations at all points in time are independent. This assumption may be too strict for many practical problems. For instance, falling sick with diabetes because of an unhealthy diet at a certain point in time is strongly correlated with suffering from diabetes at a consecutive point in time. Therefore, we generalize our model in order to account for intertemporal correlations. We take the time-horizon $\mathcal{T}$, set I and the random variables c^i_τ with the corresponding and the measurable spaces $(S_\tau, \mathcal{F})$ as introduced in Section 2. Define $S := \bigoplus_{\tau \in \mathcal{T}} S_\tau$ with the canonical σ-algebra $\mathcal{F} := \bigotimes_{\tau \in \mathcal{T}} \mathcal{F}_\tau$. Consider the probability space $(S, \mathcal{F}, p)$ for a probability measure p.

Then, we define

$$p(s_\tau) := p(\{(\tilde{s}_0, \dots, \tilde{s}_T) \in S | \tilde{s}_\tau = s_\tau\}) = \sum_{\{(\tilde{s}_0, \dots, \tilde{s}_T) \in S | \tilde{s}_\tau = s_\tau\}} p((\tilde{s}_0, \dots, \tilde{s}_T)).$$

While this gives the formal generalization of our model toward intertemporal interdependence, the examples which we will consider in the following require much less notation. As analyzing general correlations is intractable, we consider a very strong form of correlation and illustrate that our findings are robust with respect to such interdependent state realizations and do not rely on our independence assumptions. Instead, overoptimistic actions are also prevalent in settings where outcomes in different periods are interdependent.

Harmful consumption and incurable diseases. Especially for severe diseases like lung cancer or diabetes, the chance to be cured may be tiny. Therefore, we extend our analysis on harmful consumption (Section 3) by assuming that, given a disease (the downside outcome, denoted $c_{\tau,2}$) has occurred in a previous period, then it will last for all future periods. Formally, we assume that $c^u_\tau = c_{\tau,2}$ induces $c^u_{\tau+1} = c_{\tau,2}$ with probability one for all $\tau \in \mathcal{T}\backslash\{T\}$. If, however, the adverse state has not been realized in the past, then there is a fixed probability p of becoming ill at each point in time. Therefore, the probability of being ill in period $\tau \geq 1$, is

$$p^\tau := \sum_{i=1}^{\tau} p \cdot (1-p)^{i-1}.$$

In particular, $p^{\tau+1} > p^\tau$ for all $\tau \in \{1, \dots, T-1\}$. We define $f_\tau = p^\tau L$ and assume that p^{t+n} is relatively small for all n. Then, as before, we obtain $U(c^u|S) < U(c^u) < U(c^u|E)$, and a decision maker yields higher focus-weighted utility by choosing frame (E). Hence, our main insight from Section 3 does not change, and the decision maker will choose the risky option as long as

$$Fg(F) > \sum_{\tau=1}^{T} g(f_\tau) f_\tau.$$

This holds in particular if

$$\frac{g(F)}{g(f_T)} > \frac{Tf_T}{F}.$$

Therefore, excessive harmful consumption may arise due to focusing according to frame (E) and does not rely on the state independence assumption which we imposed in the previous sections.

Persistent business success. Analogously we can show that overoptimistic actions are also robust with interdependent states in the case of upside risk. For instance, if a newly founded business becomes very successful, then it could be unlikely that it will go bankrupt within the next periods, but will rather go on to be successful. Consequently, similar to the previous paragraph, we assume that if the favorable outcome (the business success) has occurred in a previous period, then it will last for all future periods. Else, the upside outcome is realized with the fixed probability q. Analogously to the previous paragraph, the probability with which the favorable outcome occurs in period $\tau \geq 1$ is

$$q^\tau := \sum_{i=1}^{\tau} q \cdot (1-q)^{i-1}.$$

Using this definition, one can show, as in Section 3, that by focusing on (S) a decision maker yields a higher focus-weighted utility. That is, $U(c^u|S) > U(c^u) > U(c^u|E)$. With focus type (S) the decision maker then chooses to go for the risky option if

$$-H + G \cdot \sum_{\tau=1}^{T} \frac{q^\tau g(G)}{q^\tau g(G) + (1-q^\tau) g(0)} > 0.$$

A sufficient condition for this to hold is Equation (TB). Consequently, according to our model, entrepreneurial overoptimism may also occur if business success is persistent over time.

B Proof of Proposition 3

i) To show: $U(A_2|S) - U(A_1|S) > 0$. We show that this holds for the case that upside risk A_2 is more asymmetric than A_1 in a single period τ, that is, if $|\mathcal{T}_1| = 1$. For notational convenience, we drop the subscript τ in the following proof. This case straighforwardly generalizes to $|\mathcal{T}_1| > 1$. We have that $U(A_2|S) - U(A_1|S) > 0$ holds if and only if

$$\frac{p^2 g(G^2)G^2 - (1-p^2)g(L)L}{p^2 g(G^2) + (1-p^2)g(L)} - \frac{p^1 g(G^1)G^1 - (1-p^1)g(L)L}{p^1 g(G^1) + (1-p^1)g(L)} > 0$$

Inserting $p^i = (L+z)/(L+G^i)$ and rearranging gives the equivalent condition

$$g(L)(g(G^2)(G^2+L)(G^1-z) - g(G^1)(G^1+L)(G^2-z)) + (G^2-G^1)(z+L)g(G^1)g(G^2) > 0. \quad (4)$$

We distinguish two cases: (1) If $g(G^2)(G^1-z)(G^2+L) \geq g(G^1)g(G^1)(G^2-z)$, then 4 holds as $G^2 > G^1$. (2) If $g(G^2)(G^1-z)(G^2+L) < g(G^1)g(G^1)(G^2-z)$, then

$$\begin{aligned} & g(L)(g(G^2)(G^2+L)(G^1-z) - g(G^1)(G^1+L)(G^2-z)) + (G^2-G^1)(z+L)g(G^1)g(G^2) \\ > \ & g(G^1)g(G^2)\underbrace{((G^2+L)(G^1-z) - (G^1+L)(G^2-z) + (G^2-G^1)(z+L))}_{=0} \\ = \ & 0. \end{aligned}$$

As evaluations in frames (E) and (N) are not affected by the mean-preserving spreads that we consider—$U(A_1|E) = U(A_2|E) = U(A_2) = U(A_2)$—we have proven part i).

ii) We have to show that $U(A_1'|S) - U(A_2'|S) > 0$ holds. As the proof in analogous to i) the details are omitted here.