Journal of Economic Psychology 51 (2015) 183–198

Contents lists available at ScienceDirect

Journal of Economic Psychology

journal homepage: www.elsevier.com/locate/joep

A Dual Process Evaluability Framework for decision anomalies

Mark Schneider *, Robin A. Coulter [1]

School of Business, University of Connecticut, 2100 Hillside Road Unit 1041, Storrs, CT 06269-1041, United States

A R T I C L E I N F O

Article history:
Received 11 September 2014
Received in revised form 1 September 2015
Accepted 13 September 2015
Available online 16 September 2015

JEL classification:
C91
D03
D81

PsycINFO classification:
2340
2346
2360

Keywords:
Preference reversals
Decision anomalies
Evaluability theory
Dual process models

A B S T R A C T

Alternative explanations have been offered to explain consumers' inconsistent preferences in decision problems. We present a Dual Process Evaluability Framework (DPEF) which suggests that the characteristics of the decision problem, including response mode, presentation mode, and choice-set structure, are critical to predicting preference reversals related to decisions under risk and uncertainty, over time, and between product assortments, as well as presentation mode reversals involving joint versus separate evaluations, and response mode reversals involving a combination of choice tasks, monetary value tasks, and attractiveness ratings. Our framework, grounded in evaluability theory and dual process models, predicts how these decision problem characteristics directly affect the ease of evaluation of alternatives which subsequently affects the relative dominance of feeling versus calculation in these tasks. Application of DPEF to previously documented preference reversals, complemented by three studies which test new predictions of DPEF, reveals that DPEF provides a parsimonious explanation for a variety of decision anomalies.

1. Introduction

Revealed preferences that are inconsistent with standard economic models of human decision making have been documented over the past five decades. Numerous specific decision anomalies, including the Allais paradox (Allais, 1953), present bias (Frederick, Loewenstein, & O'Donoghue, 2002), the Ellsberg paradox (Ellsberg, 1961), the zero price effect (Shampanier, Mazar, & Ariely, 2007), the comparative ignorance hypothesis (Fox & Tversky, 1995) and preference reversals between choice and monetary valuation tasks (Lichtenstein & Slovic, 1971), have been explained by various models which are domain-specific (i.e., models which only consider decisions under risk or which only apply to decisions over time) and which are task-specific (i.e., models which only account for changes in the choice set, or which only account for changes in the response mode or the presentation mode). Notably, however, a unifying framework that systematically explains inconsistent preferences across multiple domains of individual choice or across different types of decision tasks has yet to be offered.

* Corresponding author at: The Economic Science Institute, Chapman University, One University Drive, Orange, CA 92866, United States. Tel.: +1 (860) 268 7791.

E-mail addresses: markschneider@aya.yale.edu (M. Schneider), robin.coulter@business.uconn.edu (R.A. Coulter).

[1] Tel.: +1 (860) 486 2889.

http://dx.doi.org/10.1016/j.joep.2015.09.005
0167-4870/

In this research, we propose a Dual Process Evaluability Framework (DPEF) to explain preference reversals[2] across an array of decision problems. Our framework is grounded in two major literature streams on judgments and decisions: evaluability theory (Hsee, 1996; Hsee, Loewenstein, Blount, & Bazerman, 1999; Hsee & Zhang, 2010) and the plethora of dual process models in psychology and economics (Brocas & Carrillo, 2014; Chaiken, 1980; Hsee & Rottenstreich, 2004; Kahneman & Frederick, 2005; Rubinstein, 2007; Sloman, 1996; Stanovich & West, 2000). DPEF, in contrast to past work, suggests that objective features of a decision task, in particular, response mode, choice-set structure, and presentation mode, directly affect the ease of evaluation of choice alternatives. Consistent with theoretical work by Hsee and his colleagues, and with experimental work by Alter, Oppenheimer, Epley, and Eyre (2007) and Inbar, Cone, and Gilovich (2010), DPEF predicts that when the evaluation of choice alternatives is easy, the decision is governed by intuition or feeling-based (System 1) processes, whereas when the evaluation of choice alternatives is difficult, the decision is governed by logical or calculation-based (System 2) processes. DPEF further links evaluability with choice behavior for an array of decision domains and decision tasks involving risk, time, ambiguity, product assortment, and social preference.

We next provide a brief review of well-documented decision anomalies and behavioral decision theory explanations. We proceed with providing the theoretical underpinnings of DPEF, and document that DPEF accounts for a range of preference reversals across decision domains and across decision tasks that are not accounted for by traditional models which are typically domain-specific and task-specific. We then report on three experiments that offer evidence that DPEF provides explanations for novel choice task-attractiveness rating reversals in decisions under risk which, to our knowledge, have not been previously tested. Thus, our research contributes to the understanding of judgment and decision making by offering a framework which predicts how fundamental properties of a decision problem systematically produce well-documented decision anomalies across different decision domains and different decision tasks.

2. Decision anomalies and behavioral decision theories

A large literature has focused on addressing decision anomalies over the past fifty years. In this work, we consider three genres of decision anomalies. First, *choice task reversals* hold the response mode and presentation mode fixed, but vary the choice-set structure. Such reversals typically involve a choice between two alternatives (A and B) in one choice-set and between two different alternatives (C and D) in another choice-set, where the alternatives across choice-sets are related by a normative principle of decision making which is violated by the decision maker's pair of choices. A majority of the well-studied decision anomalies are of this nature (see exemplars in Table 1; CS refers to choice-set). Included are: the Allais paradoxes (Allais, 1953), involving decisions under risk, in which the decision maker chooses between alternatives (referred to as lotteries) with well-defined probabilities (CS-1–CS-4); present biased decisions (e.g., Frederick, Loewenstein, & O'Donoghue, 2002) involving choices between immediate and delayed outcomes (CS-5, CS-6); the Ellsberg paradox (Ellsberg, 1961) involving decisions under uncertainty (or ambiguity) in which there is some missing information about the probabilities of particular events (CS-7, CS-8); and the zero price effect (Shampanier et al., 2007) focused on decisions between product assortments where the item value and cost may vary (CS-9, CS-10). A second genre of decision anomalies, *presentation mode reversals*, includes reversals in which choice alternatives are presented jointly versus separately, while holding the choice alternatives and response mode fixed; the comparative ignorance effect (CS-11) is an example. Third, we consider *response mode reversals* which are a consequence of varying the response mode, while holding choice alternatives and presentation mode fixed; an illustration is contrasting an attractiveness rating task with a monetary valuation task (CS-12).

In addition, we consider several anomalies which have thus far been classified as response mode reversals or as presentation mode reversals in the literature, but which according to our definitions are more appropriately labeled *response mode–presentation mode reversals*, because the design of these problems confounds presentation mode with response mode. For example, the preference reversal between choice tasks and monetary valuation tasks identified by Lichtenstein and Slovic (1971) and replicated by Tversky, Slovic, and Kahneman (1990) and others, is often viewed as a response mode reversal; however, the choice alternatives (lotteries) illustrated in CS-13 were presented jointly, whereas the assessment of monetary value of each lottery was solicited in isolation. Similarly, although Hsee (1996) cites Bazerman, Loewenstein, and White (1992) as the first example in the literature of a presentation mode reversal, Bazerman et al. (1992) elicited choices jointly and attractiveness ratings separately for each alternative (CS-14).

As shown in Table 2, an array of behavioral decision theories have been offered to explain specific decision anomalies. For example, prospect theory (Kahneman & Tversky, 1979), cumulative prospect theory (Tversky & Kahneman, 1992), and the dual system model (Mukherjee, 2010) offer explanations for the Allais common ratio effect, the Allais common consequence effect, and the Ellsberg paradox. Models of hyperbolic or quasi-hyperbolic discounting (Laibson, 1997; Loewenstein & Prelec, 1992) provide an explanation for present bias. The model of probability-time tradeoffs (Baucells & Heukamp, 2012) simultaneously explains the Allais common ratio effect and present bias. Regret theory (Bell, 1982; Loomes & Sugden, 1982) and salience theory (Bordalo, Gennaioli, & Shleifer, 2012) explain the Allais paradoxes and choice task-monetary valuation reversals (Lichtenstein & Slovic, 1971). The contingent weighting model (Tversky, Sattath, & Slovic, 1988) explains

[2] We use 'preference reversal' as a general term for inconsistent responses to decision problems. We note that reversals which shift from a strict preference to an indifference (e.g., the comparative ignorance effect) may be more appropriately labeled as inconsistency or incoherence.

Table 1
Classical decision anomalies with exemplar tasks.

Classical Decision Anomaly		Key reference
Choice task reversals		
Allais common ratio effect		
CS-1 A. ($3000, 1)	B. ($4000, 0.8; $0, 0.2)	Kahneman and Tversky (1979)
CS-2 C. ($3000, 0.25; $0, 0.75)	D. ($4000, 0.2; $0, 0.8)	
Allais common consequence effect		
CS-3 A. ($2400, 1)	B. ($2400, 0.66; $2500, 0.33; $0, 0.01)	Kahneman and Tversky (1979)
CS-4 C. ($2400, 0.34, $0, 0.66)	D. ($2500, 0.33; $0, 0.67)	
Present bias		
CS-5 A. $20 now	B. $30 in one year from now	Frederick et al. (2002)
CS-6 C. $20 in five years from now	D. $30 in six years from now	
Ellsberg paradox		
CS-7 A. $100 if Red drawn from Bag A	B. $100 if Red drawn from Bag B	Ellsberg (1961)
CS-8 C. $100 if Black drawn from Bag A	D. $100 if Black drawn from Bag B	
Zero price effect		
CS-9 A. $10 gift card for free	B. $20 gift card for $7	Shampanier et al. (2007)
CS-10 C. $10 gift card for $1	D. $20 gift card for $8	
Presentation mode reversals		
Comparative ignorance effect (valuations: joint vs. separate)		
CS-11 A. $100 if Red drawn from Bag A	B. $100 if Red drawn from Bag B	Fox and Tversky (1995)
Response mode reversals		
Attractiveness rating-monetary valuation reversal (separate)		
CS-12 A. (29/36 chance to win $2)	B. (7/36 chance to win $9)	Slovic et al. (2002)
Response mode–presentation mode reversals		
Choice task (joint)-monetary valuation (separate) reversal		
CS-13 A. ($100, 0.89; $0, 0.11)	B. ($1000, 0.11; $0, 0.89)	Tversky et al. (1990)
Choice task (joint)-attractiveness rating (separate) reversal		
CS-14 A. ($500 for self; $500 for other)	B. ($600 for self; $800 for other)	Bazerman et al. (1992)

CS refers to choice-set.

Table 2
Paradoxes resolved by behavioral decision theories.

	Prospect theory and dual system model	Hyperbolic discounting theory	Regret theory and salience theory	Probability time tradeoff	Contingent weighting theory	Dual Process Evaluability Framework
Choice task reversals						
Allais common ratio effect	p		p	p		p
Allais common consequence effect	p		p	p		p
Present bias		p		p		p
Ellsberg paradox	p					p
Zero price effect						p
Presentation mode reversals						
Comparative ignorance						p
Response mode reversals						
Attractiveness rating-Monetary valuation reversal					p	p
Response mode–presentation mode reversal						
Choice task (joint)-monetary valuation (separate)				p	p	p
Choice task (joint)-attractiveness rating (separate)					p	p

p indicates that this model resolves the identified paradox.

response mode reversals between choice and monetary value tasks and between monetary value tasks and attractiveness ratings. Thus, leading theories provide explanations for decision anomalies related specifically to decision domains of risk and uncertainty, time, product assortment, and social preference, but not across these decision domains. Further, leading theories provide explanations focused on a particular genre of reversals (e.g., choice task reversals, presentation mode reversals, or response mode reversals), but not across these types of reversals. However, to the extent these phenomena are generated by the same types of decision makers, one might suspect that a domain-general approach which considers the decision making process might account for a wider range of anomalies.

3. A Dual Process Evaluability Framework

The Dual Process Evaluability Framework, introduced here, consistently predicts the decision anomalies listed in Table 2. In the following section, we provide the theoretical underpinnings of DPEF, and provide theoretical evidence that a variety of decision anomalies can be explained by examining three characteristics of decision problems (response mode, choice-set structure, and presentation mode) and by linking these characteristics to the ease of evaluation of the decision problem (evaluability theory), and subsequently to the valuation process (dual process theory) to predict preference reversals. In Fig. 1, we illustrate how the response mode (such as a choice task, attractiveness rating, and monetary valuation), the choice-set structure (categorical vs. incremental differences), and the presentation mode (joint vs. separate) are related, and how they are linked to the evaluation process and choice behavior under DPEF.

3.1. Characteristics of the decision problem

In defining the objective characteristics of the decision problem, *response mode* refers to the format in which preferences among the alternatives are expressed. We focus on three major types of response modes for which preference reversals have been established. First, choice tasks ask the decision maker to choose from a given set of alternatives in two choice-sets. Second, attractiveness rating tasks involve the decision maker indicating a favorability or preference rating for each alternative on an attractiveness rating scale. Third, monetary value tasks require the decision maker to provide a monetary valuation, such as a minimum selling price, for each alternative.

We use the term *choice-set structure* to refer to properties of alternatives in a choice set such as whether the alternatives differ categorically (risk vs. no risk; high vs. low risk) or incrementally (a small change in the degree of risk). Hsee and Zhang (2010) argue that choice tasks in which alternatives differ categorically are easier to evaluate than choice tasks where alternatives differ incrementally. We further propose that attractiveness rating tasks involve an affect-based rating and are easier to assess, whereas monetary value tasks involve a calculation and are more difficult to assess.

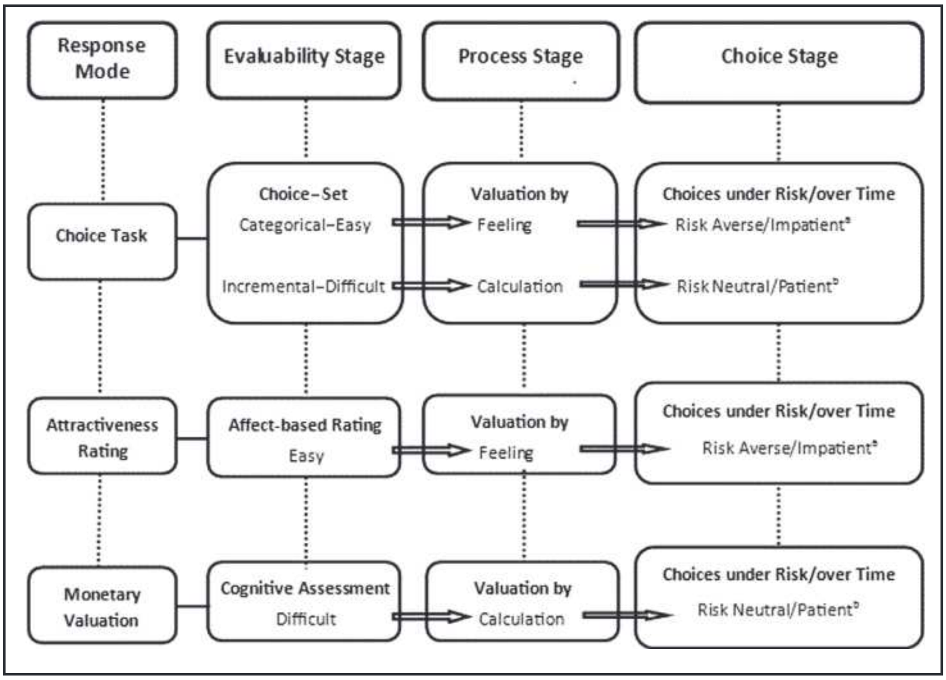
Presentation mode refers to whether the alternatives are presented and evaluated jointly (as is the case in choice tasks) or separately (as is usually the case in attractiveness rating and monetary value tasks). Hsee and Zhang (2010) propose that alternatives are easier to evaluate under joint presentation than under separate presentation. Under DPEF, a principle role of presentation mode will be to determine whether the level of evaluability (easy vs. difficult) of a decision task is based on the response mode or on the choice set structure because choice set structure is only transparent in joint evaluation. In typical studies of preference reversals, it is also the case that the effects of response mode and presentation mode are confounded in decision tasks.

Given the choice-set structure, response mode, and presentation mode, DPEF provides a mechanism for predicting when a decision maker will rely more on feeling and intuition (when the decision task is easy; i.e., when choice task alternatives differ categorically or the response mode involves an attractiveness rating), and when the decision maker will rely more on reason and calculation (when the decision task is difficult, i.e., when choice task alternatives differ incrementally, or when the response mode involves an assessment of monetary value). Note that an important role of presentation mode is to determine whether the choice-set structure (categorical or incremental differences) will affect responses, because such differences between alternatives can only be evaluated in joint presentation.

3.2. Characteristics of decision problems and ease of evaluation

Past work in judgment and decision making has linked characteristics of decision tasks to evaluability (e.g., Hsee, 1996; Hsee & Zhang, 2010; Hsee et al., 1999). Herein, we address how DPEF relates the specific aspects of response mode, choice-set structure, and presentation mode to the ease of evaluation of the decision task, drawing on generalized evaluability theory (Hsee & Zhang, 2010). First, we consider the response mode of *choice tasks* and their underlying *choice-set structure*. Several of the classic choice task reversals involve a choice-set structure where alternatives in one choice-set are categorically different (i.e., risk vs. no risk; high vs. low risk) and the other involves alternatives that are incrementally different (i.e., a small change in the degree of risk). Table 1 provides an illustration. CS-1 involves a choice between receiving $3000 with certainty (option A) and having an 80% chance of receiving $4000 (option B), and thus involves a categorical difference (no risk vs. risk). Alternatively, CS-2 involves a decision between two incrementally different risky alternatives, in which the probability of getting $3000 is .25 (option C) and in which the probability of getting $4000 is .2 (option D).

Our distinction between *presentation mode, choice-set structure*, and *response mode* reflects key features of a decision task which systematically prime the decision process and the decision process systematically influences behavior. These DPEF task characteristics might be considered in relation to the three factors of evaluability theory, *mode, knowledge*, and *nature*, which affect the ease of evaluating information (Hsee & Zhang, 2010). Hsee and Zhang refer to *mode* as whether different pieces of the information being evaluated are presented separately versus jointly, analogous to presentation mode in our context. The classic choice task reversals in the literature involve two alternatives which are jointly presented to the decision maker, whereas alternatives in attractiveness rating tasks and monetary value tasks have typically been presented in isolation such that only one alternative is viewed by the decision maker when assessing that alternative's attractiveness or monetary value (Lichtenstein & Slovic, 1971; Slovic, Finucane, Peters, & MacGregor, 2002; Tversky et al., 1990). Thus, presentation mode in DPEF and mode in evaluability theory are essentially comparable.



[a]Also for ambiguity averse, loss averse, and inequality averse decisions.
[b]Also for ambiguity neutral, loss neutral, and inequality neutral decisions.

Fig. 1. Overview of the Dual Process Evaluability Framework.

Knowledge and nature according to Hsee and Zhang (2010) are internal psychological characteristics. Hsee and Zhang (2010) argue that people have more *knowledge* about categorical distinctions whereby attributes differ in sign or type, than they do about incremental differences, which makes categorically different alternatives easier to evaluate than incrementally different alternatives. Thus in DPEF, there is a link between knowledge and choice-set structure in that choice-set structures involving categorically different alternatives are easier to evaluate than those with incrementally different alternatives. Further, Hsee and Zhang (2010, p. 345) state that *nature* "refers to whether human beings have an innate and stable physiological 'scale' (reference system) to evaluate values on an attribute. The attribute is inherently evaluable if they do or inherently inevaluable if they do not." Hsee and Zhang provide ambient temperature as an example of a scale which is inherently evaluable. DPEF posits that because attractiveness ratings require individuals to provide an assessment of how much they 'like' each of the alternatives in a decision task, an attractiveness rating scale may elicit a physiological response, and thus be inherently evaluable. Indeed, happiness rating scales, a type of attractiveness rating, have been found to correlate with biochemical factors such as dopamine levels (Depue, 1995) and with frequency of spontaneous smiling (Ekman, Davidson, & Friesen, 1990) suggesting that they do elicit a physiological response. In this respect, individuals responding to attractiveness rating scales appear to be providing an affect-based rating, and we posit that affect and liking based evaluations are relatively 'easy' to provide because affective processes are typically effortless and automatic. In contrast a *monetary value task* requires individuals to provide a numerical indifference point for each alternative (e.g., "What is the most you are willing to pay to have an 80% chance of winning $4000?"). This assessment is less evaluable, requires more thought and is more difficult to provide. In other words, the *attractiveness rating task* is more easily evaluable than the *monetary value task* because people are more likely to have an innate and stable physiological scale for assessing 'liking' than for providing a precise numerical indifferent point. Hence, we suggest a correspondence between nature, an internal, psychological factor in evaluability theory (Hsee & Zhang, 2010) and response mode, an objective characteristic of a decision task in DPEF.

With regard to the correspondence between task characteristics and evaluability factors, DPEF posits that presentation (joint vs. separate) mode influences whether the decision maker will be more sensitive to choice-set structure (knowledge) or to the response mode (nature) because categorical or incremental differences are detectable in joint (but not separate) presentation.

To summarize, and as illustrated in Fig. 1, DPEF distinguishes between three characteristics of a decision task – response mode, choice-set structure, and presentation mode. As related to the choice task response mode, DPEF posits that choice sets characterized by categorical differences are subjectively easier to evaluate, whereas those characterized by incremental differences are more difficult to evaluate, consistent with Hsee and Zhang (2010). Additionally, DPEF posits that an attractiveness rating task involves evaluating choice alternatives using an assessment of liking which is inherently evaluable and can elicit a physiological response, whereas a monetary value task is more difficult to evaluate as it requires a precise numerical response as well as learning or social comparison to judge the value of an alternative. Further, DPEF posits that choice-set structure receives more weight in joint presentation (where it is transparent and facilitates comparisons between alternatives), than in separate presentation (where it is obscured), in which case the decision maker is relatively more sensitive to response mode effects.

3.3. Linking evaluability to the process and choice stages

To link ease of evaluation to choice to explain decision anomalies, DPEF draws upon evaluability theory and dual process theory to distinguish between three stages of a decision: a perceptual *evaluability stage* (whether the decision task seems easy or difficult to evaluate), a *process stage* (whether a decision maker chooses by feeling or calculation) and a *choice stage* (in which the decision maker expresses the preference of the engaged valuation process) (see also Payne, Bettman, & Johnson, 1993). At the *evaluability stage*, DPEF proposes that the objective features of a decision task (and in particular presentation mode, choice-set structure, and response mode) influence whether the task will be perceived as relatively easy or difficult to evaluate, as outlined in Sections 3.1 and 3.2.

At the process stage, DPEF posits that the evaluability of the decision task determines whether the choice is primarily governed by feeling-based or by calculation-based processes (consistent with Hsee and Rottenstreich's distinction between two broad types of valuation mechanisms used in decision making – valuation by feeling and valuation by calculation). We use 'feeling' to refer to automatic, intuitive and affective processes, in line with common conceptions of dual process theories (Kahneman, 2003), and 'calculation' to refer to increased cognitive effort, thinking, or contemplation. (i.e., to indicate that people are engaged with thinking more about, but not necessarily calculating expected values for, the choice alternatives). Specifically, we argue that easily evaluable decisions, which induce little effort, engage intuitive or feeling-based processes, whereas difficult decisions, requiring greater effort, are evaluated by reason or calculation-based processes (see also Shah & Oppenheimer, 2008). Alter et al. (2007) found that decreasing processing fluency by presenting information in a degraded font or difficult-to-read lettering led to more analytical reasoning. In a related finding, Inbar et al. (2010) found that "More complex products elicited a preference for choosing rationally, whereas simpler products elicited preference for choosing intuitively" (p. 237). These observations suggest that the ease of evaluating information or choice alternatives can influence the type of processes that are engaged. Grounded in these observations, DPEF argues that level of evaluability (easy or difficult) corresponds to the mode of valuation (feeling or calculation). Further, whereas leading paradigms such as the somatic markers hypothesis (Damasio, 1994), the affect-as-information hypothesis (Schwarz & Clore, 1983), or the affect heuristic (Slovic et al., 2002) provide insight into how affect is used as an input to judgment and decisions, DPEF provides a mechanism for systematically predicting when affect (vs. calculation) will dominate in a given decision task.

At the choice stage, DPEF builds on dual process theory by proposing that valuation by feeling is averse to risk, ambiguity, time delays, prices, and inequitable allocations, whereas valuation by calculation has neutral attitudes toward risk, uncertainty, time delays, costs, and inequality. We thus propose that decisions in which valuation by feeling dominates are inherently risk-averse, ambiguity-averse, impatient, loss-averse, and inequality-averse, whereas those in which valuation by calculation dominates are inherently risk neutral, ambiguity neutral, patient, loss neutral, and inequality neutral[3] (see Table 3).

A large literature in both social psychology and behavioral decision theory views evaluative judgments through the lens of a dual process framework (Barbey & Sloman, 2007; Chaiken, 1980; Hsee & Rottenstreich, 2004; Kahneman & Frederick, 2005; Stanovich & West, 2000). One question which naturally arises for dual process models is what behavior would be predicted when a particular process is dominant. For the domains of risk and time delays, Frederick (2005) finds evidence that individuals who rely on calculation tend to be more consistent with expected value maximization (risk-neutrality) and more patient than individuals who rely predominantly on feeling and intuition. To the extent that greater reliance on logic and calculation is associated with higher cognitive skills, Burks, Carpenter, Goette, and Rustichini (2009, p. 7747) found, "individuals making choices just shy of risk-neutrality have significantly higher cognitive skills than those making either more risk-averse or more risk-seeking choices." Loewenstein, Hsee, Weber, and Welch (2001) argue that affect is averse to risk in a wide variety of situations, and Woelbert and Goebel (2013) provide further evidence that decisions governed by feeling are often risk-averse and impatient. Further, Hsee and Rottenstreich (2004) find that the value function for feeling (calculation) is concave (linear), consistent with the hypothesis that valuation by feeling is risk-averse and valuation by calculation maximizes expected value.

Herein, we assume that valuation by feeling is risk-averse, consistent with the shape of the affective value function estimated by Hsee and Rottenstreich (2004). This perspective enables DPEF to resolve the key violations of rational decisions under risk (Allais, 1953), even when both valuation mechanisms are consistent with the axioms of rational choice (Von Neumann & Morgenstern, 1947). Valuation by feeling, however, also may be systematically risk-seeking. For instance, Rottenstreich and Hsee (2001) find that inverse S-shaped non-linear probability weighting is more pronounced for affect-rich outcomes. If we assume this functional form for valuation by feeling, our results continue to hold. Moreover, this prospect theory perspective for valuation by feeling enables DPEF to explain the observation that the same person may

[3] 'Risk-neutral' means expected value maximization (i.e., the utility function is linear), 'ambiguity neutral' means expected utility maximization (in which case the utility function can have any shape), and 'loss neutral' implies that equivalent gains and losses are weighted equally in a decision. Thus, expected value maximization simultaneously implies risk-neutrality, ambiguity neutrality, and loss neutrality.

Table 3
Behavior triggered by valuation by feeling and valuation by calculation.

Decision domain	Valuation by feeling	Valuation by calculation
Risk	Risk-averse	Risk-neutral
Uncertainty	Ambiguity-averse	Ambiguity-neutral
Time	Impatient (delay-averse)	Patient
Product assortment	Loss-averse	Loss-neutral
Social preference	Inequality-averse	Inequality-neutral

purchase both lottery tickets and insurance policies, thereby exhibiting both risk-seeking and risk-averse behavior in common decisions.

For decisions under risk, outcomes (e.g., the chance of winning $4000) are accompanied with information about their probability of occurrence (e.g., 80%). Evidence exists that affect is also involved in evaluating decisions under ambiguity (where some probabilistic information is missing). O'Doherty et al. (2001) note that the orbitofrontal cortex (OFC) is implicated in emotion and emotion-related learning. Patients with lesions to the OFC may need to rely more on valuation by calculation than on feeling to cope with everyday decision problems. Interestingly, Hsu, Bhatt, Adolphs, Tranel, and Camerer (2005) found that patients with lesions to the OFC were both risk-neutral and ambiguity-neutral, whereas patients in a comparison group with lesions not involving the OFC were mostly risk-averse and ambiguity-averse. Further, Rubaltelli, Rumiati, and Slovic (2010) found experimental evidence that ambiguity aversion is driven by affect.

In sum and as illustrated in Fig. 1, at the process stage, DPEF posits that easily evaluable decision tasks (such as those involving categorical differences or assessments of liking) evoke valuation by feeling, whereas less evaluable decisions (such as those involving incremental differences or assessments of monetary value) evoke valuation by calculation. At the choice stage, DPEF argues that valuation by feeling is averse to risk, uncertainty, time delays, prices, and inequality, whereas valuation by calculation is neutral toward these factors. This framework thus implies that decision tasks which alter the relative influence of feeling or calculation will lead to systematic and predictable shifts in choice behavior.

4. Tenets of DPEF and resolution of preference reversals

As noted, from a theoretical perspective, the tenets of DPEF are grounded in three stages: (1) evaluability of the decision problem (as determined by response mode, choice-set structure and presentation mode), (2) process (valuation by feeling versus calculation), and (3) choice (i.e., risk-averse vs. risk neutral behavior). The main tenets are:

(i) The level of evaluability (easy vs. difficult) systematically influences the mode of valuation (feeling vs. calculation).
(ii) The mode of valuation influences choices (as outlined in Table 3).

We next consider the applicability of DPEF to choice task reversals, presentation mode reversals, response mode reversals, and response mode-presentation mode reversals. Table 4 provides a summary of these preference reversals explained by DPEF along with the predictions of DPEF at each of the three stages (evaluability, process, and choice).[4]

4.1. DPEF applied to choice task reversals

Choice task reversals account for the majority of well-studied inconsistent preferences, including the Allais paradoxes, the Ellsberg paradox, hyperbolic discounting, and the zero price effect (CS1 through CS-10). We note that the choice task problems involve a joint presentation mode of two alternatives in two choice-sets (A or B *and* C or D). With regard to five well-documented choice anomalies, DPEF provides a mechanism for *systematically* predicting *when* affect or calculation will dominate given the choice-set structure. In the following sections, we describe choice task reversals and propose the DPEF resolution.

4.1.1. The Allais paradoxes

The most noted violations of expected utility theory (EUT), the normative economic model for decisions under risk, are the Allais paradoxes (Allais, 1953). Choice-sets 1 and 2 (Table 1 and below), a variant of the Allais common ratio effect (Allais, 1953; Kahneman & Tversky, 1979), involve a choice task where the individual chooses between A and B in CS-1 and between C and D in CS-2.

CS-1:
A: Receive $3000 with certainty.
B: Receive $4000 with probability 0.80 and $0 with probability 0.20.

[4] The presentation mode (choice set structure) column in Table 4 displays the choice set structure (categorical vs. incremental differences) if the task involved joint presentation, and otherwise notes that the task involved separate presentation since choice-set structure is only transparent in joint presentation.

Table 4
Decision anomalies explained by DPEF.

Preference reversals	Decision anomaly	Response mode	Presentation mode (choice-set structure)	Evaluability stage	Process stage/ valuation mode	Choice stage/ valuation property
Choice task reversals						
	Allais common ratio					
Risk	CS-1	Choice task	Joint (Categorical)	Easy	Feeling	Risk-averse
	CS-2	Choice task	Joint (Incremental)	Difficult	Calculation	Risk-neutral
	Allais common consequence					
Risk	CS-3	Choice task	Joint (Categorical)	Easy	Feeling	Risk-averse
	CS-4	Choice task	Joint (Incremental)	Difficult	Calculation	Risk-neutral
	Present bias					
Time	CS-5	Choice task	Joint (Categorical)	Easy	Feeling	Impatient
	CS-6	Choice task	Joint (Incremental)	Difficult	Calculation	Patient
	Ellsberg paradox					
Uncertainty	CS-7	Choice task	Joint (Categorical)	Easy	Feeling	Ambiguity-averse
	CS-8	Choice task	Joint (Categorical)	Easy	Feeling	Ambiguity-averse
	Zero price effect					
Product assortment	CS-9	Choice task	Joint (Categorical)	Easy	Feeling	Loss-averse
	CS-10	Choice task	Joint (Incremental)	Difficult	Calculation	Loss-neutral
Presentation mode reversals						
	Comparative ignorance effect					
Uncertainty	CS-11	Monetary valuation	Joint (Categorical)	Easy	Feeling	Ambiguity-averse
	CS-11	Monetary valuation	Separate	Difficult	Calculation	Ambiguity-neutral
Response mode reversals						
	Attractiveness rating-monetary valuation preference reversal					
Risk	CS-12	Attractiveness rating	Separate	Easy	Feeling	Risk-averse
	CS-12	Monetary valuation	Separate	Difficult	Calculation	Risk-neutral
Response mode–presentation mode reversals						
	Choice task-monetary valuation preference reversal					
Risk	CS-13	Choice task	Joint (Categorical)	Easy	Feeling	Risk-averse
	CS-13	Monetary valuation	Separate	Difficult	Calculation	Risk-neutral
	Choice task-attractiveness rating preference reversal					
Social preference	CS-14	Attractiveness rating	Separate	Easy	Feeling	Inequality-averse
	CS-14	Choice task	Joint (Incremental)	Difficult	Calculation	Inequality-neutral

CS-2:
C: Receive $3000 with probability 0.25 and $0 with probability 0.75.
D: Receive $4000 with probability 0.20 and $0 with probability 0.80.

Expected utility theory, based on a key axiom of independence, states that preferences between two choice alternatives should be independent of the features which they have in common; if a decision maker prefers A to B, then she also prefers A to B when they are combined in the same way with a common third alternative. Thus, EUT predicts that a decision maker, choosing between A and B (CS-1) and between C and D (CS-2), will select *either* A and C *or* B and D. Research has documented, however, that people often reveal inconsistent preferences by choosing A and D which violates the independence axiom. The AD choice pattern is inconsistent with EUT because lotteries C and D can be obtained by combining lotteries A and B, respectively, with the same outcome (a 75% chance of winning $0).

Under DPEF, CS-1 involves a categorical difference (certainty vs. risk), resulting in easy evaluation and valuation by feeling is predicted to dominate at the process stage. At the choice stage, valuation by feeling favors the safer option (A), due to risk aversion (see Fig. 1 and Table 3). For CS-2, which involves an incremental difference (winning probabilities of .20 vs. .25), DPEF predicts valuation by calculation will dominate at the process stage because the evaluation is more difficult, and calculation favors the risk-neutral option D. Thus, DPEF offers an explanation for the Allais common ratio effect.

The Allais common consequence effect (Allais, 1953; Kahneman & Tversky, 1979) is illustrated in CS-3 and CS-4; alternatives A and B can be transformed into C and D by eliminating a 66% chance of winning $2400 (a common consequence) from both alternatives. Here, individuals choose between A and B and between C and D:

CS-3:
A: Receive $2400 with certainty.
B: Receive $2400 with probability 0.66; $2500 with probability 0.33; $0 with probability 0.01.
CS-4:
C: Receive $2400 with probability 0.34 and $0 with probability 0.66.
D: Receive $2500 with probability 0.33 and $0 with probability 0.67.

EUT predicts that a person will choose *either* A and C *or* B and D, depending on level of risk aversion. Here again however, a typical response pattern is choosing options A and D which violates expected utility theory.

As with the common ratio effect, the choice between A and B involves a categorical difference (certainty vs. risk). Hence, at the process stage, valuation by feeling is predicted to be dominant, and at the choice stage, valuation by feeling favors the safer option (A), due to risk aversion. In contrast, alternatives C and D involve an incremental difference (winning probabilities of .33 vs. .34). Thus, at the process stage, valuation by calculation is predicted to be dominant, and at the choice stage, calculation favors the expected value-maximizing alternative (D). DPEF thus provides an explanation for the Allais common consequence paradox.

4.1.2. Present bias

Similar to the Allais paradoxes, present bias involves choice-sets with a categorical difference (now vs. later) and an incremental difference (e.g., five vs. six years). In CS-5 and CS-6, a decision maker chooses between A and B and between C and D:

CS-5:
A: Receive $20 now.
B: Receive $30 in one year from now.
CS-6:
C: Receive $20 in five years from now.
D: Receive $30 in six years from now.

Discounted utility theory (DUT), the classical theory for choices over time, assumes people discount the future at a constant rate over time. Thus, individuals should select *either* A and C *or* B and D. However, many individuals select A and D, a robust observation referred to as ‘present bias’ or hyperbolic discounting across a variety of studies (Frederick et al., 2002; Laibson, 1997).

In considering the DPEF explanation for present bias, note that at the process stage in CS-5, valuation by feeling is predicted to dominate because evaluation is easier for categorical differences, and at the choice stage, valuation by feeling favors the immediate option (A) due to impatience (see Table 3). However in CS-6, valuation by calculation is predicted to dominate at the process stage because evaluation is more difficult for incremental differences (five vs. six years), and at the choice stage valuation by calculation favors the longer delayed option (D), due to patience. Thus, DPEF provides an explanation for present biased behavior.

Present bias is perhaps the anomaly which can be most intuitively attributed to the interaction between valuation by feeling and calculation. Models of present bias have been proposed in which choice is the outcome of an intrapersonal game between competing dual selves (Fudenberg & Levine, 2006). Evidence for different systems involved in present bias has also been tested empirically. McClure, Laibson, Loewenstein, and Cohen (2004) document separate neural systems are involved in processing immediate versus delayed rewards, reporting “parts of the limbic system…are preferentially activated by decisions involving immediately available rewards” (p. 503). It is well known that the limbic system plays a critical role in emotional processing (e.g., Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2004). McClure et al. (2004) also observe “greater relative fronto-parietal activity when subjects choose longer term options” (p. 503).

4.1.3. The Ellsberg paradox

The paradox of Ellsberg (1961), illustrated in CS-7 and CS-8, applies to decisions under uncertainty (or ambiguity) where probabilities may be unknown. A decision maker draws from one of two bags of poker chips; each bag contains 100 chips. Bag A contains 50 red chips and 50 black chips; Bag B contains red and black chips in an unspecified proportion. In CS-7 and CS-8, the decision maker is given the choice between A and B, and between C and D:

CS-7:
A: Win $100 if a red chip is drawn from Bag A.
B: Win $100 if a red chip is drawn from Bag B.
CS-8:
C: Win $100 if a black chip is drawn from Bag A.
D: Win $100 if a black chip is drawn from Bag B.

Subjective expected utility theory (SEU), the normative model for choice under ambiguity, predicts that a decision maker who has a strict preference for A will also choose D, in order to have consistent probabilistic beliefs about the number of red chips in Bag B. In Ellsberg’s paradox, however, most people choose bets A and C which have a known 50–50 probability.

The Ellsberg paradox is notably different from the other anomalies in that it involves a categorical difference (known risk vs. uncertainty) in both choice-sets. As such, DPEF predicts valuation by feeling to dominate in both, resulting in choices of A and C. Because feeling is predicted to be ambiguity-averse (see Table 3), DPEF predicts the Ellsberg paradox, a preference for Bag A (the known risk) in both choice-sets.

4.1.4. The zero price effect

Shampanier et al. (2007) identify the “zero price effect” anomaly in the domain of consumer choice when one choice-set involves a “free option” and the other choice-set has alternatives with non-zero cost. To illustrate, suppose a decision maker is faced with CS-9 and CS-10, choosing between alternatives A and B and between C and D:

CS-9:
A: Receive a $10 Amazon.com gift card for free.
B: Receive a $20 gift card for $7.
CS-10:
C: Receive a $10 gift card for $1.
D: Receive a $20 gift card for $8.

Standard consumer theory in economics predicts that demand will adjust gradually to small changes in price. Thus, if the vast majority of consumers prefer D over C, we should not observe the vast majority of consumers to reverse their preference when the price of each option is decreased by $1. However, using real Amazon gift cards, large shifts in consumer demand were observed by Shampanier et al. (2007). In particular, they found that most respondents selected alternatives A and D, revealing a disproportionate preference for free items.

In the context of DPEF, the choice between A and B involves a categorical difference (free vs. cost), whereas the choice between C and D involves an incremental difference. Thus DPEF predicts valuation by feeling to dominate in the choice between A and B, and predicts valuation by calculation to dominate in the choice between C and D. Because valuation by feeling is predicted to be loss-averse (Table 3), alternative A (the free option), is predicted by DPEF to be chosen over B. In the choice between C and D, however, DPEF predicts valuation by calculation to be loss-neutral, and D, with the larger net value ($12 surplus) is selected. Thus, DPEF provides an explanation for the zero price effect.

4.2. DPEF applied to presentation mode reversals and response mode reversals

4.2.1. The comparative ignorance effect

Reversals across presentation modes have been observed for decisions under ambiguity in a monetary value task in which alternatives were presented both jointly and separately. In a prominent example referred to as the "comparative ignorance" effect (Fox & Tversky, 1995), individuals were found to be ambiguity-averse when pricing alternatives in joint evaluation, but were found to be ambiguity-neutral when pricing alternatives in isolation. Reconsider CS-11 in which the chance of drawing a red chip from Bag A is known and the chance of drawing a red chip from Bag B is unknown. When A and B are presented jointly, most monetary valuations assign a higher price to the ambiguity-averse option (Bag A). However, when A and B are presented and evaluated in isolation, Fox and Tversky (1995) observed that most people provide very similar prices for A and B, thereby exhibiting ambiguity neutrality.

According to DPEF, when the two bets are valued in isolation (i.e., separate presentation mode), there is no categorical difference present, and the separate monetary valuation tasks cue valuation by calculation, which is predicted to be ambiguity-neutral (as in Table 3). Under the joint presentation mode, the categorical difference (risk vs. ambiguity) is transparent and evaluation is easier. Thus valuation by feeling is more influential in the joint presentation than in the separate presentation, producing a shift in preference toward the ambiguity-averse option (Bag A) when alternatives are evaluated jointly. DPEF thus predicts inconsistent preferences for a monetary valuation task that contrasts joint versus separate presentations of alternatives.

4.2.2. Attractiveness rating-monetary valuation reversal

Slovic et al. (2002) have illustrated a response mode reversal where expressed preferences differ across two response modes, an attractiveness rating task and a monetary value task in which the alternatives (Table 1, CS-12) in each task were evaluated in isolation (separate presentation mode). In other words, for each alternative, A and B, individuals provided an attractiveness rating and a monetary valuation, in isolation. The alternatives involved a high probability-low payoff bet (commonly referred to as a P-bet), and a low probability-higher payoff bet (referred to as a $-bet) as shown below:

A: P-bet: 29/36 chance to win $2.
B: $-bet: 7/36 chance to win $9.

Slovic et al. report that the P-bet (A) typically had a higher attractiveness rating than the $-bet (B), but the $-bet was typically priced higher in the monetary value task than the P-bet.

The attractiveness rating-monetary valuation reversal observed by Slovic et al. is naturally predicted by DPEF. An attractiveness rating (an assessment of liking) is easier to evaluate than a precise monetary indifference point. Thus, feeling is predicted to dominate when alternatives are evaluated in isolation using the attractiveness rating scale, and the P-bet (A) is rated higher than the $-bet (B) due to risk aversion. In contrast, calculation is predicted to dominate when alternatives are assigned a monetary value in isolation, and the $-bet (B) is priced higher than the P-bet (A) due to risk-neutrality (as the $-bet has a higher expected value than the P-bet). Thus, DPEF provides a parsimonious account of attractiveness rating-monetary valuation reversals.

4.3. DPEF applied to response mode–presentation mode reversals

The response mode–presentation mode reversals involve decision tasks that vary both the response mode and presentation mode.

4.3.1. Choice task-monetary value reversal

In the original work on preference reversals involving a choice task and a monetary valuation task (Lichtenstein & Slovic, 1971), individuals first chose between a P-bet and a $-bet with a slightly higher expected value, and then priced each bet in isolation. Participants frequently chose the P-bet in the choice task, but priced the $-bet higher in the monetary valuation task, resulting in a preference reversal. An example from Tversky et al. (1990) is CS-13 (Table 1), in which a decision maker is asked to choose between A and B (shown jointly), and subsequently is asked to give a monetary value for A and B separately:

CS-13:
A: P-bet: Win $100 with probability 0.89 and $0 with probability 0.11.
B: $-bet: Win $1000 with probability 0.11 and $0 with probability 0.89.

Normative economic theories predict preferences to be 'procedure invariant', implying that the observed preferences should be the same across response modes. However, Tversky et al. (1990) found 84% of participants chose A, but only 47% assigned a higher monetary value to A.

In the choice task, DPEF predicts that evaluation is easy and valuation by feeling is dominant because CS-13 involves a large difference in probabilities (i.e., a categorical difference of low risk (P-bet) versus high risk ($-bet)). Hence, the risk-averse option (A) is selected in the choice stage. In the monetary valuation task each alternative is valued in isolation, and DPEF links the monetary value response mode to valuation by calculation, implying a higher price for the risk-neutral alternative (B). Thus, DPEF provides an explanation for this choice task-monetary value preference reversal.

4.3.2. Social preference reversal

Another example of a response mode–presentation mode reversal was observed by Bazerman et al. (1992). They found a social preference reversal involving two monetary allocations between one's self and a stranger. Participants were presented with a choice task (Table 1, CS-14) with A and B presented jointly followed by an attractiveness rating task in which participants separately rated A and B.

CS-14:
A: Receive $500 for self; $500 for other.
B: Receive $600 for self; $800 for other.

Bazerman et al. (p. 220) report, "Modal subjects in our experiments rated the outcome of $500 for self/$500 for other as more desirable than the outcome $600 for self/$800 for other when both were evaluated independently, but they chose the latter outcome over the former when presented with the two options simultaneously."

Under DPEF, when the response mode involves rating the attractiveness of each option, the decision maker relies on valuation by feeling, and because valuation by feeling is predicted to be inequality-averse, feeling assigns a higher value to the equitable outcome in separate evaluation (A). However, when choosing between the two alternatives in joint evaluation, the difference in payoffs is incremental and calculation assigns a higher value to receiving $600 (B) instead of $500 (A). Thus, DPEF provides an explanation for this reversal.

4.4. Summary

DPEF is unique in that it offers a three stage process for the explanation for preference reversals, and the predictions of DPEF apply across different decision domains and decision tasks. We have argued that DPEF explains the Allais common consequence and common ratio paradoxes, as well as present bias, and the zero price effect as arising from the same underlying mechanism. In particular, these anomalies share a choice task response mode with an underlying choice-set structure: CS-1, 3, 5, and 9 (Table 1) involve categorical differences (risk vs. no risk, now vs. later, cost vs. free), whereas CS-2, 4, 6, and 10 involve incremental differences (a small change in the degree of risk, cost or in the length of time delays). Because the Ellsberg paradox (CS-7 and CS-8) involves categorical differences in both choice tasks, feeling is predicted to be dominant in both tasks, generating ambiguity aversion. Thus, DPEF explains these choice task paradoxes by linking the choice-set structure to the valuation process and the valuation process to behavior. Further, DPEF predicts presentation mode reversals such as the comparative ignorance effect, response mode reversals between monetary value and attractiveness rating tasks, and response mode–presentation mode reversals observed by Lichtenstein and Slovic (1971), and by Bazerman et al. (1992). In these cases, the response mode (choice task vs. attractiveness rating vs. monetary valuation), choice-set structure (categorical vs. incremental differences), and presentation mode (joint vs. separate) systematically affect the ease of evaluation, thereby evoking calculation or feeling-based processes that produce the choice behaviors noted in Table 3, and thereby account for the observed reversals.

5. Applying DPEF to investigate a response mode–presentation mode reversal

In this section we consider DPEF's prediction related to a novel response mode–presentation mode reversal which varies response mode (choice task vs. attractiveness rating task), choice-set structure, and presentation mode. In particular, we consider reversals involving a choice task under joint presentation, an attractiveness rating task under separate presentation, and an additional attractiveness rating task under joint presentation. Next we revisit CS-1 and CS-2 (Table 1) to illustrate DPEF's predictions.

As previously discussed regarding the Allais common ratio problem, DPEF argues that for choice-sets with a categorical difference, evaluation is easy, valuation is by feeling, and risk aversion results in the less risky choice (A in CS-1); further for choice-sets with an incremental difference, evaluation is more difficult, valuation is by calculation, and a risk-neutral option (D) is preferred. Now consider an attractiveness rating task (separate presentation mode) in which alternatives A, B, C, and D are shown in isolation and individuals rate each alternative separately. DPEF predicts that these attractiveness ratings are easily evaluable with valuation by feeling dominating, and that A will be rated higher than B in CS-1, and C will be rated higher than D in CS-2 if feeling is risk-averse. Thus, DPEF predicts:

P1. *When considering a choice task with jointly presented alternatives and an attractiveness rating task with separately presented alternatives, a significantly greater percentage of choice task-attractiveness rating reversals will be observed for incrementally different choice-sets than for categorically different choice-sets.*

When considering preferences assessed using the attractiveness rating task via joint and separate presentation, DPEF makes a unique prediction related to valuation by feeling and calculation. In particular, DPEF unambiguously predicts valuation by feeling to dominate in a jointly presented attractiveness rating task when alternatives differ categorically (because both the choice-set structure and response mode favor valuation by feeling). However, in a joint attractiveness rating task where alternatives differ incrementally, the response mode favors valuation by feeling, but the choice-set structure favors valuation by calculation. In such cases, DPEF predicts that individuals are likely to engage in more thinking when exposed to incrementally (vs. categorically) different choice-sets, holding all other features of the decision task fixed. Thus, DPEF posits:

P2. *When considering a choice task with jointly presented alternatives and an attractiveness rating task with jointly presented alternatives, we expect a significantly greater percentage of choice task-attractiveness rating reversals for incrementally (vs. categorically) different choice-sets.*

P3. *When considering a choice task with jointly presented alternatives, an attractiveness rating task with jointly presented alternatives, and an attractiveness rating task with separately presented alternatives, we expect a lower percentage of choice task-attractiveness rating reversals for incrementally different alternatives in joint (vs. separate) presentation mode.*

6. Experimental studies and findings

In three experimental studies, we test for hypothesized choice task-attractiveness rating preference reversals. Such a reversal occurs if the same decision maker chooses one option in a choice task (e.g., D is *chosen* over C in CS-2), but reveals a preference for the other alternative in the attractiveness rating task (e.g., C is *rated* higher than D in CS-2). In Study 1 and Study 2, we examine P1 for decisions under risk and over time, respectively. In Study 3, we focus on tasks involving decisions under risk and examine P2 and P3. Table 5 presents the hypothesized relationships and experimental results.

6.1. Study 1 and Study 2

6.1.1. Method

Study 1 focuses on choice task-attractiveness rating reversals under risk. Undergraduate students ($n = 401$) participated in an on-line survey for which they were entered in a raffle to win a $25 gift certificate to the university store. Students were exposed to CS-1 and then to CS-2 (Table 1). Participants selected either A or B (when exposed to CS-1) and selected either C or D (when exposed to CS-2). After responding to filler questions, participants completed the attractiveness rating task in which they were randomly shown each of the four alternatives (A, B, C, and D) in isolation, and asked to indicate their reaction to the alternative by clicking on one of five emoticons ranging from very sad to very happy.

Study 2 focuses on choice task-attractiveness rating reversals over time; 257 undergraduates completed an on-line survey. Students were exposed to CS-5 and then to CS-6 (Table 1). To isolate response due to certain (vs. immediate) payoffs, the questions were prefaced by the statement: "Toss a fair coin. If heads..." Participants selected either A or B (when exposed to CS-5) and selected either C or D (when exposed to CS-6). Next, participants completed filler questions and then responded to the attractiveness rating task in which they were randomly shown each of the four alternatives (A, B, C, and D) in isolation, and asked to indicate their reaction to the alternative by clicking on one of five (very sad to very happy) emoticons as in Study 1.

We identified choice-rating preference reversals for respondents who chose the option predicted by DPEF in the choice task (A in CS-1; D in CS-2), and observed whether their choice was consistent with their attractiveness ratings. Evidence of a consistent pattern of responses is, for example, a choice of A in the choice task and an attractiveness rating of A higher than B in the rating task. In contrast, a preference reversal was identified when the individual's choice from the choice task was not consistent with the relative ranking from the attractiveness rating task (i.e., the person chose A in the choice task, but rated B higher than A in the attractiveness rating task).

Table 5
Choice task-attractiveness rating response–presentation mode reversals.

Study	Decision anomaly	Choice task	Attractiveness rating task	Predicted valuation process		Choice-attractiveness rating reversals
		Choice-set (Joint presentation)	Presentation mode	Choice task	Attractiveness rating task	
Study 1	Common ratio effect	Categorical (CS-1)	Separate	Feeling	Feeling	<1% (1 of 223)[a]
		Incremental (CS-2)		Calculation	Feeling	69% (59 of 85)[b]
Study 2	Present bias	Categorical (CS-7)	Separate	Feeling	Feeling	1% (2 of 140)
		Incremental (CS-8)		Calculation	Feeling	40% (17 of 42)
Study 3	Common ratio effect	Categorical (CS-1)	Separate	Feeling	Feeling	1% (1 of 76)
		Incremental (CS-2)		Calculation	Feeling	64% (14 of 22)
	Common ratio effect	Categorical (CS-1)	Joint	Feeling	Feeling	4% (3 of 84)
		Incremental (CS-2)		Calculation	Feeling/calculation	36% (10 of 28)

[a] The choice-attractiveness rating reversal for categorically different choice alternatives is calculated as follows: the denominator is the number of participants in the sample (e.g., 223) who did not have a tie in their attractiveness ratings for the alternatives (e.g., A and B) in the choice-set (e.g., CS-1) and who chose the predicted option (i.e., A in CS-1); the numerator is the number of these participants (1) who exhibited a choice-rating reversal.

[b] The choice-attractiveness rating reversal for incrementally different choice alternatives is calculated as follows: the denominator is the number of participants in the sample (e.g., 85) who did not have a tie in their attractiveness ratings for the alternatives (e.g., C and D) in the choice-set (e.g., CS-2) and who chose the predicted option (i.e., D in CS-2); the numerator is the number of these participants (59) who exhibited a choice-rating reversal.

6.1.2. Results

In the choice task in Study 1, 46% of participants exhibited the common ratio pattern (choosing A in CS-1 and D in CS-2). In Study 2, 54% of participants exhibited present bias (choosing A in CS-5 and D in CS-6). Consistent with P1, we find a significantly greater percentage of choice task-attractiveness rating reversals for the incrementally (vs. categorically) different choice-sets. As shown in Table 5, the percentage of choice task-attractiveness rating task reversals was less than 1% for the categorically different alternatives (CS-1) and 69% for the incrementally different alternatives (CS-2) (one-tailed *Z* difference in proportions test, $p < .001$). Similarly, in Study 2, the percentage of choice task-rating task reversals was approximately 1% for the categorically different alternatives (CS-5) and 40% for the incrementally different alternatives (CS-6) (one-tailed *Z* difference in proportions test, $p < .001$). These observations are consistent with P1, that categorically different alternatives produce no choice-rating reversals because both tasks elicit the same process (feeling), whereas incrementally different alternatives produce a fairly high frequency of choice-rating reversals because the choice task elicits valuation by calculation and the rating task elicits valuation by feeling.

6.2. Study 3

6.2.1. Method

Amazon Mechanical Turk U.S. workers ($n = 191$, paid $0.50) completed an online survey. Participants were randomly exposed to CS-1 or CS-2 (Table 1), and then to CS-2 or CS-1, respectively, and then randomly assigned to an attractiveness rating task (either separate or joint presentation mode). The order of alternatives within each task was randomized. Response time was recorded for each choice-set. In the attractiveness rating task, under the separate presentation mode, participants viewed and rated A, B, C, and D, each on a separate screen (using a 0–100 sliding scale with endpoints of very sad and very happy emoticons). In the joint response mode, participants saw the two alternatives in the choice-set (e.g., A and B) on the same screen and rated A and B using the sliding attractiveness rating scale for each alternative. Inconsistent preferences were identified in the same way as in the first two studies.

6.2.2. Results

Consistent with our expectations, the choice set with the categorically different alternatives (CS-1) involved significantly less time than the incrementally different choice-set (CS-2). Specifically, the median time spent on CS-1 (4.3 s) was significantly less than that spent on CS-2 (6.2 s; Mann–Whitney *U* test, $p < .001$). When considering only participants who chose the alternatives consistent with the DPEF predictions for feeling and calculation, the median response time was 4.3 s for CS-1, and was 7.4 s for CS-2 (Mann–Whitney *U* test, $p < .001$). These findings are consistent with the proposition that categorical choice sets are easier to evaluate (take less time) than incremental choice sets, and are also consistent with the proposition that categorical choice sets activate faster evaluation processes than incremental choice sets.

Consistent with P1 and similar to Study 1, the percentage of choice task-attractiveness task reversals *in the separate presentation mode* was less than 1% for the categorically different choice-set and 64% for the incrementally different choice-set (one-tailed *Z* difference in proportions test, $p < .001$). Also consistent with P2, the percentage of choice task-attractiveness task reversals *in joint presentation* was 4% for the categorically different choice-set and 36% for the incrementally different choice-set (one-tailed Z difference in proportions test, $p < .001$). Further, in support of P3, the percentage of choice-rating reversals under the joint presentation mode for incrementally different alternatives (36%) was less than for categorically different alternatives (64%) (one-tailed *Z* difference in proportions test, $p < .03$). These observations are summarized in Table 5.

Study 3 affirms that both a "response mode effect" (contrasting choice and attractiveness rating tasks under joint evaluation) and a "presentation-mode effect" (contrasting joint and separate presentation modes in an attractiveness rating task) drive behavior under risk.

7. Discussion and future research

DPEF, as proposed here, provides an approach to *systematically* predict conditions under which a decision problem is easy or difficult to assess and whether the decision process is dominated by feeling or calculation and linked to choice behavior. In essence, our research offers a framework that provides a link between evaluability theory and dual process theory.

We applied DPEF to explain decision anomalies, in a similar spirit to how dual process models have been used to explain biases in intuitive judgments (Barbey & Sloman, 2007; Kahneman & Frederick, 2005). Models of the rational economic agent implicitly assume that the decision maker has a single mental processing system which controls all decisions. Work in the psychology of judgment and decision making, however, suggests that decisions reflect the interaction of multiple systems. Although a dual system perspective is a simplification of the complexity of actual decisions, we argue it provides significant insight into decisions, particularly when contrasted with the single-system agent of neoclassical economics.

Our work demonstrates that DPEF provides a more unified framework that resolves a variety of classic paradoxes in decision theory, and further, predicts new patterns of preference reversals. Notably, DPEF explains the Allais paradoxes, present bias, the Ellsberg paradox, and the zero price effect. Further, DPEF provides explanations of reversals that are a function of changes in response mode and presentation mode. DPEF has implicitly assumed negative or 'aversive' feelings, producing risk aversion, ambiguity aversion, loss aversion, and impatience. We note, however, that other process explanations are possible for the preference reversals discussed in Section 4. In particular, for the common ratio effect example, CS-2, it could be that $4000 "feels" better than $3000, and that feelings are much less fine-tuned for the associated small differences in probabilities (0.20 vs. 0.25). If this were the case, we would expect response times to be similar for CS-1 and CS-2 to the extent that they both evoke a valuation by feeling. However, as we observed (see Section 6.2) and as reported in Rubinstein (2007), response times are significantly longer for CS-2 than for CS-1, consistent with the hypothesis of greater deliberation or cognitive engagement in CS-2.

DPEF is a conceptual framework, not a formal analytical model. However, DPEF links objective task characteristics (choice task, response mode, and presentation mode) to internal psychological processes (valuation by feeling and calculation), which in turn link to behaviors (e.g., toward risk, ambiguity, and time). As such, DPET produces a number of novel and testable propositions, such as those considered in Section 6. One important issue in interpreting and applying DPEF relates to the ease of evaluability of choice-set alternatives in decision tasks and their identification as being categorically different versus incrementally different alternatives. In each of the choice task reversals that we assessed, the categorical distinctions were of an objective nature (e.g., certainty vs. risk, risk vs. ambiguity, now vs. later, free vs. cost), and relatively unambiguous. We discussed incremental differences in probabilities (e.g., 20 vs. .25; .33 vs. .34), time delays (five vs. six years), and prices ($1 vs. $8), and suggested that these differences may be close enough to accord with intuition that these values are in the 'same category,' and thus do not constitute a categorical difference. However, in practice, differences in risk or in time delays may not be clearly delineated; they may depend on a subjective encoding process by the decision maker. We considered categorical distinctions of high risk versus low risk, and the literature distinguishes between P-bets and $-bets suggesting there is a basis for such a categorization. Future work, however, is needed to further clarify how people categorize differences in risks or time delays. Further, some ambiguity in interpretation is evident in the attractiveness task from Bazerman et al. (1992); DPEF unambiguously predicts the decision maker to rate A higher than B when each alternative is rated in isolation. In the choice task, the DPEF prediction is that the payoff differences between $500 to self and $600 to other and between $500 to self and $800 to other are incrementally different and valuation by calculation is predicted to be dominant, resulting in a choice of a higher payoff to one's self. However, one might also interpret the alternatives as constituting a categorical difference in which the former alternative is 'fair' and the latter is 'unfair.' Research on the classification of choice alternatives as categorically versus incrementally different provides an interesting avenue for additional investigation.

By adopting a broad dual process approach, DPEF is compatible with other dual process models in psychology such as the distinction between an automatic, affective, and intuitive System 1, and a slow, logical and calculation-based System 2. A limitation of such an approach however is it does not distinguish between the effects of 'intuitive' and 'affective' processes. Future research may seek to differentiate the effects of the various processes commonly included under the umbrella of 'System 1' (Kahneman, 2003).

A further consideration of DPEF relates to whether the process (feeling or calculation) is determined based on ease of evaluability, or whether the subjective ease or difficulty of the task is determined by the process (i.e., tasks are subjectively difficult when relying on calculation). It is possible that the arrow of influence extends in both directions. Extant research provides some guidance and specifically documents that difficult tasks cue more analytical reasoning (Alter et al., 2007; Inbar et al., 2010), providing support for the assumption in DPEF that ease of evaluability (or similarly, task difficulty) moderates feeling versus calculation-based processing. Our work provides further evidence indicating that individuals took less time to assess the more easily evaluable choice-sets characterized by categorical (vs. incremental) differences. Further, this finding is consistent with research documenting that feelings are relatively automatic whereas calculation-based processing is relatively slow (Rubinstein, 2007). Neuro-imagining technology may further help to identify the underlying process and its possible dependence on the decision task. In an fMRI study, for example, Dickhaut et al. (2003) found evidence that different neural systems were involved in the processing of certain versus uncertain rewards. With increased fMRI access and technological advances, further testing of the mechanisms mediating feeling versus calculation-based processing is an exciting opportunity for future research.

8. Contributions and conclusion

DPEF provides an empirically grounded and systematic explanation for an extensive set of decision problems. Notably, by decomposing the decision problem characteristics into response mode, choice-set structure, and presentation mode, DPEF offers a new approach to explaining preference reversals across different decision domains and decision tasks as arising from the same underlying relationship between ease of evaluability and mode of valuation.

Acknowledgments

We thank Nicholas Lurie, Paul Slovic, and an anonymous referee for insightful comments on earlier versions of this paper.

References

Allais, M. (1953). Le comportement de l'homme rationnel devant le risque: Critiques des postulats et axioms de l'ecole Americaine. *Econometrica, 21*, 503–546.
Alter, A., Oppenheimer, D., Epley, N., & Eyre, R. (2007). Overcoming intuition: Metacognitive difficulty activates analytical reasoning. *Journal of Experimental Psychology: General, 136*, 569–576.
Barbey, A. K., & Sloman, S. A. (2007). Base-rate respect: From ecological rationality to dual processes. *Behavioral and Brain Sciences, 30*, 241–297.
Baucells, M., & Heukamp, F. (2012). Probability and time trade-off. *Management Science, 58*, 831–842.
Bazerman, M. H., Loewenstein, G. F., & White, S. B. (1992). Reversals of preference in allocation decisions: Judging an alternative versus choosing among alternatives. *Administrative Science Quarterly*, 220–240.
Bell, D. E. (1982). Regret in decision making under uncertainty. *Operations Research, 5*, 960–981.
Bordalo, P., Gennaioli, N., & Shleifer, A. (2012). Salience theory of choice under risk. *The Quarterly Journal of Economics, 127*, 1243–1285.
Brocas, I., & Carrillo, J. D. (2014). Dual-process theories of decision-making: A selective survey. *Journal of Economic Psychology, 41*, 45–54.
Burks, S. V., Carpenter, J. P., Goette, L., & Rustichini, A. (2009). Cognitive skills affect economic preferences, strategic behavior, and job attachment. *Proceedings of the National Academy of Sciences, USA, 106*, 7745–7750.
Carr, L., Iacoboni, M., Dubeau, M. C., Mazziotta, J. C., & Lenzi, G. L. (2004). Neural mechanisms of empathy in humans: A relay from neural systems for imitation to limbic areas. In J. Cacioppo & G. G. Berntson (Eds.), *Social neuroscience. Key readings* (pp. 143–152). New York: Psychology Press.
Chaiken, S. (1980). Heuristic versus systematic information processing and the use of source versus message cues in persuasion. *Journal of Personality and Social Psychology, 39*, 752–766.
Damasio, A. R. (1994). *Descartes' error: Emotion, reason and the human brain*. Random House.
Depue, R. (1995). Neurobiological factors in personality and depression. *European Journal of Personality, 9*, 238–265.
Dickhaut, J., McCabe, K., Nagode, J. C., Rusticini, A., Smith, K., & Pardo, J. V. (2003). The impact of the certainty context on the process of choice. *Proceedings of the National Academy of Sciences, USA, 100*, 3536–3541.
Ekman, P., Davidson, R., & Friesen, W. (1990). The Duchenne smile: Emotional expression and brain physiology II. *Journal of Personality and Social Psychology, 58*(2), 342–353.
Ellsberg, D. (1961). Risk, ambiguity and the Savage axioms. *The Quarterly Journal of Economics, 75*(4), 643–669.
Fox, C. R., & Tversky, A. (1995). Ambiguity aversion and comparative ignorance. *The Quarterly Journal of Economics, 110*(3), 585–603.
Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives, 19*, 25–42.
Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference. A critical review. *Journal of Economic Literature, 40*, 351–401.
Fudenberg, D., & Levine, D. K. (2006). A dual-self model of impulse control. *American Economic Review, 96*, 1449–1476.
Hsee, C. K. (1996). The evaluability hypothesis: An explanation of preference reversals between joint and separate evaluations of alternatives. *Organizational Behavior and Human Decision Processes, 67*(3), 247–257.
Hsee, C. K., Loewenstein, G. F., Blount, S., & Bazerman, M. H. (1999). Preference reversals between joint and separate evaluations of options: A review and theoretical analysis. *Psychological Bulletin, 125*(5), 576–590.
Hsee, C. K., & Rottenstreich, Y. (2004). Music, pandas, and muggers: On the affective psychology of value. *Journal of Experimental Psychology General, 133*, 23–30.
Hsee, C. K., & Zhang, J. (2010). General evaluability theory. *Perspectives on Psychological Science, 5*, 343–355.
Hsu, M., Bhatt, M., Adolphs, R., Tranel, D., & Camerer, C. F. (2005). Neural systems responding to degrees of uncertainty in human decision-making. *Science, 310*, 1680–1683.
Inbar, Y., Cone, J., & Gilovich, T. (2010). People's intuitions about intuitive insight and intuitive choice. *Journal of Personality and Social Psychology, 99*(2). 232-24.
Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review*, 1449–1475.
Kahneman, D., & Frederick, S. (2005). A model of heuristic judgment. In K. Holyoak & R. Morrison (Eds.), *The Cambridge handbook of thinking and reasoning* (pp. 267–294). New York: Cambridge University Press.
Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*, 263–291.
Laibson, D. (1997). Golden eggs and hyperbolic discounting. *Quarterly Journal of Economics, 112*(2), 443–478.
Lichtenstein, S., & Slovic, P. (1971). Reversals of preference between bids and choices in gambling situations. *Journal of Experimental Psychology, 89*, 46–55.
Loewenstein, G. F., Hsee, C. K., Weber, E. U., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin, 127*, 267–286.
Loewenstein, G., & Prelec, D. (1992). Anomalies in intertemporal choice. Evidence and interpretation. *Quarterly Journal of Economics, 107*, 573–597.
Loomes, G., & Sugden, R. (1982). Regret theory: An alternative theory of rational choice under uncertainty. *The Economic Journal, 92*, 805–824.
McClure, S. M., Laibson, D. I., Loewenstein, G., & Cohen, J. D. (2004). Separate neural systems value immediate and delayed monetary rewards. *Science, 306* (5695), 503–507.
Mukherjee, K. (2010). A dual system model of preferences under risk. *Psychological Review, 117*, 243–255.
O'Doherty, J., Kringelbach, M. L., Rolls, E. T., Hornak, J., & Andrews, C. (2001). Abstract reward and punishment representations in the human orbitofrontal cortex. *Nature Neuroscience, 4*, 95–102.
Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge University Press.

Rottenstreich, Y., & Hsee, C. K. (2001). Money, kisses, and electric shocks: On the affective psychology of risk. *Psychological Science, 12*(3), 185–190.
Rubaltelli, E., Rumiati, R., & Slovic, P. (2010). Do ambiguity avoidance and the comparative ignorance hypothesis depend on people's affective reactions? *Journal of Risk and Uncertainty, 40*, 243–254.
Rubinstein, A. (2007). Instinctive and cognitive reasoning: A study of response times. *The Economic Journal, 117*, 1243–1259.
Schwarz, N., & Clore, G. (1983). Mood, misattribution, and judgments of well-being – Informative and directive functions of affective states. *Journal of Personality and Social Psychology, 45*, 513–523.
Shah, A. K., & Oppenheimer, D. M. (2008). Heuristics made easy: An effort-reduction framework. *Psychological Bulletin, 134*, 207–222.
Shampanier, K., Mazar, N., & Ariely, D. (2007). Zero as a special price. The true value of free products. *Marketing Science, 26*, 742–757.
Sloman, S. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119*, 3–22.
Slovic, P., Finucane, M., Peters, E., & MacGregor, D. G. (2002). The affect heuristic. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuirstics and biases. The psychology of intuitive judgment* (pp. 397–420). Cambridge: Cambridge University Press.
Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences, 23*, 645–726.
Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty, 5*, 297–323.
Tversky, A., Sattath, S., & Slovic, P. (1988). Contingent weighting in judgment and choice. *Psychological Review, 95*(3), 371–384.
Tversky, A., Slovic, P., & Kahneman, D. (1990). The causes of preference reversal. *American Economic Review, 80*(1), 204–217.
Von Neumann, J., & Morgenstern, O. (1947). *Theory of games and economic behavior*. Princeton University Press.
Woelbert, E., & Goebel, R. (2013). Temptation in economic decision making: Effects of immediate reward and reward-cues. *Neuroscience and Neuroeconomics, 2*, 11–19.