# *Better the Devil You Know than the Devil you Don't*
# An Inductive Theory of Choice

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First Version: January 2007
This Version: November 2007

**Abstract**

We propose and develop a theory of choice free of concepts such as utility function or preference relation. We replace the primitives used in traditional rational choice theories by similarity function— used to compare any alternative to a reference alternative— and a minimum distance choice function. It is shown that this model can explain the appearance of intransitive choices, which are central to any descriptive theory of choice. Since decision-makers have computational constraints, this is all they need to make choices. Two possible biases may affect the outcome of the choice situation, but we argue that rationality is the natural mechanism of defense against these biases. Rationality is then a long-run concept, where experience and learning allows to correct such biases. Different applications are presented, ranging from market behavior, decision under uncertainty, scientific objectivity, marketing and advertisement strategies, among others. Aggregation results are obtained with the use of institutions which are defined and developed, in a clearly microeconomic fashion.

## 1 Introduction

Traditional theories of choice and their applications in economic theory, rely on the existence of a preference relation that is represented numerically by a utility function. Preference is the primitive, and axioms that guarantee the consistency of choice (assumed to be a necessary condition for rationality) allow us to interpret the act of choice as one where the decision-maker acts *as if* she maximizes the utility function. The theory is interpreted as a rough, undoubtedly intuitive, approximation to human behavior, sufficiently powerful to deliver a variety of observable outcomes in everyday's life. In this sense, the economics methodological approach to choice has explicitly been

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more preoccupied about observable outcomes (e.g. revealed preference) than about unobservable mental processes.[1]

However, experimental evidence, common sense and introspection suggest that in general human beings are neither maximizing a utility function nor behaving *as if* the are doing so, questioning the validity of a theory concerned about outcomes that it cannot explain without changing the set of assumptions.[2] In fact, the consistency requirements imposed on the preference relation (i.e. transitivity or acyclicity) or the choice function (i.e. the Weak Axiom of Revealed Preference or Sen's decomposition) have been shown to be violated in a systematic, and thus, predictable way for many years in the psychological literature.[3]. If the consistency axioms are violated in real-life choice situations, there are no empirical grounds to argue that rational choice theory is a descriptively valid theory: in short, real-life decision makers appear not to have a *preference relation*, in the technical sense that is traditionally invoked. As several researchers in other social sciences have shown experimentally, the preference relation appears to be constructed or elucidated simultaneously with the act of choice, and as a result, choice generally generates inconsistencies that violate the axioms of rational choice theory.[4] From an instrumentalist point of view,[5] this would not matter if the predictions of the theory remain the same, and this has been the case in many applications of utility theory. In this paper it will be argued that many interesting and important phenomena— such as the effects of institutions and culture on preferences or the effects of marketing and advertising— can *not* be fully understood, less predicted, unless we have a better descriptive model of the actual processes involved in decision-making. Put differently, the view defended here is that instrumental rationality should be replaced by procedural rationality (Simon, 1986, 1978), whenever the predictions and generality are improved.

This is the starting point of our theory, where we pretend to go one level deeper, and investigate what generates the systematic departures from rational choice theory found in both experimental and real-life situations. The framework proposed does not assume the existence of a preference relation— i.e. a ranking of all the alternatives available for choice— as the primitive. All that an agent needs is a reference alternative, to which all other alternatives will be compared, and a similarity relation used to perform that comparison. By doing this, we argue, we have a considerable reduction in the computational complexity of the decision process and at the same time more realism, scope and depth in our understanding of the decision process and outcome.[6]

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[1] A defense of the outcome approach can be found in Samuelson (1938, 1948), Friedman (1953), Spiegler (2006), Gul and Pesendorfer (2006). Procedural analysis is closer to the bounded rationality approach to economics and the references are numerous. See for example Tversky and Kahneman (1974), Sen (1997) and Rubinstein (1987, 1998). From a methodological point of view, the revealed preference approach is not free of criticism. See for example Sen (1973) and Grne (2004).

[2] Undoubtedly, for every empirical fact we have we can always find an expected utility function (a parametrization) that, when maximized, explains the fact *ex-post*. Nonetheless, calibrating the maximizing utility paradigm is, also undoubtedly, not an example of good scientific practice.

[3] See for example Tversky (1969), Slovic (1995), Amos Tversky and Kahneman (1990), Slovic and Lichtenstein (1983), Hausman (1991), Graham Loomes and Sugden (1991)

[4] See for example Tversky and Simonson (1993), Lutz (1975), Yigang Pan and Pitts (1995), Sanjay Mishra and Stem (1993), Mukesh Bhargava and Srivastava (2000), Dan Ariely and Prelec (2003), Slovic (1995) and the many references therein. See also Bowles (1998), for a literature review on the endogeneity of the preference relation.

[5] See Friedman (1953) or Laville (2000).

[6] Even if the maximizing utility paradigm were predictively successful, a valid scientific question is why and when it is the case. This is a deeper question which, some may argue, lies outside the domain of economics (see Gul and Pesendorfer (2006)).

In this framework rationality entails the conscious, ex-post evaluation of the accomplishment of goals: if a goal was not achieved, some correction must be made, *ex-post*. This is in clear contrast with ex-ante rationality (or *deductive* rationality) implicitly assumed in traditional decision-theoretical models (and virtually all applications of the maximizing-utility framework in economics).[7] On the other hand, *similarity* is the mechanism provided by nature to construct comparisons between actions, commodities, people, beliefs or any other object of choice. In contrast to the conscious act of reasoning, similarity assessments are generally performed unconsciously, and thus, any biases affecting this procedure, will most likely not be corrected. Put differently, similarity assessments are generally not in the domain of rationality providing a source of inconsistencies that can not be corrected in either an ex-ante or an ex-post manner.

With this framework in mind, agents are victims of two kinds of cognitive biases: on the one hand, a reference alternative that has no support from background experience can be used in particular instances of choice. If the change of reference is judged to be successful, in the sense that it accomplishes the goals and motivations of the agent, a rational decision-maker should retain it as a reference. If on the contrary, the choice situation resulted in a failure an *ex-post rational (or inductively rational)* agent should correct the anomalous behavior. This can in principle be done, since goal achievement is subjected to conscious ex-post reasoning.

A second source of biases is related with the subjective weights that affect the similarity assessment: it is possible that a relatively unimportant feature of the object of choice gains an unusual weight (e.g. due to the saliency of a particular feature), and in this way it may also affect the outcome of the act of choice. Since similarity assessments are generally performed unconsciously, the correction by introspection of this bias is less likely to occur.

As an illustration of a standard choice situation, consider a decision-maker (DM) that wants to go to the movies, and has to decide which movie she wants to see. From previous experience, she knows she likes romantic comedies, and say that in particular, she loved *When Harry met Sally*, and therefore she sets this movie as her alternative. She then goes to a theater and selects the movie that appears to be closest to her alternative, and the attributes maybe the actors that star the movie, the director, the origin of the movie (e.g. American, European, Latin American), etc.

An even more illustrative example since it enhances the close relation between preferences and similarity assessments is the Music Genome Project that runs Pandora (www.pandora.com): it starts by asking the user for the name of an artist (i.e. a *reference alternative*), and after that, it selects different artists, according to the similarity of a song with respect to more than 400 attributes. One notable aspect of this example is that most of the attributes are not clearly distinguishable, at least in a consciously manner, by the users themselves, but they are certainly the determinants of preference, *even* when the user does not know that. These examples show in a clear and practical manner the role that similarity plays in the the construction of preferences, and the importance of conscious and unconscious stimuli.

Even though the use of similarity assessments is not new in economics— and certainly not in other social sciences like psychology where it has been studied extensively, both at theoretical and empirical levels— the current approach differs in many aspects from previous ones. Rubinstein (1987), for example, uses similarity to explain the Allais paradox in uncertainty environments.[8] Rubinstein's approach can be viewed as a particular case of this general framework, where the saliency of features (in his case prizes and probabilities of lotteries) is determined endogenously by

[7]Needless to say, the stringent rationality requirements in strategic, game-theoretical, settings are assumed explicitly .

[8]Manzini and Mariotti (2007) suggest that the same approach is proposed by Rubinstein himself to understand intertemporal choice inconsistencies.

context-dependent weighting biases.[9]

A more recent approach is the one proposed in a series of papers by Gilboa and Schmeidler (GS), where decision makers are assumed to maximize a utility function that weighs acts, chosen by the DM, using similarity assessments over problems and outcomes that are recalled from the past.[10] After imposing a set of axioms, they arrive to a representation that appears very similar to an expected utility representation, but where instead of probability assessments, similarity is used to perform the corresponding weighting. By construction, the role of incentives is still central to their theory, and the set of questions that they appear to be answering is somewhat different to ours. Our approach differs from theirs in at least two respects: on the one hand, GS make the standard assumption of existence of a preference relation (utility representation) over the outcomes of the decision. On the other hand, the similarity measure is used to compare *decision problems* or "stories involving decision problems" (Gilboa and Schmeidler, 2001, p.34). Given this, the DM chooses the act that maximizes a utility function over outcomes, weighted by the similarity of the actual problem and problems that the DM stores in her finite memory. Even though this framework is elegant and normatively appealing, we contest its descriptive validity, and it can be readily seen that both approaches are different, and try to ask different questions. In our framework, DM do not know their preferences, and approximate them using an endogenous similarity function. In fact, the DM choose the alternative that appears to be the closest to her reference alternative. In this sense, our approach is closest to Rubinstein's, but undoubtedly GS's framework is related to our own.

This is the subject of this paper. It will be argued that this framework gives some valuable insights in any decision environment, and that it also embeds the traditional rational choice theory. The rest of the paper is organized as follows: in Section 2 the general model is presented and developed. In Section 3 we propose a decision-theoretical microfoundation of institutional economics, where institutions are defined and interpreted in terms of the effects they have on individual decision-making. This allows us to aggregate individual results to the macroeconomic environment in a straightforward manner. Section 4 is devoted to showing the diverse spectrum of applications. Section 5 concludes.

# 2 The Framework

Let $(\mathbb{R}^{k_o} \times \mathbb{R}^{k_s}, d)$ be the k-th dimensional Euclidean space ($k = k_o + k_s$), endowed with a product Euclidean metric $d$. For any subset $\mathcal{X} \subset \mathbb{R}^k$, interpreted as the *set of feasible alternatives*, an *object of choice* is a vector $x = (x^o, x^s) \in \mathcal{X}$ of $k$ attributes that completely characterize its existence. Each attribute can be objective or subjective. An *objective* attribute is one that is invariant with the decision-maker, while a *subjective* attribute may vary with the individual. The objective and subjective attributes are denoted by $x^o \in \mathbb{R}^{k_o}$, and $x^s \in \mathbb{R}^{k_s}$, respectively.[11] Examples of objective, physical attributes are the color, shape, size, price or quality of an object, while subjective, psychological attributes are the ethical content, trendiness and emotional value.

[9] A proposition similar to the one sketched in the applications can be used to understand why this is true. Whenever the prize of a lottery is very high, compared to the riskless option, the necessary weighting bias to induce an idealization bias is very low. Put differently, the higher the prize, the lower the subjective weight on that feature. Empirical evidence of this "prize effect" can be found in Shapira and Venezia (1992), Rogers (1998) or M. Cook and Leigh (1998).

[10] All references are found in Gilboa and Schmeidler (2001).

[11] Hereafter I will use the terms "goods", "consumption set" and "consumer" to generically denote the "objects of choice", "reference set" and "decision-maker", but the reader should keep in mind that the framework is not constrained to consumer theory only, as will be shown in the applications.

Each decision maker (DM) is endowed with a *generalized similarity relation* $\mathcal{S}$ defined as follows:

$$\begin{aligned} \mathcal{S} \quad : \quad & 2^{\mathcal{X}_t} \times 2^{\mathbb{N}} \times \mathcal{X}_t \times \mathcal{X}_t \longrightarrow \mathbb{R}_+ \\ & (A, M, x, y) \longrightarrow \mathcal{S}(A, M, x, y) \geq 0 \end{aligned} \tag{1}$$

The generalized similarity function allows for the comparison of any two alternatives in the set of feasible alternatives at time $t$, $\mathcal{X}_t$. This comparison is, in general, *frame dependent*. For any set of alternatives $A \in 2^{\mathcal{X}_t}/\emptyset$, and any subset of individuals $M \subset \mathbb{N}$, a *generalized frame* $f = (A, M)$ describes the social and physical context in which the choice situation takes place.[12] Denote by $\mathcal{F}_t = 2^{\mathcal{X}_t} \times 2^{\mathbb{N}}$ the set of all possible frames at time $t$. A generalized similarity relation need not satisfy the axioms of a distance function. For instance, the symmetry and triangle inequality axioms need not be satisfied, but the minimality axiom might sometimes be reasonable to assume.[13] A few examples will clarify this notation:

**Example 2.1** (Euclidean Distance)**.** Let $\mathcal{S}(\cdot, \cdot, x, y) = \sqrt{\|x - y\|}$. This similarity function is just the Euclidean distance function. It is frame-independent, and gives equal weights to all the features.

**Example 2.2** (Weighted Power Metric)**.** Let $\mathcal{S}(\cdot, \cdot, x, y) = \sum_{i=i}^{k} \alpha_i d^i(y^i, x^i)$, where the coefficients $\alpha_i$, $i = 1, \ldots, k$ represent the subjective weights that the DM assigns to each feature, and the functions $d_i$ correspond to the one-dimensional Euclidean metric $|y_i - x_i|$. Allowing for differences in weights generates higher descriptive accuracy and generality, since some features are naturally (and culturally) more salient.

**Example 2.3** (Weighted Power Metric with Social-Dependent Weights)**.** Let $\mathcal{S}(\cdot, M, x, y) = f(M) \cdot \mathbf{d}(y, x)$, where $f : 2^{\mathbb{N}} \longrightarrow \mathbb{R}^k_+$ assigns to any group of M individuals a set of *social-dependent* endogenous weights, **d** corresponds to a k-dimensional vector of one-dimensional distance function, and the dot denotes the inner product of the two vectors.

**Example 2.4** (Weighted Power Metric with Context-Dependent Weights)**.** Let $\mathcal{S}(A, \cdot, x, y) = g(A) \cdot \mathbf{d}(y, x)$, where $g : 2^{\mathcal{X}_t} \longrightarrow \mathbb{R}^k_+$ assigns to any subset $A$ of alternatives a set of *context-dependent* endogenous weights. The use of context-dependent allows us to take into account for asymmetries in similarity assessments. Violation of the symmetry axiom arises because the saliency of certain features depends on the reference in the similarity assessment (Tversky, 1977). In this sense, even though $\mathcal{S}(\cdot, \cdot, x, y) = \mathcal{S}(\cdot, \cdot, y, x)$, it is in general not true when it is clear that the comparison is made with between an alternative and the reference, i.e. $\mathcal{S}(\{x\}, \cdot, x, y) \neq \mathcal{S}(\{y\}, \cdot, y, x)$.

**Example 2.5** (Linear Frame-Dependent Similarity Function)**.** Let $\mathcal{S}(A, M, x, y) = h(A, M) \cdot \mathbf{d}(y, x)$, where $h : 2^{\mathcal{X}_t} \times 2^{\mathbb{N}} \longrightarrow \mathbb{R}^k_+$ assigns to any set $A$ of alternatives and any collection of individuals $M$, a set of *frame-dependent* endogenous weights.

[12]This definition is in accordance with the more abstract definition found in Salant and Rubinstein (2007), or with the "ancillary conditions" in Bernheim and Rangel (2006). Menu-dependence preference relations are also discussed by Sen (1993a, 1997).

[13]Axiomatization and representation theorems can be found in Tversky (1977) and Rubinstein (1987). The former gives a thorough discussion on what are descriptively accurate assumptions on human similarity assessments, and presents conclusive experimental evidence that show *systematic* departures from the metric axioms. Human similarity assessments have been studied for a long time in the psychological literature. See also Krumhansl (1978) and Santini and ramesh Jain (1999).

Examples 1 and 2 are particular cases of the more general frame-dependent similarity functions, since the distance function (either weighted or unweighted) is constant in the first two arguments. Whenever this is *not* the case, we say that their is a *weighting bias* on the decision process. It will be argued in the sequel that this bias is responsible for a wide variety of economically interesting phenomena, such as the effectiveness of advertising.

An agent is also endowed with a *reference alternative*, $\mathbf{x}_t^r$, interpreted as the alternative that the agent likes the most at time $t$, and as the name suggests, is used to compare the other alternatives in the choice set $\mathcal{X}$. Contrary to one plausible interpretation of standard rational choice theory, the reference alternative is the *only* object that the DM has to store in her memory.[14] The initial reference alternative $\mathbf{x_0^r}$ of any DM is assumed to be the same as her parents' or any other paternal figure[15], and a similar assumption is made for the similarity function, for which it is implicitly assumed that the initial subjective weights are the same as those of this parental figure.

The act of choice is modeled with a *minimum-distance choice function*, $c : 2^{X_t}/\emptyset \times \mathcal{F}_t \to \mathbb{R}^k$, which selects, for each nonempty subset of the consumption set and frame at each date $t$, the alternative that is most similar to the reference alternative. A *generalized choice (consumption) set* is an ordered couple $(A, f)$, with $f = (B, M)$ for some $B \subseteq A$ and $M \subseteq \mathbb{N}$.

Formally, for any generalized choice set $(A, f)$ the choice function is defined by

$$c(A, f) = a \ \text{ with } \ a \in \arg\min_{x \in A} \mathcal{S}(f, x, \mathbf{x}_t^r) \tag{2}$$

For any fixed subset $A$, frame $f$ and reference alternative $\mathbf{x}_t^r$, the generalized similarity function is assumed to be continuous *on x*, which guarantees that the problem is well defined. Whenever there are multiple solutions, the natural interpretation is that the DM considers them as the same.

It is easy to impose regularity conditions that guarantee that the minimum-distance choice function is continuous on $x$, for any fixed frame and reference alternative. Put differently, *in the absence of weighting biases, and for any fixed reference alternative, the choice function is continuous on x*. Of course, this is not the case whenever the similarity function is frame-dependent.[16] This lack of continuity is desirable from a descriptive point of view, since the class of choice situations that we pretend to describe are highly discontinuous. Also notice that whenever the reference alternative belongs to the choice set, the minimum distance will select it. However, if this is not the case, a DM chooses the alternative that appears to be most similar to the reference alternative.

To close the model we need to describe the dynamics of the reference alternative, which, as was already stated, represents what the agent prefers at each moment of time. Since the preference relation is unknown to the DM and is being uncovered by experimentation, it is natural to formally treat it as a random variable with some density function $g$ defined on a endogenous support. Formally,

[14]Needless to say, this doesn't preclude the possibility of storing more objects in the DM's memory. In fact, several choices might involve comparison to the least preferred alternative. For other psychological reasons, the extremes— most preferred and least preferred alternatives— are plausible candidates to be remembered and used in decision theoretic models.

[15]We define a *paternal figure* as any person that can influence the DM *initial* choice. This include the parents, friends, the State, an "expert", etc.

[16]It is easy to show that if the similarity function is a distance function, the revealed preference relation is continuous. This property follows immediately from the continuity of the distance function, itself a result of the triangle inequality. As shown in the Appendix, the triangle inequality is not satisfied when we have a generalized similarity function. Also, if continuity is a desirable property, assumptions like the ones used in Theorem of the Maximum will guarantee this. Of course, this is at the cost of full generality and descriptive accurateness.

for any time $t$ and any social-dependent frame $f = (\{\mathbf{x}_t^r\}, M)$[17] let

$$\mathcal{R}(f, \epsilon_t) := \{x \in \mathcal{X}_t : \mathcal{S}(f, x, \mathbf{x}_t^r) < \epsilon_t\} \tag{3}$$

denote the *set of acceptable reference alternatives* representing the support for the probability function.[18] Reference alternatives are randomly drawn from this distribution in a way that is left unspecified in the present paper; all needed is that any element in the set is chosen with some positive probability.[19] The interpretation is that the DM is willing to experiment with different reference alternatives, as long as the outcome is positive, that is, as long as experimenting is satisfactory. If the outcome is not satisfactory the DM adjusts her degree of experimentation $\epsilon_t$ accordingly.

The dynamics of the degree of experimentation are then given by

$$\epsilon_t = h(\varphi_t^s, S_{t,k}, \varphi_t^u, U_{t,k}) \tag{4}$$

with $h_1, h_2 > 0$, $h_3, h_4 < 0$, and also $\lim_{S_{t,k}\to 1} h = \mathcal{M} \gg 0$ and $\lim_{U_{t,k}\to 1} h = 0$ where as usual, the subindex represents the derivative with respect to the corresponding argument, $\mathcal{M}$ is a large enough real number[20], $S_{t,k}$ and $U_{t,k}$ represent respectively the *frequency at time t of successful and unsuccessful reference changes in the last k trials,* $0 < k \le t$, and $\varphi_t^s$ and $\varphi_t^u$ $\left(\left|\varphi_t^s\right| < \left|\varphi_t^u\right|\right)$ are relative subjective weights given to successful and unsuccessful changes. To define the corresponding frequencies, let $s \geq 0$ be any given time where there is a change in the reference alternative, that is, $\mathbf{x}_s^r \neq \mathbf{x}_{s-1}^r$. Then

$$S_{t,k} := \frac{\#\{t-k \le s < t : \mathbf{x}_s^r = c(\mathcal{X}_s) \text{ and } \mathbf{x}_{s+1}^r = \mathbf{x}_s^r\}}{k} \tag{5}$$

$$U_{t,k} := \frac{\#\{t-k \le s < t : \mathbf{x}_s^r = c(\mathcal{X}_s) \text{ and } \mathbf{x}_{s+1}^r \neq \mathbf{x}_s^r\}}{k} \tag{6}$$

The interpretation is as follows. In any choice situation, the reference alternative may either be the same as in the last choice or the DM may choose to experiment; whenever there is a change in the reference, i.e. $\mathbf{x}_t^r \neq \mathbf{x_{t-1}^r}$ we say that there is an *idealization bias*.[21] However, the DM is psychologically constrained to experiment, and allows herself to do so only on the set $\mathcal{R}(f, \epsilon_t)$. The degree

[17]The assumption here is that even though the nature of the similarity function is same when operationalizing the choice function and when defining the reference alternative, the type of similarity assessments is different: in the case of the choice function, the assessment may depend on the choice set and the social environment $f = (A, M)$. On the other hand, a similarity assessment is also performed whenever there is a change in the reference alternative, but in this case the nature of the weighting bias is different: even though social effects may alter the assessment the only element of the choice set relevant is the reference alternative, i.e. $f = (\{\mathbf{x}_t^r, M\})$. This phenomenon arises because in general, it is not the same to compare A *to* B, than B *to* A. In each case some salient features of the reference may dominate and bias the assessment. See Tversky (1977) and Krumhansl (1978) for psychological evidence.

[18]Notice that frame-dependance may alter the shape of the set of acceptable references. Hereafter, to simplify notation, we will avoid making this dependence explicit whenever this is not a cause of confusion.

[19]The exact specification— i.e. distribution function— is important in particular applications of the theory. However, one general claim can be made: the degree to which the probability function is "more" centered on a particular alternative $a \in \mathcal{R}(\epsilon_t)$ is positively related to the amount of *good remembrance* of the alternative. This can be done by social learning, advertisement or personal experience. A natural hypothesis, documented in the psychological literature (Ye and Raaij, 1997), is that the probability of choosing an alternative is concave on the number previous exposure, which can of course be related to the decreasing marginal utility hypothesis used in the traditional utility-maximizing paradigm.

[20]For example, $M = diam(\mathcal{X})$ suffices, where $diam(A)$ denotes the diameter of a set.

[21]As defined above, the bias known as anchoring (Tversky and Kahneman, 1974), which appears frequently in decision under uncertainty contexts, is just a particular type of the idealization bias.

of experimentation $\epsilon_t$ is "psychologically constrained" since good (bad) previous trembles create a predisposition for more liberal (conservative) present trembles. A change of reference is *successful* whenever the new reference alternative $\mathbf{x}_s^r$ is actually chosen by the agent, *and* it becomes the reference alternative for the next period. An analogous definition applies for unsuccessful trembles. Notice that the model explicitly includes memory constraints, given by the parameter $k$.[22]

The relative weights are included to allow for differential effects for losses and gains: a psychologically plausible and empirically well documented hypothesis is that agents weight more heavily perceived losses than perceived gains, giving rise to the phenomenon known as loss aversion (cf. Tversky and Kahneman (1991)). An immediate observation is that there is a sharp asymmetry between successful and unsuccessful experiences: for a fixed backward-looking parameter $k$, any run of successful trembles will cause a high, but *reversible*, optimistic feeling. On the other hand, a sufficiently long run of unsuccessful experiences will cause an *irreversible* pessimistic effect by taking the degree of experimentation to zero; after that, no more experimentation is allowed for, and thus, a stationary equilibrium is reached.[23]

This concludes the presentation of the model. Before exploring the consequences of this set of assumptions, it is worth discussing the meaning of rationality in our framework, and compare it to the definition used in standard decision theoretical models. In this framework, rational behavior is given by two distinctive features: on the one hand, since the DM chooses the alternative that is most similar to his reference, this *conscious*, ex-ante intentionality should be consider as rational under any reasonable definition of the term. On the other hand, it is also reasonable to classify as rational the *conscious*, ex-post, act of constraining the set of possible reference alternatives $\mathcal{R}(\epsilon_t)$, under the assumption of bounded memory.[24] This observation requires further qualification: the above argument suggests that with bounded memory, the signs of the first derivatives ($h_1, h_2 > 0, h_3, h_4 < 0$) are a necessary condition for *ex-post* rationality. However, it is not true *a priori* that the limiting behavior is so; that is, that $\lim_{U_{t,k}\to 1} h = 0$ is not necessarily rational. In fact, the rate of convergence, more than the limiting value, seems to be more important to make this qualification: total insensitivity to failed experimenting attempts is clearly irrational, but excessive sensitivity is also irrational.[25]

[22]Memory constraints may arise in at least two different ways: the one usually used in economic theory, is by including a finite number of lags in the dynamic equation. A second constraint imposes further restrictions on memory, and is well referenced in the psychology literature: agents tend to remember more easily events that happen more frequently.

[23]A different, psychologically grounded, interpretation of Equation 4 is that, since preferences are being explored or uncovered, when deciding whether or not to experiment with a different reference alternative, a DM tries to estimate the probability of success. This is done inductively, using the past experiences that are remembered, and are generalized to be true population estimates. This is the well known judgment of representativeness discovered by Kahneman and Tversky (1972); Tversky and Kahneman (1974). Notice that loss aversion follows naturally if we assume that negative experiences are more salient than positive ones, which motivates the differential weights assigned.

[24]With unbounded memory, a rational agent should just dismiss the alternatives that are disliked, and should not constrain herself for future experimentation. Nevertheless, whenever agents forget how much they disliked some alternative in the past, a natural and reasonable defence mechanism is restraining the liberty to experiment.

[25]To see that this is relevant from an empirical point of view, consider the case of a DM that every period faces the choice of buying or not a lottery ticket (assume that the prize and probabilities are fixed). Ex-post rationality suggests that after a long enough sequence of not winning, the DM should fix his reference alternative to be the "not buy" alternative. Nevertheless, the allegedly paradoxical finding is that there are people that keep buying lottery tickets every week for the rest of their lives, displaying irrational insensitivity to failure (cf. M. Cook and Leigh (1998) or Rogers (1998)). On the other side of the spectrum, an example of irrational hypersensitivity can be found in cases where a loss generates so much pain that the DM (possibly unconsciously) fixes the reference. A typical example is the case of choosing a sentimental companion after a traumatic breakup. An extreme reaction to a traumatic loss is irrational, and as such, is sometimes treated

Contrast this with the discussion of rationality in the standard rational choice theory, where consistency in choice (i.e. transitivity of preference or the Weak Axiom on choice correspondences) is a necessary condition for rationality.[26] The similarity approach, however, shows that consistency of choice, though (normatively) desirable, is not a good descriptive filter for irrational behavior. As sketched above, an important qualification for rationality is the consciousness and intentionality of actions: consistent behavior can be found in animals but this is usually not described as "rational" since it lacks the conscious intentionality. In this sense, unconscious intransitivities that may arise from the weighting or idealization biases are, by definition, out of the domain of rationality. We argue that of the two biases proposed here, the weighting bias is the one that involves deeper acts of introspection (or external help) to detect, and therefore, generates systematic deviations from normative rationality.[27]

A first natural observation is that whenever the reference alternative is fixed and the similarity function is well-behaved, similarity based choice is observationally equivalent to preference based choice. Put differently, whenever there are no weighting or idealization biases, the similarity function generates a single-peaked utility function with a maximum at the reference alternative, and the DM appears as if she is maximizing her utility.

**Proposition 1** (Equivalence of Similarity and Preference)**.** Let $\mathcal{X}_t \subset \mathbb{R}^k$ be the consumption set at time $t$, and assume that the consumption sets are closed and convex. If the reference alternative is fixed and the similarity function is a frame-independent distance function, then the choice function is rationalizable. Conversely, if a choice function $c$ is rationalizable, there exists a reference alternative and a similarity function such that the induced minimum-distance function $c'$ coincides with $c$. □

The easy proof of this proposition is presented in the Appendix, but the intuition is straightforward: if the reference alternative is fixed, the DM effectively knows what she wants, and thus, minimizing the distance is equivalent to maximizing a utility function $U(x) = u(\mathcal{S}(\cdot, \cdot, x, \mathbf{x}_t^r))$, with $u' < 0$[28]. A two-dimensional example is is depicted in Figure 1. On the other hand an agent who maximizes a utility function $U(x)$ is observationally equivalent to someone that minimizes a distance function given by $\mathcal{S}_u(\cdot, \cdot, x, \mathbf{x}_t^r) = \left\|U(x) - U(\mathbf{x}_t^r)\right\|$, with $\mathbf{x}_t^r = \arg\max U(x)$.

A different, but interesting from a computational point of view, interpretation, is that a (frame-independent) distance function provides an efficient procedure to *consistently* compare alternatives: the preference relation is coarsened or refined as the DM needs to assess the desirability for an alternative, and the *only* piece of information that needs to be stored is the reference. Notice that the coarsest revealed utility function is a simple function that takes only two values, say 1 (for the reference alternative) and 0 for every other alternative. This is the same kind of simple utility function suggested by Simon (1955).

The first proposition shows that one can interpret standard rational choice theory from the similarity perspective, and that given a set of (restrictive) assumptions, the similarity approach is ob-

by a specialist.

[26]The standard argument follows by contradiction, and uses Money Pumps or Dutch Books.

[27]On the distinction between normative and descriptive rationality, see for example Spohn (2001). A similar definition of rationality in economics is provided by Gilboa and Schmeidler (2001) who say that in broad terms, an act of choice is rational if the agent does not regret doing it. On the systematic generation of intransitivities see Tversky (1969). It is easy to see that the class of inconsistencies generated are related to weighting biases induced by the saliency of any particular feature.

[28]For example, $u(\mathcal{S}) = -S$, or $u(\mathcal{S}) = 1/\mathcal{S}$

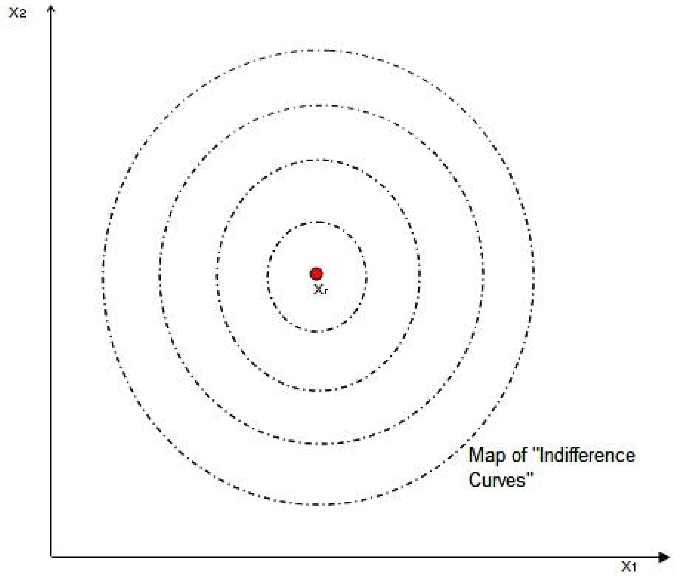


Figure 1: Indifference Curves induced by the similarity relation

servationally equivalent to the utility-maximizing paradigm. The restrictive assumptions are that: (i) the similarity function is a context-independent distance function—i.e. free of weighting biases, and (ii) the reference alternative is fixed — i.e. no idealization biases. It is easy to see that if one of the assumptions is violated, the choices are, in general, inconsistent. On the other hand, from an outside observer perspective, if one observes consistent choices, one will not be able to discern between the two interpretations. Nevertheless, our theory does not rule out inconsistent choices; as a matter of fact, the whole purpose of this framework is to have a general choice model that explains both consistent and inconsistent choices.

As mentioned above, a direct result from the assumptions on Equation (4) is that if there is a long enough run of bad experiences, the DM will restrict himself and the reference alternative will be fixed.[29] If in addition, there are no weighting biases, the DM will appear *as if* he is maximizing a utility function. Alternatively, while the idealization bias tends to naturally disappear with experience, this is not necessarily true for the weighting bias.

**Proposition 2** (Possibility of Structural Pessimism)**.** For any given individual, there exists a sufficiently long run of unsuccessful experiences that will make him *structurally* pessimistic.

The title of this paper was motivated by this kind of logic: an agent that has lived long enough will most likely have experienced many unsuccessful changes of his reference (as a result of voluntary experimentation or an involuntary idealization bias), which may reduce his propensity to try new things, even if they are potentially beneficial.

An alternative interpretation of this result is that people with shorter (greater) backward-looking (memory constraints) behavior are more prone to give up on experimentation sooner than people

[29] From the limiting assumptions, all that is needed is a run of $k$ unsuccessful experiences. This is given by the memory constraints: if a DM only remembers bad outcomes, she will most likely estimate the probability of a bad outcome to be bad. See Footnote 18.

with longer time spectrums. In this sense, younger people have a structural tendency for experimentation: it will take a run of $k$ unsuccessful experiences to make a young person become structurally pessimistic; that is, young people have at least the initial $k$ choice situations as degrees of freedom for experimentation, which might explain why younger people are more prone to make new discoveries.[30]

# 3 Aggregating Across Individuals: An institutional economics approach

Let $N_t = \{1, 2, \cdots, n_t\}$ be a collection of individuals at time t. In this section we assume that for each alternative in the economy, every agent $i$ in the economy is characterized by the subjective weights given to each of the features $\{\alpha^i_{l,t}\}_{l\leq k}$. For each individual $i \in N_t$, denote the *relative weight* she gives to feature $f$ at time $t$ by $w^i_{f,t} := \frac{\alpha^i_{h,t}}{\sum_{l=1}^k \alpha^i_{l,t}}$, $f = 1, \cdots, k$.[31]

**Definition 1** (Institution)**.** Let $M \subseteq N_t$ be a collection of individuals, and $\delta \geq 0$ a nonnegative real number. For any feature $f = 1, \cdots, k$, and any real number $z \in [0, 1]$, an *$f$-institution of degree $z$*, for M, is defined as

$$wi^f_t(z, \delta) := \#\left\{i \in M : \left|w^i_{f,t} - z\right| \leq \delta\right\}$$

For any given choice situation and a reference alternative $\tilde{x}$, an ***r**-institution* is defined as

$$ri^{\tilde{x}}_t := \#\{i \in M : \mathbf{x}^r_t = \tilde{x}\}$$

The *strength* of an institution $\kappa_t \in \{wi^f_t, ri^x_t\}$ at time $t$ is defined by $\zeta(\kappa_t) := \frac{\kappa_t}{\#M}$. Similarly, the *stability* of the institution for a time period $\mathcal{T} = \{t_1, t_2, \cdots, t_T\}$ is defined by $\sigma(\kappa) := \frac{\sum_{t\in\mathcal{T}}(\kappa_t - \overline{\kappa})^2}{\#\mathcal{T}}$, where $\overline{\kappa} = \frac{\sum_{t\in\mathcal{T}} \kappa_t}{\#\mathcal{T}}$. □

Several comments and examples are in place. As defined above, institutions are of two types: for any feature $f$, an $f$-institution represents the number of people with similar relative weights. The parameter $\delta$ represents the *tightness* of the institution: if $\delta = 0$ an institution is tight in the sense that it only counts the individuals that have a relative weight of *exactly* $z$. For example, if the feature "catholic belief" is a tight $f$-institution of degree 1 the outcome of an election will uniquely depend on the strength of this institution in the voting population.[32]

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[30] This is well documented in the history of science and mathematics. See for instance, G.H. Hardy's famous observation on old mathematicians (cf. his "A Mathematician's Apology"), Einstein and his relativity theory, Cantor and his theory of infinite cardinals, Newton and his development of his his theory of fluxions and Darwin, who at the age of 40 published his *The Origin of Species*. Evidence, and a different interpretation, of this phenomenon can be found in (Kanazawa (2000, 2003))

[31] The relative weight of any individual is always well defined, since we posit that if an individual exists, at least one of the weights is positive.

[32] Bartels and Brady (2003) suggest that religious belief is a determinant factor in political choices in the US.

Similarly, an *r*-institution is the number of individuals that share the same ideal or reference alternative. A particular example of an *r*-institution is taken from marketing and advertising: suppose that in a particular city, say New York, the use of Ipods has become trendy or fashionable. In this case, thanks to media and advertising, agents preferences are coordinated on the set of MP3 players, and the reference alternative becomes an Ipod. If the perceived distance between Ipods and other MP3 players is sufficiently large— which can happen whenever the subjective weight on trendiness is relatively high— most people will appear *as if* they are coordinating on buying Ipods instead of the competitors.[33]

As the previous examples show, the definition of an institution allows us to model formal and informal institutional arrangements: in a *formal or explicit* arrangement, groups of individuals agree upon behaving in a similar way, either in terms of the relative weights or the reference alternative. An informal institutional arrangement is one that arises *without* the need to make explicit the agreement.

The definition also formalizes the idea of the strength and stability of a particular institution, which may be important in different applications. The strength is related to the *coverage* of the institution on the whole population, while the stability refers to the relative change in time of an institution. A *cultural trait* can now be defined as as a stable institution. *Culture* is then, the set of cultural traits in a given population. An example of a *strong cultural trait* is given by the Christian religious belief in the Western hemisphere.

Observe that *f*-institutions are fundamentally distinct from *r*-institutions in the sense that induction plays a major role in shaping the strength of the latter, since an unsuccessful choice of a reference tends to reduce the degree of experimentation, and thus, to constrain the set of acceptable references. For instance, if buying a particular good is fashionable, but consumers notice that the good usually get damaged very quickly, an ex-post rational DM will most likely not purchase it in the future. Similarly, a good reference tends to perpetuate itself, and thus, if an *r*-institution has desirable properties for a particular group of people, these institutional arrangements will tend to perpetuate. In this sense, *r*-institutions are endogenously formed and transformed. This feature, which is also present in strategic definitions institutions, is characteristic of *r*-institutions.[34]

Institutions serve a dual role in the theory: on the instrumental side it allows to aggregate individual effects to a collection of DM with similar characteristics.[35] On the other hand, institutions affect choices by inducing social-dependent effects, via both the weighting and idealization biases; this might happen at the early stages of childhood (setting the initial subjective weights and references) or later in life. While the former is usually associated to vertical transmission of cultural traits, the latter is a horizontal effect, which may or may not be cultural transmission. Put differently, the class of social effects is larger than the transmission of cultural traits.

Finally, notice that in this framework choice problems are path-dependent by construction: the

[33] This definition of institutions concentrates on the revealed effects of institutions, thus, the *as if* character is justified.

[34] The usual microeconomic approach to institutions is strategic in the sense that these are defined as formal incentive compatible agreements designed to solve coordination problems (North (1991), Schotter (1981)). Since incentives are still the driving force of *r*-institutions, this approach is implicit in this framework. However, the revealed approach here is more general, since it allows also for non-strategic considerations which may influence choice. For instance, it is hard to argue that certain attitudes that are by-products of religious beliefs, like trust, moral behavior or civic participation are equilibria of a given coordination game, even though they may be correlated with another institution that developed in that way. Similarly, focal points arise in our framework as alternatives with some objective salient feature, which may or may not solve coordination problems.

[35] A similar aggregation procedure is used by Tversky and Simonson (1993).

reference alternative varies with time, starting from an initial reference $\mathbf{x}_0^r$, and the perceived success of any change in the reference affects the degree of experimentation. The initial reference for any particular act of choice is interpreted as one imposed by some higher or paternal authority *before* the first act of choice takes place. Similarly, the initial similarity function reflects the influence of the same paternal figure. As mentioned before, this allows for the intergenerational transmission of cultural values and beliefs, giving the proposed institutional microfoundation the intergenerational character that is generally associated with it.

What are then the conditions that guarantee cultural transmission of values and beliefs or stability of institutions?[36] For any institution $\kappa_t \in \{wi_t^f, ri_t^x\}$ denote the change from times $t$ to $t+1$ by $\Delta\kappa_{t+1}$. Clearly, an institution is stable if $\Delta\kappa_{t+1} = 0$ for $t \in \mathcal{T}$. Denote the entry (indoctrination) and exit (liberalization) of an institution as $I(\kappa_t)$ and $L(\kappa_t)$. Clearly then, $\Delta\kappa_{t+1} = 0$ if and only if $\Delta I(\kappa_t) = \Delta L(\kappa_t)$. Stability then depends on the determinants of the entry and exit rates of each type of institution.

In the case of an $r$-institution, entry and exit rates depend on the degree of experimentation that the individuals in a community have. A sufficient condition for $\Delta L(ri_t^{\tilde{x}}) = 0$ for all $t$ is that $\epsilon_t = 0$ for every individual in the institution. This can be achieved through, for example, enforcing a very quick convergence rate of the dynamic equation 4. Guilt,shame or the threat of punishment, are usual ways to achieve very quick convergence, for example.[37] Another sufficient condition, for any $\epsilon_t \geq 0$ is that $\mathcal{R}(f, \epsilon_t) = \{\tilde{x}\}$, i.e. the set of acceptable references is a singleton with the r-institution, that's chosen with probability one. This can be achieved via social-dependent weighting biases.[38] By enforcing a zero exit rate, the size of a given institution is guaranteed to increase, given a non-negative demographic growth. The entry rate, on the other hand, depends on social-dependent effects (e.g. the degree of trendiness) and the *objective* benefits of the reference alternative.

$f$-institutions exhibit a different dynamic, since the nature is also different. Since subjective weights depend on framing-effects (i.e. social and context effects), a sufficient condition for stability or cultural transmission is social isolation. Nevertheless, context effects that are the result of physical saliency are difficult to control since in general, they operate at an unconscious level. This suggests that cultural transmission of values can be guaranteed if the salience of "undesired" attributes operates at a conscious level, which can very well be induced by shame or guilt.[39]

This has been a very short discussion of a set of sufficient conditions for institutional stability and cultural transmission of values and beliefs that can be easily derived from this framework. The topic is extensive and has an importance of its own so further research should throw further restrictions and predictions on cultural evolution.

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[36]Cultural transmission has been formally studied in the economics literature by Bisin and Verdier (2000b), Bisin and Verdier (2000a) and Bisin and Verdier (2001). In their model, transmission of values is the result of a conscious and rational cost-benefit analysis made by parents, who decide how much "effort" to exert on the "socialization activity" of their children. This choice affects the probability that children develop a particular type of utility function, and this is assumed to affect the utility of the parents (so there is what Bisin and Verdier call "imperfect empathy"). One advantage of this approach is that it focus on the incentives that social groups have to transmit a particular set of social values.

[37]Psychological and sociological evidence can be found in Carroll (1981), Gundreson and McCary (1979), Lutwak and Ferrari (1996), McConahay and Hough (1973), O.J. Harvey and Batres (1998), Tangney (1991) and Hauser (2006), among many other references.

[38]See the next section to see how this is actually achieved in practice.

[39]A simple example is sexual attraction, where the saliency of a particular physical characteristic evokes guilt or shame in the individual. See Gundreson and McCary (1979) and many other similar references, for example.

# 4 Applications

The similarity approach to choice proposed here is a modeling framework that can be used— we argue— to understand decision-making outcomes that are usually outside the domain of the maximizing-utility paradigm. In this section several applications are sketched.

**Example 4.1. Advertising 1: Optimal Advertising (Pure Idealization Bias)**
Advertising and marketing strategies are designed to increase the probability that an alternative is chosen by a collection of individuals. With this in mind, the first immediate observation is that for advertising to be effective there has to be an idealization bias, i.e. the DM has to be willing to consume the advertised alternative. If the act of choice is done for the first time, advertising of an alternative $a$ is effective whenever $\mathbf{x_0^r} = a$. If the DM has already performed similar choices, advertising is intended to make $\mathbf{x}_t^r = a$.

At any moment of time, and given a collection $M$ of individuals, an advertising strategy for alternative $a$ is *effective* whenever the corresponding $r$-institution is non-decreasing in time, i.e. whenever $ri_t^{\tilde{a}} \leq ri_{t+1}^{\tilde{a}}$ or $\Delta ri_{t+1}^{\tilde{a}} \geq 0$.

The effectiveness of advertising depends, then, on factors that affect the entry and exit rates of the $r$-institution, and in particular, of the degree of experimentation $\epsilon_t$ of a DM, of its distribution in a given population and on strategic considerations regarding the amount an type of advertising strategies among competitors. For instance, if an alternative has very close substitutes, an idealization bias can be created by increasing the amount of brand remembrance, which of course depends not only on the amount of advertising that the firm chooses, but also on the amount of advertisement of the competitors.

To make things clear, assume that $\mathcal{X} = \{x_1, x_2\}$ is set of alternatives, and suppose that $\mathcal{S}(\cdot, \cdot, x_1, x_2) = \bar{\epsilon}$, i.e. the alternatives are *objectively* $\bar{\epsilon}$-similar, and this is known by the firms. What is the optimal advertisement strategy for each of the firms assuming that consumers' similarity assessments are frame-independent?

According to the above discussion, the firms have to take into account the entry and exit rates from the institution, which in the case of firm 1, are consumers of the second alternative $x_2$ that switch to the first alternative $x_1$ and viceversa, respectively. In a frame-independent world, the entry rate is determined by the distribution of the degree of experimentation in the population. Those individuals in the M-population for which their degree of experimentation is less than the objective similarity are *not* going to switch with probability 1, i.e. the set of loyal consumers for $x_j$, $j = 1, 2$ is given by $LC_j(\bar{\epsilon}) = \{i \in M : \epsilon_t < \bar{\epsilon} \wedge x_{t-1}^r = x_j\}$. Therefore, the targeted *entry* population by firm $j$ is given by $\mathbf{T}_j = \{i \in M : \epsilon_t \geq \bar{\epsilon} \wedge x_{t-1}^r = x_{-j}\}$. For these potential switchers the choice of the alternative is random, but as discussed above, the probability function depends on the amount of "good brand remembrance", which we assume depends on the amount of advertisement $(a_1, a_2)$, and the previous status, i.e. $g(x_1; a_1, a_2, x_2) := \text{Prob}(x_t^r = x_1 | a_1/a_2, x_{t-1}^r = x_2)$. Assume that this probability function is concave on the ratio $a_1/a_2$, that it is the same for all potential consumers and that $g(x_1; a_1, a_2, x_1) > g(x_1; a_1, a_2, x_2)$. The expected entry rate for firm $i$ is then $\mathbf{T_i}(\epsilon) g(x_i; a_1, a_2, x_j)$.

The exit rate can be found similarly: firm 1 has a set of loyal consumers $LC_1(\bar{\epsilon})$, and only those that are not loyal should be taken into account in the design of the optimal amount of advertisement. An *optimal Cournot advertisement strategy* for firm 1 is the solution to the problem

$$\max_{a_1} \Pi_1 = \mathbf{T_1}(\bar{\epsilon}) g(x_1; a_1, a_2, x_2) + \mathbf{T_2}(\bar{\epsilon}) g(x_1; a_1, a_2, x_1) - C(a_1) \tag{7}$$

Where all quantities have been normalized by the price of the good $p_1$ and $C(a_1)$ is a convex cost function. This is an advertisement Cournot game: firm 1 chooses the level of advertisement expenditure $a_1$ assuming that $a_2$ is the optimal choice of firm 2, and viceversa. The advertisement equilibrium, which exists under standard assumptions, is given by the intersection of the two optimal reaction curves.

A natural question is whether this optimal strategy is implementable in practice, since informational requirements are very high. The optimal strategy assumes that the firms know that the goods are $\epsilon$-similar and given this, the entry and exit rates are easily constructed, given some assumptions on the probability of an idealization bias being on action. In practice these informational requirements can be proxied with variables that are correlated with the distribution of the degree of experimentation in the population, such as demographical variables. For instance, according to Proposition 2, there is a correlation between the degree of experimentation and age: younger people are more prone to experiment than older people, and therefore, this distribution can easily be proxied. Also, the exact functional dependency of the probability of an idealization bias is difficult or impossible to know ex-ante, but ex-post it might be estimated with real data for a particular firm or industry.

Finally, it is important to recall that this very simple example assumed that similarity assessments are frame-independent, and therefore, there was no role for inducing weighting biases. This seems to be an important part of efficient advertising strategies, as will be discussed below. Nevertheless, a well documented example of a pure idealization bias is known in the psychological literature as the "mere exposure effect", where preference is generated by a previous exposure of an alternative.[40] Exposure effects are the driving force behind this model of optimal advertising strategies. □

**Example 4.2. Advertising 2 - Idealization Bias induced by a Weighting Bias**
Another class of efficient advertising strategies is created by changing the "shape" of the set of possible reference alternatives $\mathcal{R}(f, \epsilon_t)$. Recall that given a degree of experimentation $\epsilon_t$ a DM allows for experimentation inside the set $\mathcal{R}(f, \epsilon_t) := \{x \in \mathcal{X}_t : \mathcal{S}(f, x, \mathbf{x}_t^r) < \epsilon_t\}$ which depends on the frame of the choice situation. A firm can affect the shape, for any given degree of experimentation, by inducing a different frame. The following two examples will clarify this.

Assume that the generalized similarity function is context dependent, but social-independent,[41] i.e. $\mathcal{S}(A, \cdot, x, y) = g(A) \cdot \mathbf{d}(y, x)$. The interpretation is that the set of alternatives, generates a set of salient features. For instance, let the set $A = \{x, y\}$ and for $i \neq j$ $d^i(x_i, y_i) = 0$, but $d^j(x_j, y_j) >> 0$, that is, the $j$-th feature is salient. Assume that the saliency of the feature is such that the DM places all weight on that feature, i.e. $g(A) = (0, \cdots, 0, 1, 0, \cdots, 0)$. Therefore, $\mathcal{S}(A, \cdot, x, y) = g(A) \cdot \mathbf{d}(y, x) = d^j(x_j, y_j)$. The effect of advertising is therefore to (possibly unconsciously) set priorities on the DM's attention on the features, which, for any given $\epsilon_t$ and previous reference alternative $\mathbf{x}_t^r$, deforms the set $\mathcal{R}(\epsilon_t)$ in such a way that the advertised alternative belongs to the set. A two-dimensional example is depicted in Figure 2.

Examples of this strategy are ubiquitous in advertising. Figure 3 depicts how this is done in the case of Apple vs (Windows run) PC and in the case of advertising of Apple Ipods. The left panel shows a comparison between a consumer of (Windows run) PC and an Mac consumer, and exploits the subjective feature "degree of trendiness": a reasonable (unconscious) conclusion is that the owner of a Mac computer is more appealing (young, fresh, etc) than the PC consumer (old,

[40] See for example, Ye and Raaij (1997), Tom (2004) or Zizak and Reber (2004).
[41] See Example 2.4 above.

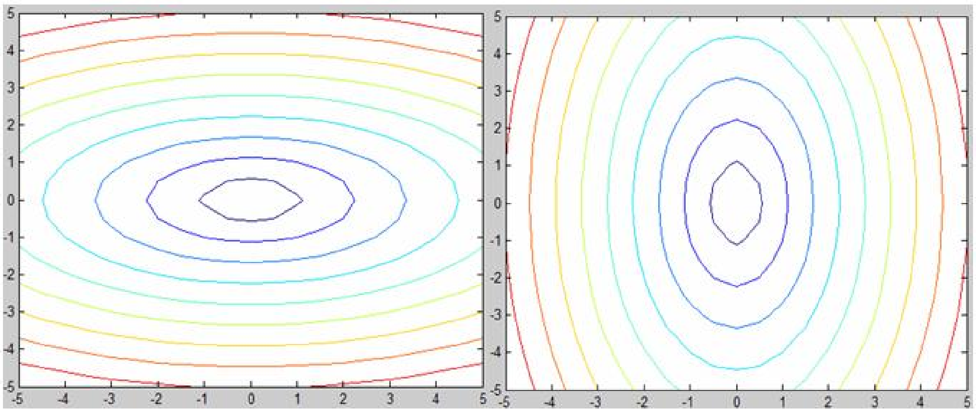


Figure 2: Effect of a Weighting Bias on $\mathcal{R}(\epsilon_t)$

boring, etc.). The right panel exploits in a different way the feature of "trendiness": according to this advertisement costumers of Ipods are "cooler", know what they want, live by their own standards, etc. In sum, both ads induce a weighting bias that deforms the similarity function, and the bias operates at a possibly unconscious level. This last point is important: if the consumer is not satisfied with the new reference (an Ipod, for example) she will consciously go back to the previous reference, as suggested by the dynamic equation 4. But when the bias operates at an unconscious level, their are no grounds for rational conscious correction.

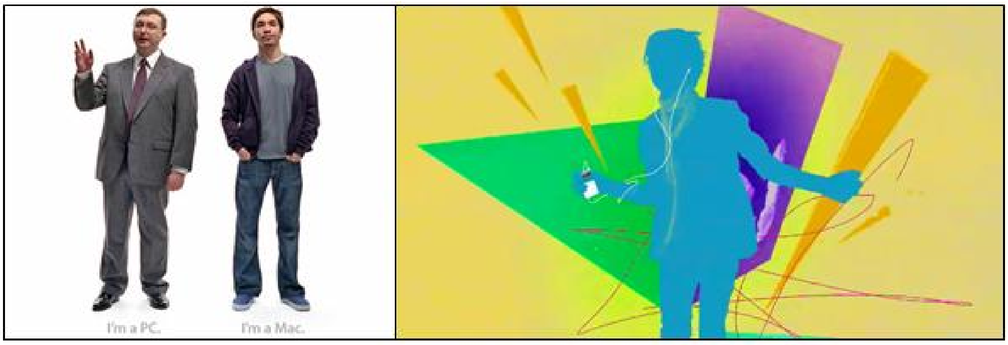


Figure 3: Examples of Weighting Biases in Advertising

□

**Example 4.3. Advertising 3 - Role Models and the Idealization Bias**
Another ubiquitous type of advertising strategy exploits the image of role models, i.e. individuals that are socially admired for any particular reason (e.g. athletes, artists, actors, models, etc). A pure idealization bias is generated by making the DM think that the advertised good will look as good on them as it looks on their role model. This creates an immediate change of the reference alternative $\mathbf{x}_t^r \neq \mathbf{x}^{\mathbf{r}}_{\mathbf{t+1}} = a$, that can be modeled as follows: if the advertised good $a$ is objectively very similar

to the previous reference[42], then for any $\epsilon_t \geq 0$, $a \in \mathcal{R}(\epsilon_t)$. Since a successful strategy affects the probability that the alternative $a$ becomes the reference, the use of role models concentrates the probability mass on the advertised alternative, i.e. $g(x) = \text{Prob}(\mathbf{x^r_{t+1}} = x) = \begin{cases} 1 & \text{if } x = a \\ 0 & \text{otherwise} \end{cases}$. Needless to say, if the the DM is not intrinsically satisfied, the effect of advertisement should disappear with time and experience.□

**Example 4.4. Advertising 4 - The Attraction Effect and the Weighting Bias**
Another well known advertising strategy is commonly referred in the psychological literature as the *attraction effect*:[43] a DM that chooses $x$ when only $x$ and $y$ are available, but selects $y$ when a third element $z$ is introduced in the set, in clear violation of the Weak Axiom.

One way to understand this phenomenon with the similarity approach, is by appealing to context-dependent weighting biases, i.e. whenever the choice set itself makes some particular feature salient. In the example above, suppose that when comparing $x$ and $y$ to a reference alternative, $\mathcal{S}(\{x, y\}, \cdot, x, \mathbf{x}^r_t) < \mathcal{S}(\{x, y\}, \cdot, y, \mathbf{x}^r_t)$, but the introduction of a third alternative induces a context-dependent weighting-bias due to the saliency of a feature, that changes the direction of the similarity assessment, i.e. $\mathcal{S}(\{x, y, z\}, \cdot, x, \mathbf{x}^r_t) > \mathcal{S}(\{x, y, z\}, \cdot, y, \mathbf{x}^r_t)$.[44]

A real-life example is the following: suppose that a DM who wants to buy a new TV is offered a 70 inches Sony high-definition TV (HDTV) at price of $4.999.97 , and a 65 inches Mitsubishi HDTV at a price of $2.299.97 (that is, to the DM there appear to be 3 features: dimensions, HD/Normal and price). The choice set is $\{t_1, t_2\}$, and the relevant features are $\{d, ty, p\}$, where $d$ are the dimensions, $ty$ the type and $p$ the price. Under these circumstances it is plausible that the DM decides to buy the second one, where clearly the price appears to be a salient feature, determining the direction of the choice. Suppose now that the manager of the store adds a third TV, a Panasonic 65" plasma HDTV with a price of $9.999.97. What could the DM do? It is plausible that the DM may now choose the Sony TV, and again, this is explained because the introduction of a third TV makes the price less salient, compared to a previously unobserved feature, the quality $q$. In this case the quality feature becomes salient, presumably because the price is acting now as a signal of the quality.

With this in mind, we can actually ask the size of the context-dependent weighting bias needed to explain this kind of behavior. Without loss of generality, assume that the features "price" and "quality" are the first and second features of the alternatives, respectively.

**Proposition 3** (Price signaling Quality)**.** Let $a = \mathbf{x}^r_t$ and $b \in X_{t+1}$, such that $a_l = b_l$ for $l = 3, \cdots, k$. Assume also that there is a non-decreasing function $g : \mathbb{R} \rightarrow \mathbb{R}$, such that $x_2 = g(x_1)$. If $p_a > p_b$, then, for every $\epsilon_t \geq 0$, there exists $\underline{\alpha} \in \mathbb{R}^k$, such that $\mathcal{S}(\cdot, \cdot, b, \mathbf{x}^r_t) \geq \epsilon_t$, i.e. we can always find some weights such that $b \notin \mathcal{R}(\epsilon_t)$, and therefore, will not be chosen with probability one.

*Proof.* For simplicity, let $\underline{\alpha}_l = 0$, for $l = 3, \cdots, k$, and $(\underline{\alpha}_1, \underline{\alpha}_2) > 0$ be such that

$$\underline{\alpha}_1 d^1(x^r_1, b_1) + \underline{\alpha}_2 d^2(x^r_2, b_2) = \epsilon_t$$

[42] This assumption is made to make absolutely clear how role models induce a pure idealization bias, or put differently, to show that even for two identical goods, the use of a role model can change the pattern of consumption.

[43] See for example Tversky and Simonson (1993), Sanjay Mishra and Stem (1993) or Lutz (1975). An application to voting behavior can also be found in Yigang Pan and Pitts (1995).

[44] See Tversky and Simonson (1993) for experimental evidence of this kind of behavior. They also propose a model with utility functions that is equivalent to the one presented here, but assumes that for every feature there is indeed a complete hedonic ordering.

These weights suffice for $d_{\mathbf{s}_t^r}(\mathbf{x}_t^r, b) \geq \epsilon_t$ □

Notice, that the last equation can be expressed as

$$\underline{\alpha}_1 = \frac{\epsilon_t - \underline{\alpha}_2 d^2(g(x_1^r), g(b_1))}{d^1(x_1^r, b_1)} \tag{8}$$

Equation 8 makes clear the tradeoff between the weights for price and quality. Also, notice that the perceived distance of quality $d^2(g(x_1^r), g(b_1))$ is negatively related to the weight for price: larger deviations from the reference have to be compensated by decreasing the weight in price. [45]

This proposition is an optimistic result for advertisers: no matter how averse to experimentation a DM is, there is always a weighting-bias that induces experimentation, and it is just a matter of finding a right frame to do so. Also, it hints the type of advertising strategies that can be devised: it is not only a matter of increasing advertising expenditures ("brute force advertising") but also a matter of the quality of advertising.

**Example 4.5. Market Behavior**

The relation between price and quality in the previous example showed that it is theoretically possible that an increase in price results in an increase in demand, if the price is signaling some other unobservable feature like quality, for example.[46] A natural question to any decision theory concerned with explaining market behavior is under what conditions the law of demand is satisfied, that is, under what conditions an increase in the price of a good will result in a decrease in the quantity consumed. As the previous example showed, the price of a good can be considered as an objective feature of the good.[47] Without loss of generality, assume that the first feature is the feature "price".

**Proposition 4** (Individual Law of demand)**.** Let $a = \mathbf{x}_t^r$ and $b \in X_{t+1}$ and assume that $x_1^r = p_a < p_b = b_1$. For any $\epsilon_t \geq 0$, there exists $\underline{\alpha} = \{\underline{\alpha}_1, \cdots, \underline{\alpha}_k\} > 0$ such that for all $0 < \alpha_1 \leq \underline{\alpha}_1$, $\mathcal{S}(\cdot, \cdot, b, \mathbf{x}_t^r) < \epsilon_t$. That is, for any positive $\epsilon$ we can always find weights such that a *more expensive* alternative will be chosen with some positive probability.

*Proof.* Let $\epsilon_t > 0$. Choose $\underline{\alpha} = \{\underline{\alpha}_1, \cdots, \underline{\alpha}_k\}$ with $\alpha_l = 0$ for $l \geq 2$, such that

$$0 < \underline{\alpha}_1 < \frac{\epsilon_t - \sum_{i=2}^k \alpha_i^t d^i(a_i, b_i)}{d^1(p_a, p_b)}$$

Clearly such set of weights suffices for $\mathcal{S}(\cdot, \cdot, b, \mathbf{x}_t^r) < \epsilon_t$. □

[45] In an experimental test of context effects, and in particular attraction effects, Tversky and Simonson (1993) conducted experiments where a similar tradeoff between price and quantity was found. We can rationalize their result (the *tradeoff contrast hypothesis*) from our theory by appealing to weighting biases generated by the introduction of a third object (in a two-element choice set) that is dominated by one of the alternatives. In particular, their result is that the relative weights (of a generalized value function) of quality/price depend on the relative differences with respect to the third good, in exactly the same way that equation 8 portrays.

[46] This intuitive observation is not new, of course, as it has been well discussed in the information economics literature. The classical reference is Akerlof (1970).

[47] This interpretation is also used by Tversky and Simonson (1993).

This result shows that for the law of demand to be satisfied, the weight given to the feature price has to be relatively large. In fact, it is negatively related to the perceived distance between the prices: the larger the difference in price between to alternatives, the lower the weight on the feature has to be for the law of demand no to be satisfied. From the perspective of a firm's advertising strategy, the larger the price difference between them and their competitors, the larger that weighting bias that has to be induced, by shifting attention to other features like shape and color (design), trendiness, social status, quality or ethical content, for example.

The subjective weight given to the price feature is correlated to many factors, some of them demographic. For instance, it is reasonable that the saliency of the price feature is greater the more constrained is the budget of the individual, or put differently, the *psychological price* of a good is higher for the poor than for the rich. This *psychological income effect* is in sharp contrast to the income effect studied in standard consumer theory. Similarly, the degree and size of a market economy should be associated to higher subjective weights in the population, suggesting that indeed, under our definition, the market economy corresponds to a price-institution. A natural extension of the above result is an aggregation result for the individual law of demand, the strength depending on the strength of the institution, i.e. on the coverage of the price-institution. The stability of the institution may explain significant cultural differences that are observable in present times, the case of the savings rate in China and USA being an immediate example.

**Example 4.6. The Endowment Effect, Loss Aversion and Status-Quo Bias**
Recent work by psychologists and experimental economists has focused on certain biases the appear to be ubiquitous in choices under certainty and uncertainty. Three of theses biases are the status-quo bias, the endowment effect and loss aversion.[48] As mentioned before, the latter is incorporated naturally in the theory by assuming a differential response to losses and gains in experimentation, which itself generates a status-quo bias whenever the other options in the choice set appear to be sufficiently dissimilar. For instance, a status-quo bias emerges naturally whenever $\mathcal{S}(\{\mathbf{x}_t^r\}, \cdot, y, \mathbf{x}_t^r) > \epsilon_t$ for every alternative in the choice set $y \in \mathcal{X}_t$. This implies that there is no role for experimentation, and therefore, if the reference alternative is in the choice set, it will be selected by the minimum-distance choice function. Similarly, whenever the degree of experimentation is zero (because of a history of unsuccessful changes), the effect is permanent. This status-quo bias is history dependent since the degree of experimentation $\epsilon_t$ depends on the recent past successful and unsuccessful experiences, providing a rationale for the bias.

**Example 4.7. Freedom, Preference for flexibility and Self-Control**
The dynamic equation 4 provides a rationale for a preference for flexibility Kreps (1979) and for self control Gul and Pesendorfer (2001). According to Kreps, individuals exhibit a preference for flexibility whenever for any two sets $A$ and $B$, $A \subseteq B \Leftrightarrow A \preceq B$, that is, an agent prefers a set over another whenever the set is larger, since it gives the DM more flexibility to choose. Similarly, an agent does not exhibit a preference for flexibility whenever $A \succeq B \Leftrightarrow A \sim A \cup B$, that is, whenever adding the elements of $B$ to $A$ does not improve the welfare of the DM. Gul and Pesendorfer consider a variant which they call *set betweeness*: $A \succeq A \cup B \succeq B$, which they interpret as a desire for self-control.

Even though the intuitive appeal of these axioms is not being disputed, we claim that the psychological basis for such phenomena is provided naturally by the inductive approach. A preference

[48] Experimental evidence can be found in Samuelson and Zeckhauser (1988) or Daniel Kahneman and Thaler (1991). Rational choice theory attempts to axiomatically explain this behavior can be found in Masatlioglu and Ok (2005) or Mandler (2004), arising either from incomplete preferences or from changing tastes.

for flexibility arises naturally as a result of previous experience: if past experimentation has been successful, the DM is open to experimentation. Similarly, if past previous experience was negative, an individual will constrain the set $\mathcal{R}(\epsilon_t)$. This history-dependence endogenizes this phenomena, and allows for the possibility of both a preference for flexibility and self-control along the life-time.

Another closely related application of the similarity approach to decision-making has to do with the axiomatization of freedom.[49] It is easy to see that a measurement of freedom in terms of the cardinality of sets (i.e. the number of identities) instead of the diversity is restrictive, and several of the axioms for the first approach are not satisfied if diversity plays a major role in the assessment of freedom.[50]□

**Example 4.8. Voting Behavior**
Rational decision theories have not been very successful in explaining political behavior.[51] On the supply side, politicians usually use strategies similar to the ones used in advertising,[52] and thus, with exogenously fixed preferences this type of interaction is difficult to model and understand. On the demand side— the voters side— a modeling approach that focuses only on incentives has little explanatory power whenever the incentives are not egoistical or monetary, giving rise to what is known as the "voting paradox": if voters know that they are not pivotal, why do they still vote?

There is now considerable empirical evidence suggesting that civic values play a fundamental role in explaining voters turnout (Campbell, 2006). The choice set of a potential voter has only two actions { "vote" , "don't vote" }, each one characterized by a vector of features. One particular feature is the degree of civic content: in democratic societies the act of voting has more civic content than the act of not voting. In this sense, communities with higher turnout rates are effectively strong institutions of the two types: since the reference alternative is voting, this constitutes an $r$-institution. This $r$-institution is correlated with the $f$-institution that captures the weight for the civic-feature.[53]

Other features affect the way that people actually vote. For instance, in the US, partisan and religious background are features that have high subjective weights.[54] As with the case of advertisement, the relative weights may be correlated with socioeconomic and demographic characteristics, such as educational level or race. □

**Example 4.9. Moral Behavior and the Rationale for the "Everyone has a price"-type of argument**
Reconciling the standard maximizing-utility framework with moral behavior has been particulary difficult, since it is undeniable that the latter reduces, by definition, the experienced utility of the moral decision-maker.[55] This would not be problematic if social and ethical considerations do not

[49] See for example Baujard (2006), Walter Bossert and Xu (2003), Sen (1993b) or Suppes (1987).

[50] For instance, Suppes (1987) Axiom 4 is easily violated if similarity is not taken into account: $A \cap C = \emptyset$ and $B \cap C = \emptyset \rightarrow A \geq B \Leftrightarrow A \cup C \geq B \cup C$, where the relation $\geq$ is interpreted as an order for freedom, i.e. $A \geq B$ means $A$ is at least as free as $B$. Suppose that $A \geq B$ if and only if the radius $(A) \geq$ radius $(B)$, where the radius is defined as usual as radius $(A) = \arg\max_{x_i, x_j \in A} \mathcal{S}(\cdot, \cdot, x_i, x_j)$. Suppose also that $y \notin A \cup B$ but $\max_{x \in A} \mathcal{S}(\cdot, \cdot, x, y) < \max_{x \in B} \mathcal{S}(\cdot, \cdot, x, y)$. In this case Suppes' axiom can be seen to be violated. This observation is not new, though. See Baujard (2006) and a similarity/diversity approach to freedom in Walter Bossert and Xu (2003). Psychological biases emerge easily from the findings in Tversky (1977) which are explicitly included in the current approach via the weighting biases.

[51] See for instance, Campbell (2006) and Bartels and Brady (2003).

[52] An application of the attraction effect to political decisions can be found in Yigang Pan and Pitts (1995).

[53] Evidence of this can be found in Campbell (2006).

[54] See for example (Bartels and Brady, 2003), Martinez and Gant (1990), Richard Niemi and Weisberg (1991) and Patterson and Caldeira (1984).

[55] On this topic see Sen (1977) discussion on the differences between motivation by sympathy and by commitment in decision-making.

affect outcomes in decision-making, and this has in general been the position in economic theory. However, since ethical considerations are implicit in all decisions, a decision theory that is not capable to incorporate them is, by construction, descriptively impaired. In this example it will be shown that the similarity approach provides a very convenient way to include ethical considerations in decision-making.[56]

**Proposition 5** (Everyone has a price)**.** For any given degree of experimentation $\epsilon_t \geq 0$, there exists a weighting bias big enough to make any ethical consideration ineffective.

*Proof.* Without loss of generality assume that there are only two features: price ($p$) and ethical content ($m$). We know that with probability 1 an *ethically wrong* alternative $w$ will not be chosen if $w \notin \mathcal{R}(\epsilon_t)$. Therefore, in order for the wrong alternative to be chosen with positive probability we need to find weights $\alpha_m, \alpha_p$ such that $\alpha_m d^m(w_m, \mathbf{x}^r_{t\,m}) + \alpha_p d^p(w_p, \mathbf{x}^r_{t\,p}) < \epsilon_t$, that is, any weighting bias that induces weights that satisfy

$$\alpha_p < \frac{\epsilon_t - \alpha_m d^m(w_m, \mathbf{x}^r_{t\,m})}{d^p(w_p, \mathbf{x}^r_{t\,p})} \tag{9}$$

will suffice. □

The proof has followed the same reasoning as in the previous propositions: features are in essence substitutes of each other; if a DM weighs more heavily ethical content, he will dismiss other features that are correlated with that feature.[57] Notice that since weights are nonnegative if $\epsilon_t/\alpha_m = d^m(w_m, \mathbf{x}^r_{t\,m})$ there is no weighting bias that affects only the price weight that satisfy Equation (9). Put differently, for a fixed subjective moral weight $\alpha_m$ the larger the dissimilarity on the ethical weight $d^m(w_m, \mathbf{x}^r_{t\,m})$ the lesser the scope of inducing a weighting bias that induces unethical behavior. Similarly, if the DM idealizes a low price alternative (i.e. lower prices are desired) and the unethical alternative has a lower price such that $d^p(w_p, \mathbf{x}^r_{t\,p}) \approx 0$, the range of weighting biases needed is considerably increased.

Given that at least theoretically there is space for inducing changes in ethical attitudes that affects decision outcomes, what kind of weighting biases operate in practice? Moral behavior is commonly associated with social-dependent effects, and what an individual considers ethically right or wrong depends on the corresponding community value. That is, the ethical-institution creates and reinforces a weighting bias that operates consciously or unconsciously depending on the situation.[58] This kind of weighting bias is social dependent, since weights vary endogenously with the social context.[59]

However, it is also possible that a weighting bias arises from context-dependent motives, and the attraction effect discussed above is a very simple example of how this can happen. If the introduction

[56]Recent neuroscience research suggests that ethical and social behavior and decision-making are functionally closely related. See for example Damasio (2007) and Hauser (2006).

[57]For instance, a DM that decides not to buy illegal CDs or DVDs because it is *wrong* even though illegal ones are substantially cheaper (even free).

[58]When a choice contradicts communal values, as in breaking a law, the effect is salient and conscious. When a choice is affected by communal values *but* agrees with these, the effect is most likely operating at an unconscious level.

[59]This suggests and interesting future extension of the theory where weights are adjusted endogenously in a fashion similar to equilibrium prices in general equilibrium theory.

of an alternative in the choice set makes one feature particularly salient, other previously weighted alternatives— like the ethical content, for example— will not be perceived. Notice also that in the absence of social-dependent effects, nothing guarantees the stability of the ethical-institution.[60]

# 5 Conclusions

The standard modeling framework in economics— the maximizing-utility paradigm— focuses almost exclusively on the incentive and information structures that individuals have when making decisions. In this sense, one of the distinguishing aspects of economics, compared to other social sciences, is the central role that incentives play on decision-making.

In this paper a somewhat different modeling framework is proposed, one where the procedural aspects play a central role, and incentives, although implicit, play a secondary role. It is indeed a "framework" since it allows us to study many kinds of decision situations, and a few specific applications were sketched and discussed in Section 4. Both approaches should be viewed as complementary, since by focusing on incentives or procedural aspects different questions can be asked, and hence, different predictions and conclusions can be reached.

In the static model the primitives are a frame-dependent similarity function, a reference alternative, and a minimum-distance choice function. While the minimum-distance choice function reflects the intentionality of the DM, the reference alternative allows him to approximate how "suitable" are other alternatives. The degree of suitability is multidimensional, and we argue that the usual hedonic aggregation is too raw to make decision theory descriptively accurate. Even though many other alternatives can be stored in the memory— but undoubtedly not all, constraining by construction the experimentation observed in real-life choice suituations— experimental data suggest that extreme cues are more easily remembered. This is the rationale behind storing the *most preferred* alternative, but in many decisions the *least preferred* alternative will be more salient, and the DM instead of minimizing the dissimilarity, will maximize it. The extension and rationale are straightforward.

The generalized similarity function is the natural mechanism to perform comparisons. Similarity assessments are ubiquitous in nature, and in decision-making contexts, allow for the inclusion of both sensory and emotional elements, that creates the endogeneity of the preference relation. The fact that both sensory and social cues induce different decision outcomes is supported by personal experience and from large amounts of experimental data coming from sources as different as psychology, biology, neuroscience, sociology, etc.

Boundedly rational experience is the mechanism that links the static and dynamic framework. References may very because of experimentation, and the degree of experimentation depends on recent past experience. Our approach is motivated by regret matching adaptive heuristics (Hart and Mas-Colell, 2000).

One natural source of criticism is that we "just" replace a complete and transitive preference relation with a complete but frame-dependent similarity function. In the absence of weighting or idealization biases, the similarity function is indeed equivalent to a "nice" preference relation and therefore, the critics may argue, we have really only changed the language and interpretation, without any substantive changes. A reply to this source of criticism starts with a reminder that our approach is focused on the procedure and not on the outcomes. One can certainly find an expected

[60]This is in line with evidence from socialist countries where the substitution of material for moral incentives has been in general unsuccessful. See for example Bernardo (1971).

utility function that rationalizes an outcome, but this ex-post reasoning is, by construction, outcome based, and says nothing about the nature of the "utility function". Moreover, given that sensory and emotional information affects outcomes, it is reasonable to try to understand how this information is linked to actual decision processes. Put differently, if our aim as social scientists is understanding and predicting the phenomenon under scrutiny, not taking into account this information biases the analysis from the beginning. It is important to make clear that we do not contend that standard decision theories are useless. In fact, we argue that since our concern as economists are the incentive and informational structures that affect the *directionality* of outcomes, the maximizing-utility framework is indeed the most appropriate one whenever material incentives are salient.

Another possible source of criticism is that we are assuming too much, or overfitting the model. Compared to the standard approach, the only one additional feature that we include is the frame-dependence of the similarity function. The empirical fact is that choices are reference dependent, and therefore, some kind of mechanism has to be assumed. One could alternatively define a reference-dependent preference order like in Tversky and Kahneman (1991), but the underlying mechanism would not be fully specified since the change of a reference generally induces a weighting bias (Example 2.4) that is most naturally understood with the similarity approach. A related source of criticism is that the sources of frame-dependence are left unspecified, and in this sense, might be used ex-post to rationalize any kind of behavior: for any observed outcome we can always find a set of subjective weights that explains it. This criticism applies, of course, and is related to the problem of *falsifiability of a theory*.[61] Confirmation of the theory, or of any of its multiple ingredients, can be found in the vast experimental psychology literature.[62]

One might still wonder if the theory is refutable or falsifiable, since confirmation of a theory is difficult to assess, especially when there are multiple competing theories that claim to explain an observable outcome. This is a difficult, but important question: are there any tests of the theory that completely falsify it? One might imagine experiments that try to induce weighting biases with artifacts that appeal to sensory or emotional cues (e.g. by stimulating the DM's senses we can predict the directionality of the choice, using similar strategies to those used in advertising, like exerting odor cues — "the smell of recently baked bread"— and other similar artifacts) and one possible test of the theory uses statistical tools, as those usually used in experimental psychology papers: if a large proportion of individuals do not behave in the predicted way, there is some evidence against the theory. This approach is in general not satisfactory, however,[63] and in our particular case even more problematic, since the theory has one additional degree of freedom that can in general be used to explain almost any outcome: the degree of experimentation $\epsilon_t$.[64] By varying the demographic

[61] See Popper (1981). The same criticism applies to utility theory of course: for every decision outcome we can find a utility function (or subjective beliefs) that rationalizes the outcome. It must be said, though, that maximizing-utility theory is readily falsified by considering decision situations such that include moral behavior (e.g. Sen's commitment and the dictator game, frequently used in experimental economics) or even voting applications.

[62] On similarity and the violations of the geometrical axioms see Tversky (1977) and Tversky and Gati (1982). The systematic intransitivity of preferences can be found in Tversky (1969) and is generated by what the author calls "lexicographic semi-order" that is effectively generated via a context-dependent weighting bias. As mentioned above, there is substantial evidence of idealization biases, known in the literature as "mere exposure effects" (Ye and Raaij (1997), Zizak and Reber (2004)), the "attraction effect" (Maylor and Roberts (2007), Mukesh Bhargava and Srivastava (2000), Sanjay Mishra and Stem (1993), Tversky and Simonson (1993), Yigang Pan and Pitts (1995))or "reference dependence" (Tversky and Kahneman (1991)).

[63] On this issue see Meehl (1981).

[64] The propositions sketched in the Section 4 show that the possibility of purposefully inducing a weighting bias depends on the one-dimensional similarity assessments, the relative weights, and the degree of experimentation. In this sense, one

composition of the subjects one might try to overcome this difficulty and try to falsify the theory. This is a problematic point, however, and should be taken into consideration.

Finally, an analysis of cultural transmission and the cultural effects on decision-making was sketched. Some very general sufficient conditions for cultural transmission were discussed, but at this moment, the most likely contribution is setting up the terminology for future analysis. The effects of culture on decision-making were two-fold: on the one hand, vertical transmission was used to explain the initial source for the reference alternative and subjective weights. On the other hand, social-dependent weighting biases generate horizontal cultural transmission along the lifespan. A theoretical, and to the best of our knowledge yet unsuccessfully answered question is whether the one or the other is more efficient.[65,66] Our own conjecture is that horizontal transmission has larger effects than vertical transmission, but this is to be explored in future research.

Our approach, however, allows for another interesting and difficult to assess, cultural effect, not caused, at least in the initial stages, by social-dependent biases, but by the physical context. Suppose that for any reason, all of a sudden the consumption set of a DM expands considerably, in terms of the variety of the set.[67] The new consumption set may change the saliency of some particular features that were previously unobserved, which constitutes a pure context-dependent weighting-bias. If this is true for some part of the population, a previously unnoticed feature may become an $f$-institution. The effect may reinforce itself through social-dependent biases. This is the kind of effect one usually has in mind when considering globalization or any other exogenous shock that suddenly, and considerably, changes the diversity of the consumption set, another example being the information revolution.

can always try to argue that the sample used was characterized by a low $\epsilon_t$ which makes almost impossible inducing the bias.

[65]For instance, the main result on Bisin and Verdier (2000a) depends on the assumption that the two types of transmission are substitutes, but nothing is said about the relative efficiency of one or the other.

[66]One recent notable exception is Acerbi and Parisi (2006), who construct an agent-based simulation, in the spirit of evolutionary biology models (e.g. Boyd and Richerson), where oblique and horizontal transmission play different roles: the former is simulated as transmission from the "best individuals of each generation to the individuals of the next generation" and it's role is the implementation of social learning of techniques that increase the fitness of a population. On the other hand, horizontal transmission is "a way of introducing random noise in the cultural transmission process", noise that is required with a changing environment. This interpretation is very similar to the transmission of genes: on the one hand, the replicator dynamics are fitness-improving (oblique transmission in the cultural case), and on the other hand, mutations are accumulated that allow for fitness flexibility under changing environments.

[67]We have in mind the cultural effects of globalization, as usually analyzed in other social sciences. See for example Holton (2000).

# Appendix

Recall that an alternative $a \in X$ is said to be *revealed preferred* to $b$, denoted by $a \succeq^* b$, whenever $a = c(X)$, and $b \in X$.

**Proof of Proposition 1**

Since the consumption sets are closed and convex, and the distance function is a metric, and thus continuous, the minimization problem is well defined, and the solution is unique. If $a \succeq^* b$, then by definition, $d(a, \mathbf{x}_t^r) \leq d(b, \mathbf{x}_t^r)$. On the other hand, if $a$ is more similar to $\mathbf{x}_t^r$ than $b$, a minimum distance function will always select $a$ instead of $b$. □

The next proposition establishes that minimum distance functions satisfy the Weak Axiom of Revealed Preference (WARP), which implies that consumers using minimum distance functions act *as if* they maximize utility. A well known result in the rational choice literature is that WARP can be decomposed into Sen's Properties $\alpha$ and $\beta$, which for the sake of completeness we enunciate in what follows (see e.g. Kreps (1988)).

**Property $\alpha$.** If $x \in B \subseteq A$, and $x \in c(A)$, then $x \in c(B)$

**Property $\beta$.** If $x, y \in c(A)$, $A \subseteq B$ and $y \in c(B)$, then $x \in c(B)$.

**Proposition 6** (Minimum Distance Choice Functions Satisfy Properties $\alpha$ and $\beta$)**.** Fix a reference alternative $\mathbf{x}_t^r$ and a distance function $d$. A minimum distance choice function satisfies Sen's Properties $\alpha$ and $\beta$.

*Proof.* We first proof that Property $\alpha$ is satisfied. Let $x \in B \subset A$, and assume that $x \in c(A)$. Then, by definition $d(x, \mathbf{x}_t^r) \leq d(y, \mathbf{x}_t^r)$, for all $y \in A$. Since $x \in B \subset A$, the latter condition is also true, and thus, $x \in c(B)$.

Now let us proof that Property $\beta$ holds. Let $x, y \in c(A), A \subseteq B$ and $y \in c(B)$. Since $x, y \in c(A)$, it must be that $d(x, \mathbf{x}_t^r) = d(y, \mathbf{x}_t^r)$. Then, since $y \in c(B)$, clearly a minimum distance function will also select $x$, that is $x \in c(B)$. □

An immediate corollary from the previous proposition is that if a reference bundle is fixed, a decision maker that uses a similarity function satisfying the triangle inequality and chooses according to the minimum distance criterion will appear to be *as if* he maximizes utility.

**Corollary 1.** Fix a reference bundle $\mathbf{x}_t^r$ and a distance function. Assume that the reference sets $X_t$ are closed. An agent that chooses using a minimum distance choice function acts *as if* she maximizes her utility. □

If we start from an increasing utility function (on a compact domain) representation we can also define a similarity function as follows: let $\mathbf{x}_t^r$ be the alternative that maximizes the utility function on it's domain (i.e. $\mathbf{x}_t^r = \arg\max_{\{y \in \text{ Dom } u\}} u(y)$), and define the similarity function by $d(a, \mathbf{x}_t^r) = |u(a) - u(x)|$ which trivially satisfy the axioms of a metric.[68] Finally notice that a multi-utility representation (e.g. Ok (2002), Masatlioglu and Ok (2005))— that is, a vector valued utility function— corresponds more exactly to the similarity theory proposed here.

[68]Notice that to satisfy the (P) axiom we need to impose that the utility function is monotonic.

A reasonable similarity function is the *lexicographic similarity function* defined as follows:

Let $K = \{1, \cdots, k\}$, and $\sigma : K \to K$ be a permutation of the indices of the features of the commodities, interpreted as the *subjective ranking* that an individual gives to each of the features. Also, let $g : K \to \mathbb{R}_{++}$ by a positive and decreasing function, such that $g(\sigma^{-1}(1)) = M >> 0$, and $g(\sigma^{-1}(k)) = 0$, with $M$ a large real number. Finally, let $\Xi = \{\epsilon_1, \epsilon_2, \cdots, \epsilon_k\}$ be a collection of $k$ non-negative real numbers, and $F = \{d_1, \cdots, d_k\}$ be a collection of distance functions, where $d_l : \mathbb{R}^2 \to \mathbb{R}$, for all $l = 1, \cdots, k$.

**Definition 2** (Lexicographic Distance)**.** For any $a, b \in \mathbb{R}^k$, the lexicographic distance between $a$ and $b$ is defined by

$$d^{\mathcal{L}}(a,b) = \begin{cases} g(\sigma^{-1}(1)) & \text{if } d_{\sigma^{-1}(1)}(a_{\sigma^{-1}(1)}, b_{\sigma^{-1}(1)}) > \epsilon_{\sigma^{-1}(1)} \\ & \text{if } d_{\sigma^{-1}(l)}(a_{\sigma^{-1}(l)}, b_{\sigma^{-1}(l)})) \leq \epsilon_{\sigma^{-1}(l)} \\ g(\sigma^{-1}(j-1)) d_{\sigma^{-1}(j)}(a_{\sigma^{-1}(j)}, b_{\sigma^{-1}(j)}) & \text{for all } \sigma^{-1}(l) < \sigma^{-1}(j) \\ & \text{and } d_{\sigma^{-1}(j)}(a_{\sigma^{-1}(j)}, b_{\sigma^{-1}(j)})) > \epsilon_{\sigma^{-1}(j)} \\ g(\sigma^{-1}(k)) & \text{otherwise} \end{cases}$$

Two comments about this definition are in place: on the first hand, the function $g$ is to be chosen such that the perceived difference from going to one feature to another is large enough, and this, of course, may vary with the scale of the features. A function such as $g(x) = 10^{-(x-k)}$, for example, may work in applications where the scale of the features is such that a one-place shift in the decimal place is enough to make the change in the distance significant enough to be perceived.

Notice that we also allow for a degree of fuzzyness in the evaluation of the similarity for each feature (see the $\epsilon$s), and for different distance functions for each feature, giving the model more generality and realism.

With this in mind, it is interesting to see what properties does the lexicographic distance function satisfy. It is straightforward to verify that it satisfies the minimality and symmetry conditions: for all $a, b \in \mathbb{R}^k$, $d^{\mathcal{L}}(a,b) \geq 0$ and $d^{\mathcal{L}}(a,a) = 0$, $d^{\mathcal{L}}(a,b) = d^{\mathcal{L}}(b,a)$, respectively, and that for a suitably chosen function $g$ it also satisfies the triangle inequality $d^{\mathcal{L}}(a,b) + d^{\mathcal{L}}(b,c) \geq d^{\mathcal{L}}(a,c)$. This last point is important: in general the triangle inequality will *not* be satisfied, since the similarity in one particular feature can be confounded with similarity of other features, as the next example shows, and therefore, this function is actually a semimetric.

**Example 5.1** (Lexicographic Distance not Satisfying the Triangle Inequality)**.** Let $a = (1,2,8)$, $b = (2,2,3)$, $c = (1,2,2)$, $\sigma(k) = k$, for $k = 1,2,3$, $g(k) = 3 - k$, $\Xi = \{0,0,0\}$, and $F = \{d_1, d_1, d_1\}$, where $d_1$ represents the absolute value distance function. Notice that $d^{\mathcal{L}}(a,c) = 6$, $d^{\mathcal{L}}(a,b) = d^{\mathcal{L}}(b,c) = 2$, a clear violation of the triangle inequality.
Nevertheless, if we take $g(j) = 10^{3-j}$, we have $d^{\mathcal{L}}(a,c) = 0.5$, $d^{\mathcal{L}}(b,c) = d^{\mathcal{L}}(a,b) = 0.01$, so the triangle inequality is satisfied. □

Nevertheless, the properties that a similarity function satisfy should conform to behavioral assumptions. Tversky (1977) discusses instances where the properties of a distance function are not reasonable to expect, and therefore, proposes axioms that a similarity function should have. See also Rubinstein (1998).[69]

[69]For instance, Tversky (1977) proposes a monotonicity axiom that states that two for any three alternatives $a, b, c$, $a$ is said to be more similar to $b$, than $c$ to $b$, if $a$ and $b$ have more common features than $a$ and $c$, and if the number of features that $b$ has and $a$ does not is less than the number of features than $b$ has and $c$ dos not. The monotonicity arises when this axiom is posed in set theoretical terms. Clearly the lexicographic distance function does not satisfy the Tversky's monotonicity axiom as the first case in Example 5.1 shows.

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