Rational Choice with Category Bias: Theory and Experiments

Amnon Maltz (NYU) **Job Talk**

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Abstract

This paper develops, using the revealed preference approach, a model of choice with initial endowments and in the presence of alternatives that are grouped into categories. Our model generalizes the classical individual choice model which is rationalized by utility maximization, and reduces to that model in the absence of an initial endowment. Given an exogenous endowment, our decision maker follows the following steps: First, she identifies the best alternative in the choice set which belongs to the same category as her endowment. This alternative serves as her endogenous reference point and induces a "psychological consideration" set. Finally, she chooses the best available alternative in her consideration set according to her reference-free utility. The model gives rise to a "category bias" which generalizes the status quo bias by attracting the decision maker towards the endowment's category but not necessarily towards the endowment itself. It also accommodates recent experimental findings on the absence of status quo bias among similar goods. Finally, we empirically test and find support for the main assumptions of our model.

Keywords: Status Quo Bias, Categories, Reference dependence, Experiments.
JEL Codes: C91, D11.

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1 Introduction

Many empirical studies, both within economics and psychology, have established that individuals' decisions are dependent on references. One common such reference is the current status quo held by the agent. The status quo bias, a term coined by Samuelson and Zeckhauser (1988), describes a specific type of reference effect in which individuals tend to choose their initial endowment more frequently than would be predicted by the standard model of choice. Since these original findings, evidence for this bias has emerged from a wide range of markets and for different types of goods[1].

Alongside the abundance of evidence in support of the bias, some recent experimental findings highlight situations in which it is absent. An example is given by Maltz and Romagnoli (2014) who investigate how ambiguity affects the bias. They find that when the choice set consists only of risky lotteries or only of ambiguous bets there is no evidence of the bias. More examples are given by Dean (2008) as well as Ren (2014) who study how the size of the choice set affects the bias. For some of their smaller choice sets, they report no significant effect of the endowment on choices. The interesting aspect of these findings is that they all share a common feature - the similarity of alternatives in the choice set.

In the experiment by Maltz and Romagnoli (2014) for example, the alternatives available for choice are Anscombe-Aumann acts. In this context, it is natural to consider a state-contingent claim (act) which involves uncertainty as "dissimilar" to one which is not uncertain (but is still risky). Viewed this way their findings show that when alternatives were "similar to each other" the bias was absent. To the contrary, they ran other treatments that involved both ambiguous bets and risky lotteries (hence "dissimilar" alternatives) in which the bias emerged. In Dean (2008) no status quo bias was reported for small choice sets of 2-3 alternatives, all comprising risky lotteries. The same is true for Ren (2014).

Our paper takes a closer look at the role of similarity of alternatives on status quo bias. We investigate this role theoretically as well as experimentally. On the theoretical front, we use the revealed preference approach to derive a representation theorem in a world in which alternatives are grouped together into disjoint categories which are determined exogenously. To test the model's assumptions and predictions, we design a choice experiment in the presence of goods that naturally fit into disjoint categories.

Although many models of choice are adequate for studying the status quo bias, for example, the loss aversion model by Kahnemann and Tversky (1979, 1991), "constrained optimization" by Masatlioglu and Ok (2014) and Ortoleva (2010), we are unaware of a model that examines this phenomenon with relation to a similarity structure on the space of alternatives. Moreover, it seems to have been overlooked by experimental studies as well. This gap, which the above findings suggest is of great importance, we try to fill in

[1] See among many others: Knetsch (1989) as well as Knetsch and Wong (2009) who study the phenomenon using every day ordinary goods, Madrian and Shea (2001) and Choi et al. (2004) for a close examination of 401(K) retirement plans, Johnson and Goldstein (2003) for a study on organ donations and Kempf and Ruenzi (2006) for evidence from mutual fund markets.

this paper.

Our representation maintains a strong rationality structure and reduces to standard utility maximization in the absence of a status quo alternative. When facing a choice set given an initial exogenous endowment, our agent follows this procedure: First, she recognizes the best feasible alternative which is similar to her endowment according to her reference free utility [2]. This alternative becomes her "psychological endogenous reference point". In turn, this point induces a "psychological constraint set" which consists of all alternatives which are deemed "choosable" from the perspective of that reference. Finally, the decision maker evaluates all feasible alternatives in her constraint set and picks the one that maximizes her reference-free utility function. Figure 1 illustrates this choice procedure.

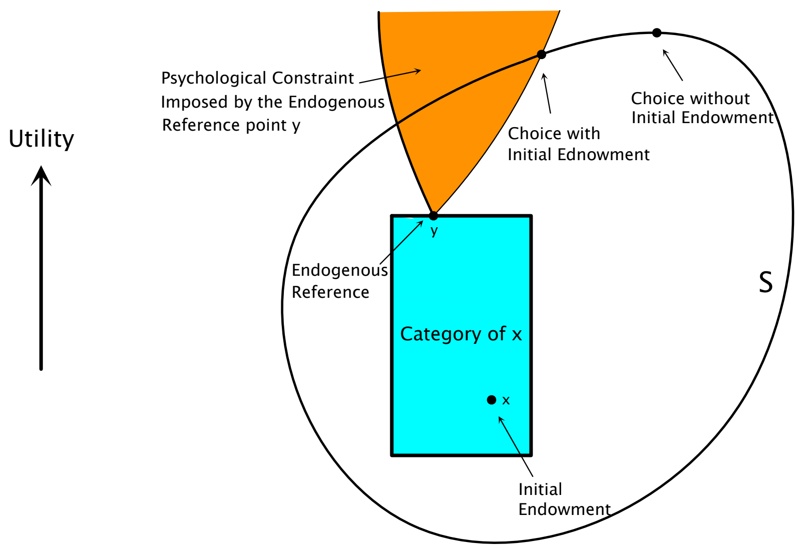


Figure 1
Initial Endowment highlighting endogenous reference which induces constraint set

The first step of the above procedure is the novel aspect of this model. In this step the decision maker could be thought of as making an "easy comparison" - one in which she considers only goods which are similar to her endowment. This step highlights the endogenous reference point, one which is both similar to her endowment and dominates it (in the endowment-free utility sense). If such an alternative exists, the decision maker will abandon her exogenous endowment regardless of the remainder of her choice procedure. She might however, end up with her endogenous reference point in which case her choice remains in the same category of the exogenous endowment, a behavior we call "category

[2]If there is more than one such alternative, she picks among them randomly.

bias".

The final two steps are identical to those developed in Masatlioglu and Ok (2014) which they dub "constrained utility maximization". In the second step a "psychological constraint set" is induced by the newly found reference point. This set contains all alternatives which the decision maker would consider form the point of view of that reference and may very well include alternatives which are outside the endowment's category. Importantly, this set always contains the reference point itself (the one highlighted earlier by the endowment). Finally, the decision maker chooses the best feasible alternative in the constraint set according to her reference-free utility.

The main axiom of our model, which we name "Categorical Referential Equivalence" (CRE) states that similar alternatives have the same effect on choice. More formally, for any set S and any two similar alternatives x and y that belong to S, we have $c(S,x) = c(S,y)$. We also impose the Weak Axiom of Revealed Preference (WARP) which translates into the strong rationality structure exhibited by our decision maker. Two more axioms relate directly to the (weak) status quo bias effect of the exogenous endowment.

We define a category to be a subset of the set of available options that are perceived by the decision maker, as well as an outside observer, as tied together in a particular application. Thus, besides the intrinsic properties of the various goods, there is also a characteristic - for instance the brand or the country of origin, that induces consumers to see the alternatives as being grouped into categories. We assume exogenous categories and do not attempt to derive them from choice. Importantly, our categories are disjoint and yield a partition of the grand space. What determines the categories is the application at hand

Our model makes the following unique prediction: In the presence of choice sets comprising only similar goods, the status quo bias will be absent. Given the choice procedure described above, the agent finds no difficulty in realizing what the best available option similar to her endowment is. In the presence of only such alternatives she will simply choose the best one, just as she would absent an endowment. Thus, without compromising the prediction of status quo bias in general contexts, the model accommodates the findings regarding its absence reported above.

In the experimental part of this work we design a choice experiment involving six goods which naturally fit into three disjoint categories - chocolates, pens and umbrellas. We conduct a between subject design in which subjects make choices from different subsets of these six goods. The experiment consists of five treatments. In the first, subjects are not given any endowment when making their choices. In the other treatments, subjects are given either a chocolate or a pen and are asked to make choices framed as a switch from their endowment to one of the other alternatives. We run this experiment both in the lab and on Amazon Mechanical Turk (AMT). The lab version uses real incentives for subjects while on AMT incentives are weaker but the subject pool larger.

Utilizing this design we test our CRE axiom. Comparing the distribution of choices made in the same questions across different treatments, allows us to assess the reference effects of different goods when serving as the endowment. We find support for the behavior described by the CRE axiom, namely that similar goods have the same effect on choices when designated as an endowment. We also check and find support for the prediction regarding the absence of the status quo bias, when choice sets involve only goods within the same category.

The remainder of this paper is organized as follows: In section 2 we briefly review the related literature. Section 3 describes the model and the results. Section 4 describes the experiments and findings while section 5 concludes. Proofs are given in the appendix.

2 Related Literature

Our paper is closely related to Masatioglu and Ok (2014, henceforth MO). We use a similar set up to theirs and add an exogenous partition on the grand space of alternatives. In the extreme case of the finest partition on the space, i.e. when every category is a singleton, our model reduces to theirs. Moreover, in that case our axioms also reduce to theirs. The departure from their model, emerges exactly in those cases in which the partition is not trivial and the space contains alternatives which are distinct from each other yet similar to each other. It is in this case where our reference equivalence axiom has bite and leads to the endogenous reference point.

We also relate to models of endogenous references, such as Ok et al. (2014). In their model, when facing a choice set, the agent highlights an endogenous reference point from which a constraint set is induced as in our model. The models share the emergence of the endogenous reference point but differ in the set up as well as the axiomatic approach. Most notably, their model, which captures behavioral biases such as the attraction effect, does not deal with similarities or categories and also examines choice problems without an exogenous endowment.

Barbos (2010) develops a model of choice from categories in which the decision maker evaluates the different categories and then chooses the best alternative within the chosen category. The choice of category is affected by not only the best alternative in that category but also the worst. His work shares the structure of categories with our model although he allows for an overlap in the categories facing the decision maker while our categories constitute a partition of the space. As in Ok et al. (2014) his work is intended in capturing some type of attraction effect and hence choice problems do not include an exogenous endowment. The axiomatic development and representation are also very different than those we utilize in this work.

On the empirical front, our paper relates to the vast literature on status quo bias starting with Knetsch (1989)[3]. As in his experiment, we use ordinary every day goods and a design made up of simple choice problems. As mentioned in the introduction, our model predicts and is motivated by some recent reports on the absence of the status quo bias in

[3]For a critical view see Plott and Zeiler (2007) and for a reply Knetsch and Wong (2009).

laboratory set ups involving goods which were similar to each other (Maltz and Romagnoli (2014), Dean (2008) and Ren (2014)).

3 Model

3.1 The basic framework

We adopt the framework developed by MO. We designate a finite set X to act as the universal set of all mutually exclusive alternatives. The set X is thus viewed as the grand alternative space and is kept fixed throughout the exposition. The members of X are denoted as x,y,z, etc.. We assume there exists an exogenous partition on the set X, denoted by $X \equiv \sqcup_{i=1}^{n} X_i$ for some $n \in \mathbb{N}$. Each cell in the partition should be thought of as a category of goods, i.e. a group of alternatives linked by some characteristic. For every $z \in X$ we denote by X_z the cell in the partition which z belongs to[4].

We designate the symbol $\lozenge$ to denote an object which does not belong to the set X. We shall use the symbol σ to denote a generic member of $X \cup \{\lozenge\}$. We let Ω_X denote the set of all subsets of X. By a choice problem we mean a list (S, σ) where $S \in \Omega_X$ and $\sigma \in S \cup \{\lozenge\}$[5]. The set of all choice problems is denoted by $\mathcal{C}(X)$. The interpretation of a choice problem (S, x) with $x \in S$ is that the decision maker is confronted with choosing an alternative from S while currently endowed with $x \in S$. Alternatively, a choice problem $(S, \lozenge)$ is interpreted as a choice from S absent an endowment.

By a choice correspondence in this set up we mean a function $c : \mathcal{C}(X) \to \Omega_X$, such that

$$c(S, \sigma) \subseteq S \quad \text{for every} \quad (S, \sigma) \in \mathcal{C}(X).$$

3.2 Axioms

We introduce four axioms. The first two are taken directly from MO while the third is a natural adjustment of their Status Quo Irrelevance (SQI) axiom to the current set up. The fourth axiom is the novel behavioral postulate of this model as it relates and restricts the choice function with respect to the partition structure we have imposed on X.

We begin our axiomatic development by introducing a rationality property familiar from the classical theory of revealed preference. As in that theory, this property warrants that some type of utility maximization does take place in the decision-making procedure.

Weak Axiom of Revealed Preference (WARP). *For any (S, σ) and (T, σ) in $\mathcal{C}(X)$,*

$$c(S, \sigma) \cap T = c(T, \sigma)$$

[4]Throughout the paper we refer to alternatives in the same category as "similar to each other" although the relation underlying our set up is in fact an equivalence relation.

[5]By this formulation, the endowment is always available for choice.

provided that $T \subseteq S$ *and* $c(S,\sigma) \cap T \neq \emptyset$.

This property conditions the behavior of a decision maker across two choice problems whose endowment structures are identical. In this sense, it is merely a reflection of the classical weak axiom of revealed preference to the framework of individual choice in the (potential) presence of an exogenously given reference alternative. When $\sigma = \Diamond$, our formulation of WARP reduces to the classical formulation of this property.

Next, we impose the weak status quo bias property first introduced formally by MO.

Weak Status Quo Bias (WSQB). *For any* $x, y \in X$,

$$y \in c(\{x,y\}, x) \quad \textit{implies} \quad y \in c(\{x,y\}, \Diamond)$$

and

$$y \in c(\{x,y\}, \Diamond) \quad \textit{implies} \quad y \in c(\{x,y\}, y.)$$

The Weak Status Quo Bias property is a very natural postulate to impose on a decision maker who may be vulnerable to the status quo bias phenomenon (at least in the weak sense). Put simply, it states that if y is chosen over x when x is the status quo alternative then it must also be chosen over x in the absence of a status quo alternative. The second part is similar - if y is revealed preferred to x without a status quo option then it must also be revealed preferred to it when acting as the status quo [6]. It is important to note that the axiom is stated in a "weak" manner which allows the decision maker to exhibit, or not to exhibit status quo bias, depending on the alternatives at hand.

The next axiom describes situations in which the presence of a status quo option would not have any effect on choices. As mentioned earlier, this axiom is an extension to the Status Quo Irrelevance (SQI) axiom proposed by MO. Roughly, it states that if the status quo bias is a "bad" enough alternative it will not have any effect on choice.

Category Status Quo Irrelevance (CSQI). *For any given* (S,x), *suppose that* $c(T,x) \not\subseteq X_x$ *for every subset* T *of* S *such that* $[S \cap X_x] \subset T$. *Then* $c(S,x) = c(S,\Diamond)$.

CSQI delineates how "bad" need an alternative be in order for it to become irrelevant when serving as a status quo. Specifically, suppose the decision maker faces a choice problem (S,x). Moreover, suppose that for any subset T of S, that contains all alternatives in S that are similar to x and at least one alternative which is not, the decision maker chooses an alternative dissimilar to x. According to CSQI, x will be irrelevant if designated as a status quo in the sense that the choice from (S,x) would be the same as the choice from $(S,\Diamond)$. This axiom reduces to MO's SQI in the case of the finest partition, i.e. when

[6] For a more elaborate discussion of this axiom see MO.

every alternative is similar only to itself. Once again, for a more elaborate discussion of this property alongside a critical point of view, the reader is kindly referred to MO.

So far, we have imposed only seemingly weak links between choices and the partition on our grand set X. In fact, the only link provided so far (through CSQI) simply emphasizes the inferiority of the status quo alternative in some choice problems. Our next behavioral postulate, which we consider the main axiom of our model, gives such a link in a very straightforward manner. Putting succinctly, it states that two alternatives which are similar to each other have the same referential effects.

Categorical Referential Equivalence (CRE). *For any given $S \in \Omega_X$,*

$$c(S,x) = c(S,y)$$

provided that $x, y \in S \cap X_x$.

CRE simply states that if two alternatives are in the same category, and both are in the choice set S, replacing one with the other as the status quo alternative should have no impact on choice. This assumption takes a stand on the variety of effects a status quo option may have in the presence of categories. If WSQB is viewed as a weak highlighting of the status quo alternative in the decision maker's mind then, combined with CRE, we may view the status quo alternative as weakly highlighting its category rather than itself. This axiom is at the heart of this model and the representation to follow. As far as we know, this axiom is novel and we directly test it in the experimental part of this work.

3.3 Partial characterization of the model

We start by stating a lemma en route to our main representation theorem.

Lemma 1 *Let X be a non-empty finite set and c be a choice correspondence on $\mathcal{C}(X)$. If c satisfies WARP, WSQB, CSQI and CRE, then there exists a (utility) function $U : X \to \mathbb{R}$ and a self-correspondence Q on X such that*

$$c(S, \Diamond) = \arg\max U(S) \tag{1}$$

and for every $(S,x) \in \mathcal{C}(X)$,

$$c(S,x) = \arg\max U(S \cap Q(z)) \tag{2}$$

where $z \in \arg\max U(S \cap X_x)$, and

1. *For any $x_1, x_2 \in X$ such that $x_1 \in X_{x_2}$*

$$U(x_1) \geq U(x_2) \;\Rightarrow\; Q(x_1) \subseteq Q(x_2).$$

This lemma provides sufficient conditions for the representation outlined in the introduction. To understand its nature let c be a choice correspondence on $\mathcal{C}(X)$, U a real function on X, Q a self-correspondence on X and suppose that the representation holds for any choice problem $(S, \sigma) \in \mathcal{C}(X)$. When dealing with a choice problem without an initial endowment, an agent whose choice behavior is modeled through c makes her decisions by maximizing the (ordinal) utility function U. That is, in this case, her final choice is realized by solving the problem:

$$\text{Maximize } U(\omega) \text{ subject to } \omega \in S.$$

In turn, when facing a choice problem with a given status quo option, say (S, x) the agent proceeds by following a 3-stage procedure. In the first stage she identifies the best alternative in S that is similar to x. We denote this option x'. This is a stage in which "easy" comparisons are made, i.e. only alternatives which are in the same category as x are evaluated. Formally, x' is the solution to the following maximization problem:

$$\text{Maximize } U(\omega) \text{ subject to } \omega \in S \cap X_x.$$

After this alternative has been identified, it becomes the endogenous reference point in the decision maker's mind. If there are no alternatives in the choice set that are similar to x, the agent simply keeps x as her reference point.

In the second stage she uses a "psychological constraint set" $Q(x')$, induced by her endogenous reference point, and eliminates all alternatives which do not belong to this set. In other words, the agent forms the set $S \cap Q(x')$. (This set is non-empty since $x' \in S$ and by (2) and the fact that $\{x\} = c(\{x\}, x)$ we have $x \in Q(x)$ for every $x \in X$.) The last property relating U and Q imposes some structure on the constraint set. It states that within a category, the consideration set shrinks as one considers reference points with greater utility.

In the third and final stage, the agent evaluates all alternatives in the set $S \cap Q(x')$ and chooses the best one according to her reference-free utility function U. If only x' belongs to both S and $Q(x')$ then the decision maker will stay with x', exhibiting a "category bias". If in addition $x' = x$, i.e. x is the best alternative in $S \cap X_x$, the agent will exhibit a status quo bias. On the other hand, in case there are other alternatives in $S \cap Q(x')$ as well, she may or may not stay within her endowment's category. Her final choice will be realized by solving the problem:

$$\text{Maximize } U(\omega) \text{ subject to } \omega \in S \cap Q(x').$$

The role of the endowment x is simply in highlighting the category to which it belongs and "directing" the decision maker to the best feasible alternative in that category. The role of the endogenous reference point x' is generating the constraint set $Q(x')$. The reference effect kicks in whenever the constraint set eliminates alternatives which are utility superior to x'. Notice that, since the agent recognizes as a first step the best feasible alternative similar to her endowment and combined with the fact $x \in Q(x)$ for all $x \in X$, she will not exhibit any status quo bias when S contains alternatives from a single category.

To illustrate the above procedure consider the following example. Suppose you own a black stylus pen by brand Z and you are shopping for a new pen. As you enter Staples you see that there are more stylus pens by Z, one of which is silver, which is your favorite color. At this point you know that you will not stay with your black pen. Even if you are forced to leave the store now, you will for sure buy the silver pen. However, when you continue shopping you look at other pens which you are attracted to from the reference point of the Z-silver pen that you have already switched to in your mind. You might, for example, have a look at all stylus silver pens in the aisle before making your final decision. You might very well end up buying a silver pen of a different brand. In this illustration, your stylus black pen made you realize immediately the Z-stylus silver pen which then became the endogenous reference point for the remainder of the decision process.

3.4 Characterization of the main model

Lemma 1 describes sufficient conditions for the existence of U, Q and the representation given by (1) and (2) to hold. However, one can easily provide an example to show that they are not necessary for this type of representation [7]. In this section we add structure on the relationship between U and Q which will ensure the axioms we used are also necessary for a similar type of representation. In order to do so we need two definitions. Suppose that U is a real function on X and Q is a self correspondence on X.

Definition 1. We say that U and Q are **categorically-negatively-comonotonic** if for every $x, y \in X$ such that $x \in X_y$:

$$U(x) \geq U(y) \;\Leftrightarrow\; Q(x) \subseteq Q(y).$$

Definition 1 is a slightly stronger requirement than the one made in Lemma 1. In light of the representation under pursue, it states that for two similar elements, the one with the lower reference-free utility generates a larger constraint set and vice versa. It seems a rather natural requirement for two goods which are similar to each other. They both point in roughly the same "direction" but from the lower valued of the two, the agent considers (weakly) more alternatives.

[7] The two axioms which fail are WARP and CSQI. With a very slight modification of the representation we may also ensure CSQI to hold. However, a more substantial change is needed in order to ensure WARP is satisfied as well.

Definition 2. We say that Q is **U-monotonic with respect to dissimilar alternatives** if for every $x \in X$ and $y_1, y_2 \notin X_x$ such that:

- $U(y_1) \geq U(y_2)$
- $y_2 \in Q(x)$
- $y_1 \in Q(x')$ for some $x' \in X_x$

we have $y_1 \in Q(x)$.

Unlike the first definition, this one links U and Q with respect to alternatives outside the category of the reference point. It is intuitively close to stating that if an alternative y_1, dissimilar to the reference x, is considered from the perspective of x, then so will any other dissimilar alternative y_2 which has greater utility than y_1. Our formal statement given in the definition is slightly weaker by adding a requirement that y_2 needs to be considered from the point of view of some other reference point x' which is similar to x.

We are now ready to state our main result.

Theorem 1 *Let X be a non-empty finite set and c be a choice correspondence on $\mathcal{C}(X)$. Then c satisfies WARP, WSQB, CSQI and CRE if, and only if, there exists a (utility) function $U : X \to \mathbb{R}$ and a self-correspondence Q on X such that*

$$c(S, \Diamond) = \arg\max U(S) \tag{3}$$

and for every $(S, x) \in \mathcal{C}(X)$,

$$c(S, x) = \arg\max U(S \cap Q(z)) \tag{4}$$

where $z \in \arg\max U(S \cap X_x)$ and

1. *U and Q are categorically-negatively-comonotonic.*
2. *Q is U-monotonic with respect to dissimilar alternatives.*

The representation given in the theorem describes the exact same choice procedure as in Lemma 1. The only difference is that it imposes more structure on the interaction between U and Q. First, they are negatively comonotonic when looking within a category of goods, i.e. the worse the alternative the greater the constraint set it induces. Second, it requires the type of monotonicity of Q with respect to U given by the second condition.

3.5 Examples

This section presents a few examples that illustrate the type of choice behavior allowed by the above model.

Example 1. *(Rational Choice)* A decision maker who is not vulnerable to any referential effects and simply maximizes utility could be described by our model. In fact, we can describe such an agent by imposing two different restrictions - one on the exogenous partition, the other on the endogenous constraint set.

- **Example 1.1** *(Coarsest Partition Rational Choice)* Conisder the coarsest exogenous partition on the grand set X where all alternatives belong to one cell and are hence similar to each other. Suppose the agent faces choice problem (S, x). In the first step of her choice procedure, our agent identifies the best feasible alternative which is similar to x, say alternative y. In this example, this simply means that y is the best feasible alternative overall. Since $y \in Q(y)$, our agent will consider y in her final maximization stage (perhaps alongside other altetnaitves). Given that y has the highest utility in S, it will be chosen.

- **Example 1.2** *(Largest Constraint Set Rational Choice)* Our agent may also act as a utility maximizer when the partition on X contains more than one category. This may be the case if her constraint set is so large that she considers the whole space X from the viewpoint of every alternative. Formally, we describe such behavior by setting $Q(x) := X$, for every $x \in X$. Here, the endogenous reference has no bite in terms of choice since the decision maker deems all alternatives choosable prior to arriving at her final choice.

Example 2. *(No Extreme Status Quo Bias)* An interesting feature of our model is that aside for the finest partition case, our decision maker cannot exhibit extreme status quo bias, i.e. $c(S, x) = \{x\}$, for every choice problem (S, x). To this end, consider two alternatives in the same category x_1 and x_2 and assume $U(x_1) > U(x_2)$[8]. If the agent faces the problem (S, x_2) where $x_1 \in S$, she will never keep x_2 as her final choice. Rather, she will choose from $S \cap Q(z)$, where $z \in X_{x_1}$ and $U(z) \geq U(x_1)$. Since $z \in Q(z)$, x_2 will not be chosen at her final maximization stage. The MO model allows as a special case for extreme status quo type of behavior, hence this example illustrates well the difference between the two models in the presence of a non-trivial partition[9].

Example 3. *(Extreme Category Bias)* Consider a decision maker whose choice behavior is vulnerable to the category bias at the highest level. Such an agent is captured by our

[8]This is whithout loss of generality. In the following example, if $U(x_1) = U(x_2)$ the agent will still not end up choosing her endowment alone.

[9]As mentioned above, for the trivial (finest partition) case, our model reduces to theirs.

model when setting $Q(x) \subseteq X_x$ for every $x \in X$. Such an agent would never leave the category which her exogenous endowment belongs to.

Example 4. *(No Cycles)* The choice model of Theorem 1 does not allow behavior that exhibits cycles. For instance, for any distinct alternatives x, y and z, the following situation is incompatible: $\{y\} = c(\{x, y\}, x), z \in c(\{y, z\}, y)$ and $x \in c(\{x, z\}, z)$. For, by the representation derived in Theorem 1, these statements would entail $U(y) > U(x)$, $U(z) \geq U(y)$ and $U(x) \geq U(z)$ yielding a contradiction. We reach this contradiction regardless of the nature of similarity between the goods. Thus, our model (just like MO in this respect) embodies a considerable amount of rationality[10].

Example 5. *(Attraction Effect)* The procdedure followed by our decision maker gives the initial endowment the role of highlighting the best feasbile alternatives which are similar to it. Thus, in a very natural way, our model may lead to the attraction effect relative to the endowment. That is, it allows an agent to choose x over y absent a status quo and choose y over x and z, when z is the status quo. This may hold for example, if $U(x) > U(y) > U(z)$, y is similar to z but both are dissimilar to x and $x \notin Q(y)$. This type of behavior is also allowed by MO. However, there is a subtle, yet substantial difference between the two models, in terms of the behavior they describe leading to this effect in the presence of non-trivial categories. This subtle point is discussed in the next subsection.

3.6 A Comparison to MO

As discussed in the introduction and throughout the presentation of the axioms, this model is closely related to the status quo bias model of MO. In this section we briefly describe their representation theorem and outline the similarities as well as the main distinction between the two models.

Given the same set up described above, the decision maker in MO also acts as if she has a (utility) function U and a self-correspondence Q on X. Unlike in our model the constraint set is always induced by the exogenous endowment. Formally, the decision maker's choices are described by:

$$c(S, \Diamond) = \arg\max U(S)) \tag{5}$$

and,

$$c(S, x) = \arg\max U(S \cap Q(x)) \tag{6}$$

[10]Notice that our model allows $c(\{x, y\}, x) = \{x\}, c(\{y, z\}, y) = \{y\}$, and $c(\{x, z\}, z) = \{z\}$. This is not a cycle because the decision maker always stays with the initial endowment. Cycles occur when the decision maker moves away from the initial endowment in each choice problem and comes back to where she started.

As can be seen both models share the constrained maximization step. The difference between the two lies in which alternative generates the constraint set. In MO it is the exogenous endowment. In our model it may or may not be that alternative. When facing choice sets in which the exogenous endowment is the best alternative (in the reference-free sense) in its category, it will also be the generator of the constraint set. One special such case is when it is the only alternative available within the category (thus, in the case of the finest partition on X the models coincide). However, when a utility improving alternative similar to the endowment is available, our decision maker will abandon her exogenous endowment and the constraint set will be induced by a different, yet similar, alternative.

Despite the common features of the models, they predict different choices in the presence of a non-trivial partition on X. To illustrate consider a decision maker facing three laptops: An old Mac (m), a new Mac (M) and a Windows (W). Assume that both M and W are clearly a better deal than m so that it is safe to assume $U(M) > U(m)$ and $U(W) > U(m)$. Suppose that among the three alternatives, absent an endowment, the decision maker chooses W. However, when endowed with m she chooses M from the same choice set. Suppose we are interested in predicting the choice between m and W when m is the endowment. Formally, we are given $c(\{m, M, W\}, \diamondsuit) = \{W\}$, $c(\{m, M, W\}, m) = \{M\}$ and we would like to predict the choice from the problem $(\{m, W\}, m)$

According to both models the first choice (plus the assumption m worse than M) reveals that $U(W) > U(M) > U(m)$. According to MO, that together with the second choice is only compatible if W is not considered from the point of view of m ($W \notin Q(m)$). This leads to the prediction

$$c(\{m, W\}, m) = \{m\}.$$

However, according to our model, after we observe the second choice we may only conclude that $W \notin Q(M)$. Hence, it is completely plausible that $W \in Q(m)$. This also seems reasonable given that m is substantially inferior to M and W. If this is indeed the case, our model predicts

$$c(\{m, W\}, m) = \{W\}.$$

Figure 2 illustrates the Q sets implied by the first two choices in the different models and the corresponding predictions of choices from $(\{m, W\}, m)$.

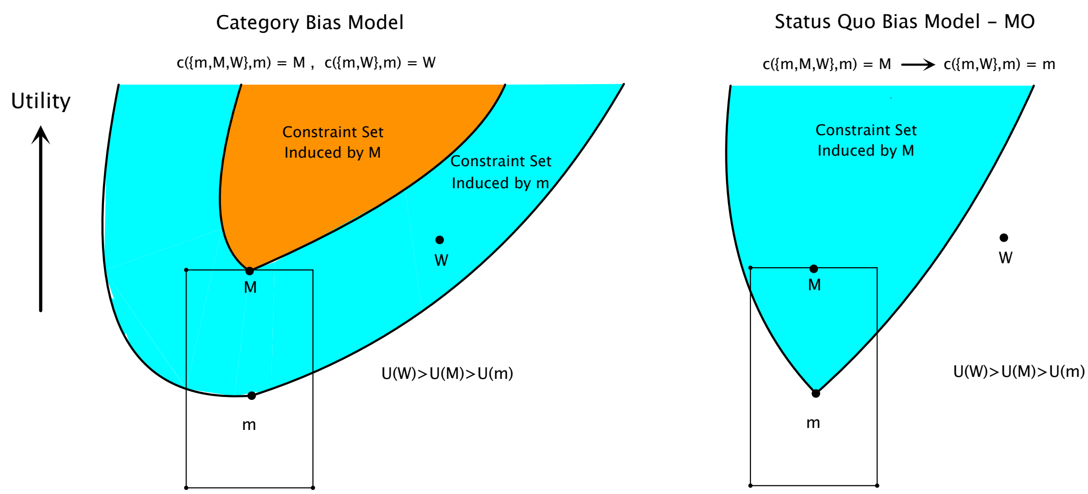


Figure 2

Comparison between CBM and SQBM

4 Experiment

We designed an experiment to test the following:

1. Axiom CRE.
2. Prediction of no status quo bias among similar goods.
3. Separation of our model from MO according to their different predictions in the context described in section 3.6.

We ran two very similar experiments in two different environments: The Cess lab at NYU and Amazon Mechanical Turk (AMT). Since the experiments were very similar we mainly describe and focus on the procedure we followed on AMT. We report the results from both experiments.

4.1 Experimental Design

Both experiments consisted of the following six items:

- 3-Godiva milk chocolate bars (G).
- 3-Hershey's milk chocolate bars (H).
- Black stylus pen by Zebra (B).

- Silver stylus pen by Zebra (S).
- 42” manual umbrella (M).
- 38” automatic umbrella (A).

The categories to which these items belong are obvious and we will refer to them as chocolates, pens and umbrellas. On the instruction page, participants were asked to examine the goods and were told that all items are worth roughly \$10 [11]. We conducted a between subject design with 5 different treatment - No Ednowment, 3-Godiva as endowment (G), 3-Hershey's as endowment (H), Black Pen as endowment (B) and Silver Pen as endowment (S). In each treatment, after examining the items, subjects were asked to answer 16 multiple-choice questions in which they had to mark their preferred choice among some of the above goods. The treatments differed according to the endowment “given” to the subjects before answering the questions. In the No Endowment treatment participants were simply asked to mark their preferred choice among different goods. In treatments G,H,B and S participants were given 3-Godiva bars, 3-Hershey's bars, a Black Pen and a Silver Pen respectively. In these treatments the questions were framed as keeping the endowment or switching to one of the other items [12].

Some of the 16 different questions were asked in all treatments and hence provided a comparison across all types of endowments. Other questions were common to 2,3 or 4 treatments out of 5 and were used to compare only some types of endowments. There were roughly 10 questions for comparison between any two given treatments. For any two given treatments we compared all common questions. We were interested in the distribution of answers across the different options and used the Pearson Chi Square Test to determine whether the choices in a given question were affected by the endowment, i.e. dependent on the treatment, or not. If they were dependent, we examined the direction in which the distribution of answers shifted according to the hypothesis under investigation[13].

4.2 Hypotheses

Our first hypothesis comes from our CRE axiom. It states that two similar goods which belong to a feasible choice set S have the same effect on choice from S when given as an exogenous endowment. Formally:

Hypothesis 1:

[11] We decided to give this information to the subjects in order to avoid a situation in which they try to evaluate the goods according to which they think is more expensive. All goods' prices ranged from \$7.8 to \$13.5.

[12] In the lab we had only 15 questions and subjects were physically endowed with the goods. We also did not run treatment S.

[13] The instructions as well as a screenshot from one of the treatments are presneted in the appendix E.

- $c(T,H) = c(T,G)$ whenever G and H belong to T.
- $c(T,B) = c(T,S)$ whenever B and S belong to T.

The second hypothesis asserts that no status quo bias arises among goods within the same category. We had only two sets of goods which allowed us to test this hypothesis - the two chocolates and the two pens.

Hypothesis 2:

- $c(\{H,G\},\Diamond) = c(\{H,G\},H) = c(\{H,G\},G)$.
- $c(\{B,S\},\Diamond) = c(\{B,S\},B) = c(\{B,S\},S)$.

Our third and final hypothesis is designed to test the different predictions of our model and MO described in the previous section. To this end, we use G and H as the two goods which are clearly ranked (Godiva higher quality chocolate than Hershey's) and the black pen as the non-similar good which should also dominate the Hershey's bars [14].

Hypothesis 3: If $c(\{H,G,B\},\Diamond) = \{B\}$ and $c(\{H,G,B\},H) = \{G\}$, then $c(\{H,B\},H) = \{B\}$.

4.3 Results

4.3.1 Results from AMT

280 subjects participated (between 50 to 63 in each treatment), each one received a compensation of \$1 per completing all answers and filling a questionnaire at the end.

We find support for hypothesis 1. Out of 10 questions that were asked in treatments G and H none had significantly different distributions of answers (using the 10% significance level as a threshold). Out of the 8 questions asked in both treatments B and S, once again none gave significantly different distributions of answers. In other words, a similar distribution of answers emerged for a given question whenever the two endowments were picked from the same category as stated by axiom CRE.

One immediate question that arises from these results is whether there was any reference effect in the experiment at all. The answer to this question is yes. Out of 10 questions asked in the No Endowment treatment and in the B treatment 8 had significantly different distribution of answers (3 at significance levels of 1% or better 3 at 5% or better and 2 at 10% or better)[15]. All differences in distributions were in line with a category bias, meaning a higher percentage of choices of pens compared to the other category goods.

[14] We also used the silver pen and one of the umbrellas in other questions.

[15] The question $\{G,H\}$ is excluded here since our model predicts no effect for that question and it is therefore discussed in support of Hypothesis 2.

When comparing the S treatment to No Endowment we find that out of 5 questions 3 were significantly different at the 5% level or better. Once again all differences were in the direction of more pen choices compared to the No Endowment treatment[16]. We did not find a reference effect/category bias when comparing the two chocolates treatments to the No Endowment treatment[17]. We elaborate the discussion on the possible explanations for an effect showing up only when comparing the pens treatments to No Endowment in appendix D. To conclude, we find support of our main assumption of the model.

Hypothesis 2 is also supported by the data. When comparing the choices from $\{H, G\}$ in the No Endowment treatment to the G or H treatments, we cannot reject that choices are independent of the treatments. As there were almost no reference effects in other questions as well when comparing chocolates treatments to the No Endowment treatment we cannot really view this finding as evidence for the hypothesis. However, there were also no significant differences in distributions of answers when comparing the choices from $\{B, S\}$ in the three relevant treatments. As stated above, stark differences between the pens treatments and the no endowment treatment were found for most other questions. Hence, this finding serves as strong evidence for our hypothesis[18].

Hypothesis 3 was not supported nor rejected since we did not find any differences in the distributions of answers from the choice problem $(\{H, G, B\}, \lozenge)$ compared to $(\{H, G, B\}, H)$. In order to test this hypothesis we are currently designing a within subject treatment with slightly different goods. Without finding a shift in choices from the Black Pen towards the Godiva bars we are unable to test this hypothesis. We hope to utilize the greater power of a within design in order to examine whether such a shift takes place for a substantial percentage of participants. If the data will confirm this shift, we will be able to compare the predictions of the models.

4.3.2 Results from the lab

105 undergraduates from NYU participated in 4 different treatments (No Endowment, H, G and B, between 19 to 31 in each group). Subjects were paid a show up fee of $10 and received an item that they chose from a randomly selected question. Among the 15 questions asked, roughly 7 were common to two or more of the treatments.

Counter to the findings on AMT we found some reference effect between the No Endowment treatment and the chocolates treatments and no reference effect between the B treatment and the No Endowment (for a discussion see Appendix D).

We again find some support (although weaker than on AMT) for the first hypothesis, i.e. for axiom CRE. Since we didn't have the S treatment, we could only compare across

[16] See figures 3-10 in appendix B.1 for the distributions of answers in two questions.

[17] In fact, two questions showed a marginally significant movement away from the category in the G treatment compared to No Endowment. No effect in either direction was found when comparing the H treatment to No Endowment.

[18] See tables 11-16 in appendix B.2 for the distribution of answers in the two questions across the different treatments.

treatments H and G. Of 8 questions shared by both treatments only two had significant differences at the 8% level[19]. Regarding general reference effects, we find some when comparing No Endowment to H (4 out of 9 questions different at the 10% level or better) but almost none when comparing No Endowment to G (only 1 question out of 7 is different)[20].

We find similar support for the second hypothesis to that found on AMT, i.e. no differences in distribution of choices from $\{H, G\}$ across the 3 treatment (No Endowment, H and G). This finding is mitigated by the weak evidence for a reference effect across the other questions as reported above. Finally, we are once again unable to check the third hypothesis since no reference effect of the Hershey's bars showed up in the choice between H, G and B or H,G and S.

4.4 Summary of Results

In general we find evidence for our main axiom CRE stating that similar goods have the same referential effects on choice. The evidence is somewhat stronger on AMT perhaps due to the larger number of observation. More possible explanations and a discussion regarding differences in results between AMT and the lab are discussed in appendix D. We also find support for the no-status-quo-bias-among-similar-goods prediction of our model. However, given our simple set up and limited number of goods, this prediction could only be tested for two doubleton sets. In both environments (AMT and the lab) we found limited positive evidence for some reference effect showing up across the different treatments, an effect which may count as validation for our findings[21].

5 Conclusion

We use the revealed preference approach to develop a model of choice with initial endowments and in the presence of goods that are grouped into categories. Our decision maker first focuses on goods that are similar to her endowment. Among those she identifies the one with greatest (reference-free) utility and treats it as her endogenous reference point. This reference induces a constraint set from which she makes her final choice by picking the utility-maximizing alternative.

The model is a generalization of the rational choice with status quo bias model by Masatlioglu and Ok (2014) and reduces to their model when categorization is trivial. The

[19]These differences vanished when we grouped answers by categories. Thus the reference effects in those questions did not shift choices across categories rather only within categories.

[20]In this case, grouping the answers into categories leads to more reference effect showing up between No Endowment and G. Thus, it is possible that the small number of observations in each treatment is behind the relatively weak separation level across these treatments.

[21]In Appendix D we elaborate on reasons why this effect was relatively weak. We also discuss a list effect which might have been more pronounced on AMT and may have contributed to the reference effect found there. We are currently in the process of running more sessions with different goods and more controls to try and strengthen the reference effects between the no endowment treatment and the other treatments.

main axiom of our model posits that choices from the same set given different, yet similar, status quo alternatives are identical. We find supporting evidence for this axiom in an experiment using ordinary every day goods.

Our decision maker's behavior could be summarized as "rational choice with category bias". Rather than an inclination to choose her endowment she is biased towards choosing an alternative which is similar to it. This is a generalization of the status quo bias in the presence of categories. The model predicts rational choice in the presence of similar goods, a recent empirical finding reported in different set-ups. In our experiment, we find and report further support for this prediction.

6 Appendix

A Proof of Theorem 1

We first prove the "if" part of the theorem. Let $U : XR$ be a function and Q be a self- correspondence on X, that satisfy conditions (1) and (2) and take any choice correspondence c on C(X) that satisfies (3) and (4) for any $(S, \sigma) \in \mathcal{C}(X)$. We first make the following observations:

Claim 1.1. For every $x, x' \in X_x$, $U(x) = U(x') \Rightarrow Q(x) = Q(x')$.

Proof of Claim 1.1. Follows immediately from property (1).

Claim 1.2. $x \in Q(x)$ for every $x \in X$.

Proof of Claim 1.2. Since c is a choice correspondence on $\mathcal{C}(X)$, we must have $c(\{x\}, x) = \{x\}$ for any $x \in X$. Our claim this follows from (4).

WARP. For the case in which $\sigma = \Diamond$ it is trivial. So take $x \in X$ and choice problems $(S, x), (T, x)$ such that $T \subseteq S$ and $c(S, x) \cap T \neq \emptyset$.
Case 1: $\arg\max U(S \cap X_x) \cap \arg\max U(T \cap X_x) \neq \emptyset$. In view of claim 1.1 and (4) this is obvious.

Case 2: $\arg\max U(S \cap X_x) \cap \arg\max U(T \cap X_x) = \emptyset$. Let $\bar{z} \in \arg\max U(S \cap X_x)$ and $z \in \arg\max U(T \cap X_x)$. By case 2, we have $U(\bar{z}) > U(z)$. Let $y \in c(S, x) \cap T$. By (4), $y \in \arg\max U(S \cap Q(\bar{z}))$. Thus, $y \in T \cap Q(\bar{z})$. By property (1), $Q(\bar{z}) \subseteq Q(z)$. Therefore, $y \in T \cap Q(z)$. Let $t \in \arg\max U(T \cap Q(z))$. We are to show that $U(y) \geq U(t)$.

2.1. $y \in X_x$. In this case, $y \in \arg\max U(S \cap X_x)$. Thus, $y \in T \cap X_x$. Since $T \subseteq S$ this implies $y \in \arg\max U(T \cap X_x)$, Contradicting case 2.

2.2 $y \notin X_x$. By the choice of t, $U(t) \geq U(y)$. If $t \in X_x$, then $U(\bar{z}) > U(z) \geq U(t)$. We obtain $U(y) \geq U(\bar{z}) > U(t)$ which contradicts our choice of t. If $t \notin X_x$ then by property (2) we obtain $t \in Q(\bar{z})$. Hence, $t \in S \cap Q(\bar{z})$ and so $U(y) \geq U(t)$ which completes the first inclusion.

To show the second inclusion, let $y \in c(T, x)$. By (4,) $y \in \arg\max U(T \cap Q(z))$. Let $q \in \arg\max U(S \cap Q(\bar{z})) \cap T$. Since $Q(\bar{z}) \subseteq Q(z)$ it follows that $q \in T \cap Q(z)$. By choice of y, we have $U(y) \geq U(q)$. We are thus left to show that $y \in S \cap Q(\bar{z})$. Since $y \in T \subseteq S$, this reduces to $y \in Q(\bar{z})$. We consider the following three cases:

2.3. $q \in X_x$. We must have $q \in \arg\max U(S \cap X_x)$ which in turn implies that $q \in \arg\max U(T \cap X_x)$ contradicting case 2.

2.4. $q \notin X_x, y \notin X_x$. Since $q \in Q(\bar{z})$, $y \in Q(z)$, and $U(y) \geq U(q)$ we can use property (2) to obtain $y \in Q(\bar{z})$.

2.5. $q \notin X_x, y \in X_x$. Since $y \in T$ we have $y \in T \cap X_x$. By case 2, $U(\bar{z}) > U(y)$. By claim 1.2 $\bar{z} \in Q(\bar{z})$ and hence $\bar{z} \in S \cap Q(\bar{z})$. We obtain $U(q) \geq U(\bar{z}) > U(y)$, a contradiction.

WSQB. Take any $x, y \in X$ and suppose that $x \in c(\{x, y\}, y)$. By (4), $x \in \arg\max U(\{x, y\} \cap Q(z))$ where $z \in \arg\max U(\{x, y\} \cap X_y)$. If $y \in \arg\max U(\{x, y\} \cap X_y)$, we have $x \in Q(y)$. By claim 1.2 we obtain $U(x) \geq U(y)$, which by (3) is equivalent to $x \in c(\{x, y\}, \Diamond)$. If $z \notin \arg\max U(\{x, y\} \cap X_y)$ then $x \in X_y$ and $U(x) > U(y)$ which by (3) yields $\{x\} = c(\{x, y\}, \Diamond)$. On the other hand, if $x \in c(\{x, y\}, \Diamond)$, that is, $U(x) \geq U(y)$, then $x \in \arg\max U(\{x, y\} \cap X_x$. and in view of claim 1.2, $x \in \arg\max U(\{x, y\} \cap Q(x)$. By (2) we obtain $x \in c(\{x, y\}, x)$ as we sought.

CSQI. Take any $(S, x) \in \mathcal{C}(X)$ and let $z \in \arg\max U(S \cap X_x)$. Suppose that $c(T, x) \not\subseteq X_x$ for every subset T of S such that $[S \cap X_x] \subset T$. If S is itself a singleton we have $c(S, x) = \{x\} = c(S, \Diamond)$ by virtue of c being a choice correspondence. If S is not a singleton then, by hypothesis, $y \in c(\{y\} \cup (S \cap X_x), x)$ for every $y \in S \setminus X_x$. That is, $y \in Q(z)$ for every $y \in S \setminus X_x$. Moreover, by claims 1.1 and 1.2 we obtain $\arg\max U(S \cap X_x) \subseteq Q(z)$. Note that

$$S = [S \setminus X_x] \cup [\arg\max U(S \cap X_x)] \cup [(S \cap X_x) \setminus (\arg\max U(S \cap X_x))].$$

Denote the sets in the decomposition by A, B and C respectively. We have already obtained $A \subseteq Q(z)$ as well as $B \subseteq Q(z)$. Note that

$$\arg\max U(S) = \arg\max U(S \setminus C).$$

Hence,

$$c(S, x) = \arg\max U(S \cap Q(z)) = \arg\max U([A \cup B \cup C] \cap Q(z)) =$$
$$\arg\max U([A \cap Q(z)] \cup [B \cap Q(z)] \cup [C \cap Q(z)]) =$$
$$\arg\max U([A \cap Q(z)] \cup [B \cap Q(z)]) = \arg\max U(A \cup B) =$$
$$\arg\max U(A \cup B \cup C) = \arg\max U(S) = c(S, \Diamond)$$

where the fourth equality follows from $z \in B \cap Q(z)$ and $U(z) > U(c)$ for every $c \in C$.

CRE. Let $S \in \Omega_X$ such that $x, y \in S \cap X_x$. Take any $z \in \arg\max U(S \cap X_x)$. By (4)

$c(S,x) = \arg\max U(S \cap Q(z)) = c(S,y)$, as we sought.

We now move to prove the "only if" part of Theorem 1. Let c be a choice correspondence on $\mathcal{C}(X)$ that satisfies WARP, WSQB, CSQI and CRE. Define the binary relation $\succsim$ on X by

$$y \succsim x \text{ if and only if } y \in c(\{x,y\})$$

A standard argument based on WARP shows that $\succsim$ is a complete preorder on X and that

$$c(S,\Diamond) = \{\omega \in S : \omega \succsim x \text{ for all } x \in S\} \text{ for every } S \in \Omega_X.$$

Furthermore since X is finite there exists a real function U on X such that $y \succsim x$ if and only $U(y) \geq U(x)$ for any $x,y \in X$. Therefore:

$$c(S,\Diamond) = \arg\max \{U(\omega) : \omega \in S\} \text{ for every } S \in \Omega_X.$$

Claim 1.3. Let $X_i \subset X$ be a cell in the partition. For any $x,y \in X_i$, we have: $c(\{x,y\},x) = c(\{x,y\},y) = c(\{x,y\},\Diamond)$.

Proof of Claim 1.3. Suppose $c(\{x,y\},x) = \{x\}$. By CRE $c(\{x,y\},y) = \{x\}$. By WSQB $c(\{x,y\},\Diamond) = \{x\}$. The other cases are handled similarly.

Claim 1.4. Let $X_i \subset X$ be a cell in the partition. Take any $S \in \Omega_X$ such that $S \subseteq X_i$. Then, $c(S,s) = c(S,\Diamond)$ for every $s \in S$.

Proof of Claim 1.4. Follows from claim 1.3 and WARP.

Claim 1.5. Let $X_i \subset X$ be a cell in the partition. For any $x,y \in X_i$ and $z \in X$ we have:

$$x \in c(\{x,y\},\Diamond) \text{ and } z \in c(\{x,z\},x) \Rightarrow z \in c(\{y,z\},y).$$

Proof of Claim 1.5. Let $x,y \in X_i$ and $z \in X$. If $z \in X_i$ then by claim 1.3 and WARP the proof os complete. So suppose $z \notin X_i$. Consider the following three cases:

Case 1: $z \in c(\{x,y,z\},y)$. WARP implies $z \in c(\{y,z\},y)$ as we sought.

Case 2: $x \in c(\{x,y,z\},y)$. By CRE $x \in c(\{x,y,z\},x)$. WARP implies:

$$c(\{x,y,z\},x) \cap \{x,z\} = c(\{x,z\},x).$$

By assumption $z \in c(\{x,z\},x)$ so we conclude $z \in c(\{x,y,z\},x)$. By CRE once again we have that $z \in c(\{x,y,z\},y)$ and we are back in Case 1 and so $z \in c(\{y,z\},y)$.

Case 3: $y \in c(\{x,y,z\},y)$. CRE implies $y \in c(\{x,y,z\},x)$. By WARP $y \in c(\{x,y\},x)$.

By assumption $x \in c(\{x, y\}, \lozenge)$. Using WSQB we obtain $x \in c(\{x, y\}, x)$. Combining, we obtain $\{x, y\} = c(\{x, y\}, x)$. Using WARP once again we have

$$c(\{x, y, z\}, x) \cap \{x, y\} = c(\{x, y\}, x) = \{x, y\}.$$

We may conclude $x \in c(\{x, y, z\}, x)$ and using CRE that $x \in c(\{x, y, z\}, y)$ which brings us back to Case 2. Conclusion: $z \in c(\{y, z\}, y)$ which completes the proof of Claim 1.5.

Now define

$$Q(x) := \{y \in X : y \in c(\{x, y\}, x)\}.$$

Claim 1.6. U and Q are categorically-negatively-comonotonic.

Proof of Claim 1.6. Take $x_1, x_2 \in X$ such that $x_1 \in X_{x_2}$. Suppose $U(x_1) \geq U(x_2)$. By the first part of the proof, $x_1 \in c(\{x_1, x_2\}, \lozenge)$. If $y \in Q(x_1)$ then $y \in c(\{y, x_1\}, x)$. By Claim 1.5 $y \in c(\{y, x_1\}, x_2)$ thus by defintion $y \in Q(x_2)$. Now suppose that $U(x_1) > U(x_2)$. Following the same steps we have that $Q(x_1) \subseteq Q(x_2)$. Note that, by definition $x_2 \in Q(x_2)$. If $x_2 \in Q(x_1)$ then $x_2 \in c(\{x_1, x_2\}, x_1)$. By claim 1.3 we obtain $x_2 \in c(\{x_1, x_2\}, \lozenge)$. But by first part of the proof this is true iff $U(x_2) \geq U(x_1)$, a contradiction. Thus, we conclude $Q(x_1) \subset Q(x_2)$.

Claim 1.7. Q is U-monotonic with respect to dissimilar alternatives.

Proof of Claim 1.7. Let $z' \in X$. Take any $y, x \notin X_{z'}$ such that:

- $U(y) \geq U(x)$
- $x \in Q(z')$
- $y \in Q(z'')$ for some $z'' \in X_{z'}$.

We are to show that $y \in Q(z')$. By definition and the eariler part of the proof, our assumptions can be rewritten as $y \in c(\{y, z''\}, z''), x \in c(\{x, z'\}, z'), y \in c(\{x, y\}, \lozenge)$. If $\{z''\} \in c(\{z', z''\}, \lozenge)$ then $U(z'') \geq U(z')$. By Claim 1.6 we have $Q(z'') \subseteq Q(z')$ and thus $y \in Q(z')$ as we sought. So suppose $\{z'\} = c(\{z', z''\}, \lozenge)$. Define $A = \{x, y, z', z''\}$. We examine the following four cases:

Case 1: $y \in c(A, z')$. WARP implies $y \in c(\{y, z'\}, z')$ so $y \in Q(z')$ as we sought.

Case 2: $z'' \in c(A, z')$. By CRE $z'' \in c(A, z'')$. WARP implies

$$c(A, z'') \cap \{y, z''\} = c(\{y, z''\}, z'').$$

By assumption $y \in c(\{y, z''\}, z'')$ and thus $y \in c(A, z'')$ Using CRE once again we have $y \in c(A, z')$ and we are back to Case 1 which completes the proof.

Case 3: $x \in c(A, z')$. CRE implies $x \in c(A, z'')$ and using WARP:

$$c(A, z'') \cap \{x, z'', y\} = c(\{x, z'', y\}, z''). \tag{7}$$

Thus $x \in c(\{x, z'', y\}, z'')$. We also have by WARP that $x \in c(\{x, z''\}, z'')$ and by assumption $y \in c(\{y, z''\}, z'')$. We can thus use CSQI with respect to the choice problem $(\{x, z'', y\}, z'')$ to obtain

$$c(\{x, z'', y\}, z'') = c(\{x, z'', y\}, \Diamond) \tag{8}$$

Now if $y \in c(\{x, y, z''\}, \Diamond)$, (7) and (8) imply that $y \in c(A, z'')$ and using CRE we are back to Case 1. If $x \in c(\{x, z'', y\}, \Diamond)$ then by WARP and the assumption $y \in c(\{x, y\}, \Diamond)$ we may conclude that $y \in c(\{x, z'', y\}, \Diamond)$ once again. Finally, suppose $z'' \in c(\{x, z'', y\}, \Diamond)$. By WARP

$$c(\{x, z'', y\}, \Diamond) \cap \{z'', y\} = c(\{z'', y\}, \Diamond). \tag{9}$$

By assumption $y \in c(\{y, z''\}, z'')$ and hence by WSQB $y \in c(\{y, z''\}, \Diamond)$. Combining (8) and (9) we have yet again $y \in c(\{x, z'', y\}, \Diamond)$.

Case 4: $z' \in c(A, z')$. WARP alongside our assumption that $x \in c(\{x, z'\}, z')$ implies $x \in c(A, z')$ which brings us back to Case 3 and completes the proof of Claim 7.

We are left to show (4), that is

$$c(S, x) = \arg\max U(S \cap Q(z)), \text{ where } z \in \arg\max U(S \cap X_x).$$

Take any $(S, x) \in \mathcal{C}(X)$ and $z \in \arg\max U(S \cap X_x)$. By CRE $c(S, x) = c(S, z)$. We now prove two final claims.

Claim 1.8. $c(S, z) = c(S \cap Q(z), z)$.

Proof of Claim 1.8. Let $T := S \cap Q(z)$. and pick any $y \in c(S, z)$. By WARP $y \in c(\{y, z\}, z)$ and hence $y \in Q(z)$. which implies $y \in T$. Conclusion: $c(S, z) \subseteq T$. Therefore $c(S, z) \cap T = c(S, z)$, which ensures that this is a non-empty set. We may thus apply WARP to conclude that $c(S, z) = c(S, z) \cap T = c(T, z)$ and we are done.

Claim 1.9. $c(S \cap Q(z), z) = c(S \cap Q(z), \Diamond)$.

Proof of Claim 1.9. If $S \cap Q(z) \subseteq X_x$ then by claim 1.4 we are done. So Suppose $S \cap Q(z) \not\subseteq X_x$. Take any $T \subseteq S \cap Q(z)$ such that $[S \cap X_x] \subset T$. We wish to show that

$c(T,z) \nsubseteq X_x$. There exists $\omega \in T$ such that $\omega \notin X_x$ and such that $\omega \in Q(z)$. By definition of $Q(z)$, we have

$$\omega \in c(\{\omega, z\}, z). \tag{10}$$

Suppose $c(T,z) \subseteq X_x$. Take any $y \in c(T,z)$. $c(T,z) \cap \{y,z,\omega\} \neq \emptyset$. We may apply WARP to obtain $c(T,z) \cap \{y,z,\omega\} = c(\{y,z,\omega\}, z)$. Thus, given our assumption, we have $c(\{y,z,\omega\}, z) \subseteq X_x$. This means that

$$\omega \notin c(\{y,z,\omega\}, z). \tag{11}$$

Moreover, $y \in c(\{y,z,\omega\}, z)$. We may apply WARP once more to get

$$c(\{y,z,\omega\}, z) \cap \{y,z\} = c(\{y,z\}, z). \tag{12}$$

$z \in X_x$ and by assumption also $y \in X_x$ and thus in view of Claim 1.3, we obtain $c(\{y,z\}, z) = c(\{y,z\}, \lozenge)$. Putting this together with (12), we may conclude

$$c(\{y,z,\omega\}, z) \cap \{y,z\} = c(\{y,z\}, z) = c(\{y,z\}, \lozenge).$$

By the fact that $z \in \arg\max U(S \cap X_x)$ and $y \in X_x$ we have that $z \in c(\{y,z\}, \lozenge)$. Therefore, $z \in c(\{y,z,\omega\}, z)$. Apply WARP once again to obtain $c(\{y,z,\omega\}, z) \cap \{z,\omega\} = c(\{z,\omega\}, z)$. By (11) this implies that $\omega \notin c(\{z,\omega\}, z)$. Hence, $z = c(\{z,\omega\}, z)$ which contradicts (10). Conclusion: $c(T,z) \nsubseteq X_x$. Thus we may apply CSQI to conclude that Claim 1.9 holds. Together with Claim 1.8 and CRE we obtain:

$$c(S,x) = c(S,z) = c(S \cap Q(z), z) = c(S \cap Q(z), \lozenge)$$

which in view of (3) completes the proof of Theorem 1.

B Results for Axiom CRE

Below we report the distribution of answers for two out of the four questions that were common to all treatments. We draw this distribution only for the data collected through AMT. We picked the questions corresponding to the following choice sets:

- {Godiva, Hershey's, Black Pen, Silver Pen} (Question GHBS).
- {Godiva, Hershey's, Black Pen, Silver Pen, 42" Umbrella} (Question GHBSM).

For each question the table compares the distribution of answers across two different treatments according to the following order: (Silver Pen, Black Pen), (Hershey's, Godiva), (No Endowment, Black Pen), (No Endowment, Hershey's). In both questions the only significant difference according to the Pearson Chi Square Test is between the black pen treatment and the no endowment treatment[22]. The others are not significantly different from each other according to the Pearson Chi Square Test. These results hold roughly for the other questions as well. As discussed in section 4 this provides support for our CRE axiom. The finding of no significant difference between No Endowment and Hershey's is discussed in Appendix D.

Figure B.1: Question GHBS: Black Pen and Silver Pen Treatments

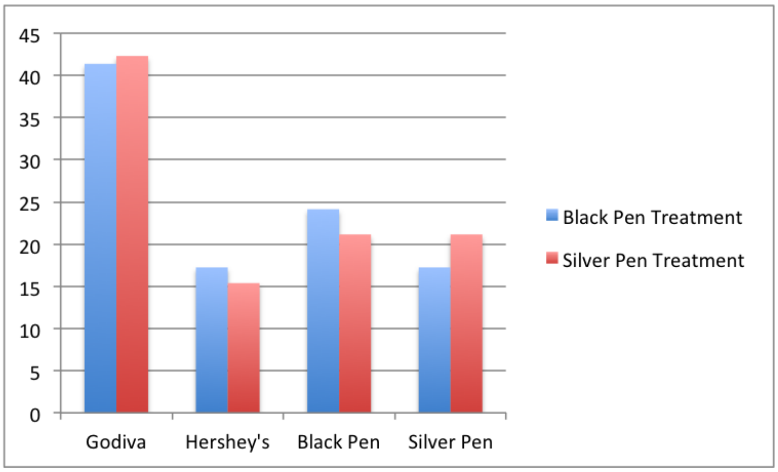
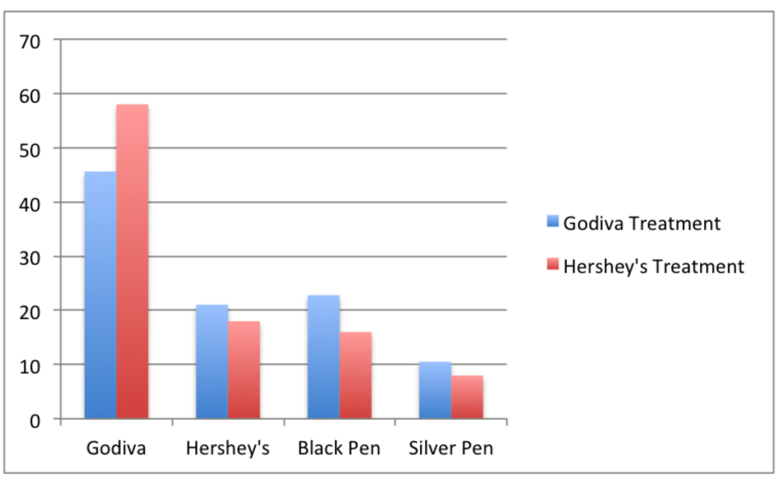


Figure B.2: Question GHBS: Hershey's and Godiva Treatments



[22]There is also a significant difference when comparing the Silver Pen treatment to the No Endowment treatment but that is not reported here.

Figure B.3: Question GHBS: No Endowment and Black Pen Treatments

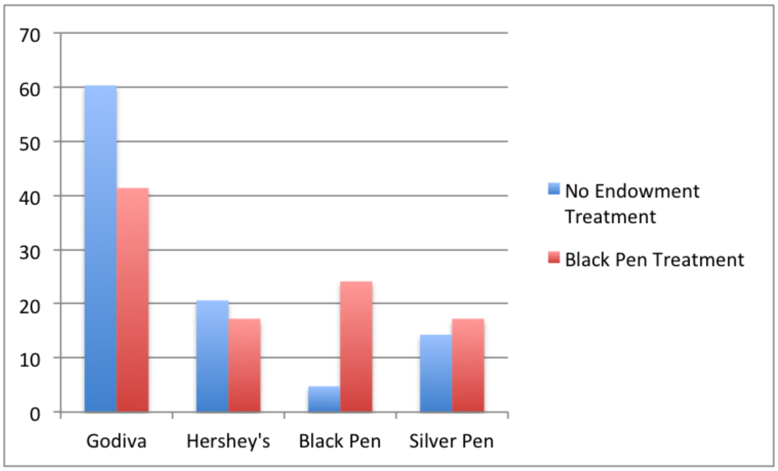


Figure B.4: Question GHBS: No Endowment and Hershey's Treatments

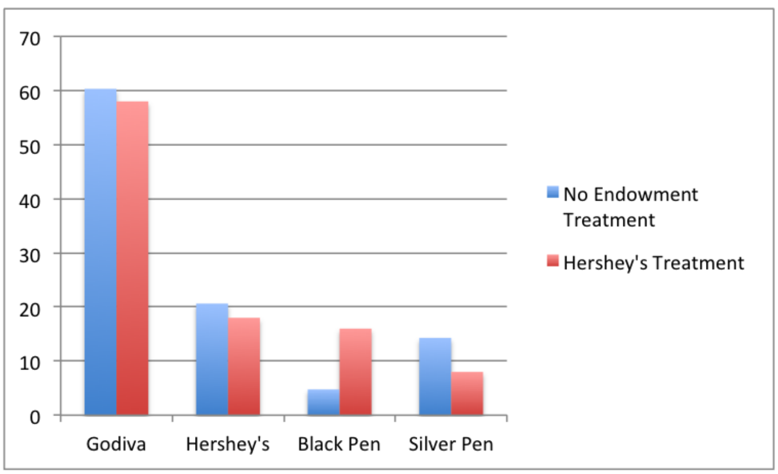


Figure B.5: Question GHBSM: Black Pen and Silver Pen Treatments

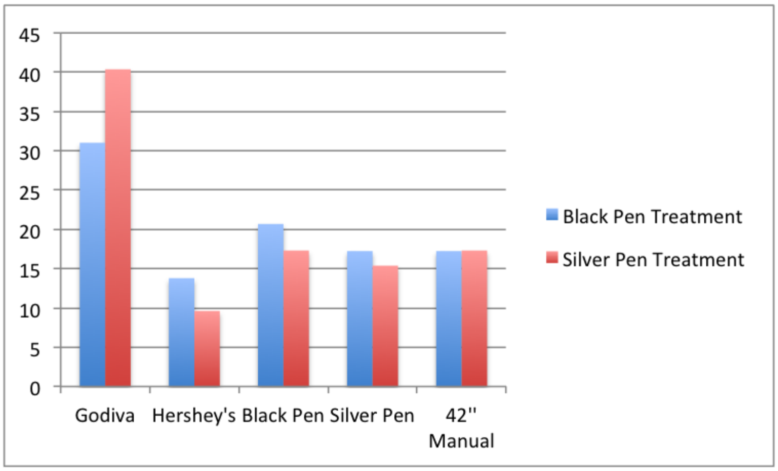


Figure B.6: Question GHBSM: Hershey's and Godiva Treatments

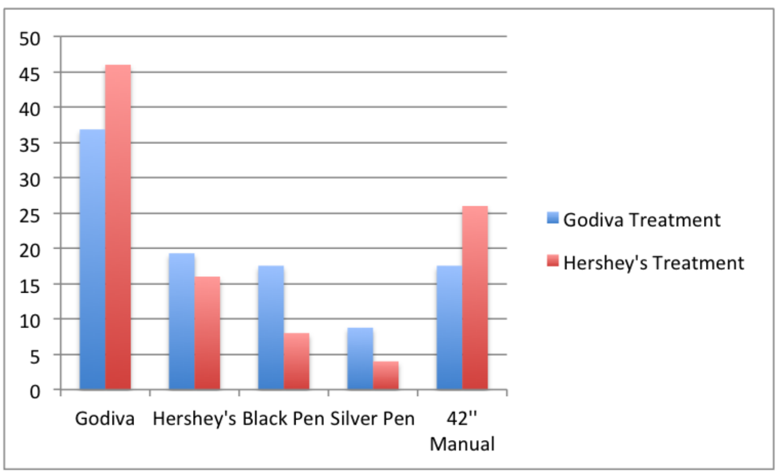


Figure B.7: Question GHBSM: No Endowment and Black Pen Treatments

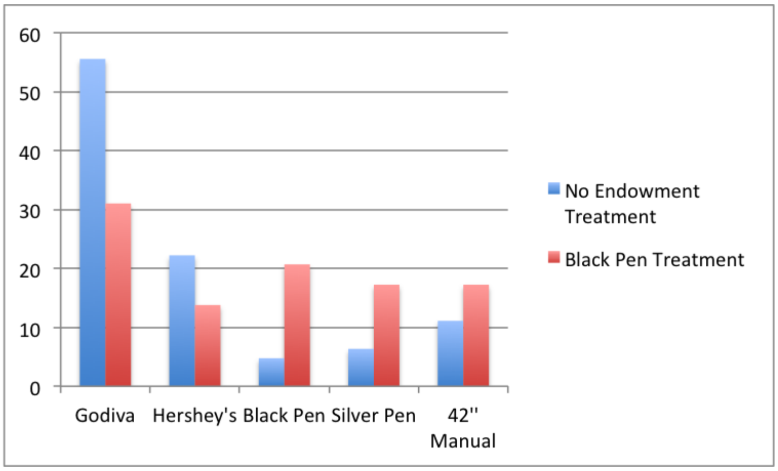
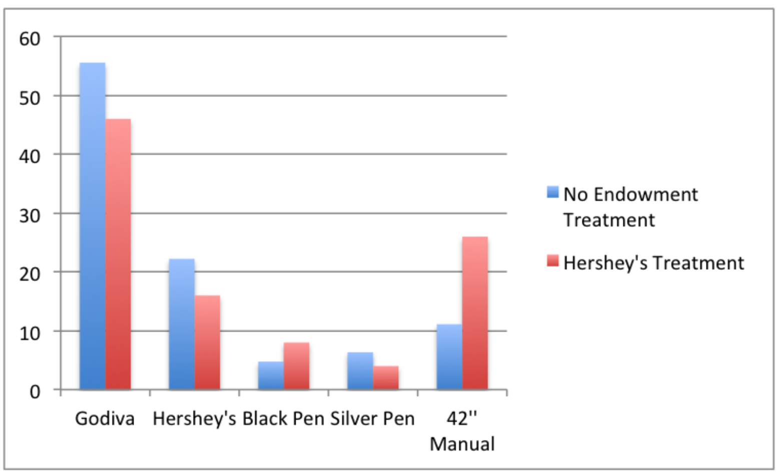


Figure B.8: Question GHBSM: No Endowment and Hershey's Treatments



C No Status Quo Bias Prediction

We report below the distribution of choices from the set {Godiva, Hershey's} in the No Endowment, Godiva and Hershey's treatments and from the set {Black Pen, Silver Pen} in the No Endowment, Black Pen and Silver Pen treatments. For both questions, no two out of three distributions were significantly different from each other.

Figure C.1: Question GH: No Endowment, Godiva and Hershey's Treatments

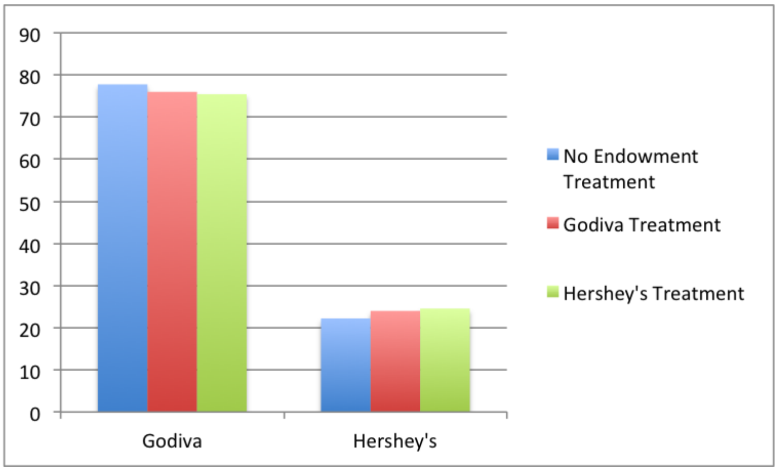
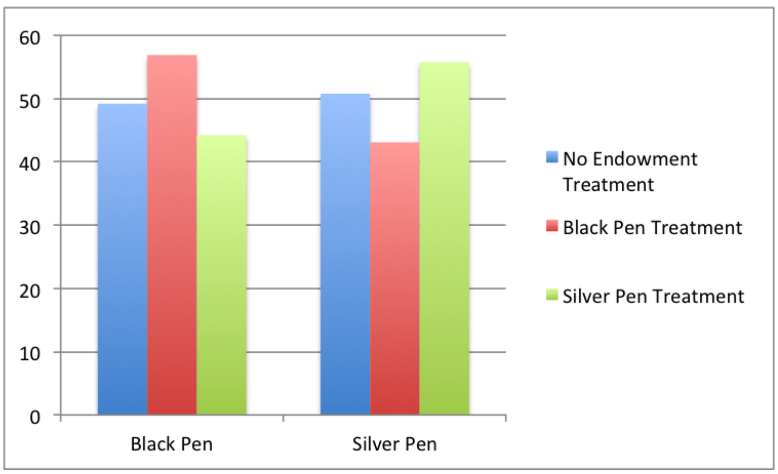


Figure C.2: Question BS: No Endowment, Black Pen and Silver Pen Treatments



D Differences between Lab and AMT Results

We discuss some of the differences between the two environments in which the experiment took place (AMT and the lab). As pointed out reference effects showed up on AMT when comparing the pens treatments to the No Endowment treatments while in the lab some reference effects showed up when comparing the chocolates treatments to No Endowment but not when comparing the Black Pen to No Endowment. The following may be explanations for these disparities:

1. In general the reference effect may have been weakened by the fact that 16 questions were asked rather than one or two. If a subject gives up her endowment in a question she might feel less attached to the endowment in later questions, even is she is asked to imagine that it is still her endowment.

2. The effect of receiving a physical chocolate as an endowment may be enhanced compared to a hypothetical such endowment. The answers to the questionnaire support this possibility as many subjects in the lab stated they craved for the chocolate on their desk and started feeling hungry.

3. The order of appearance of the questions may have affected the results on AMT more than in the lab setting. The answers to every question were listed in the following order: The endowment, the other good from the same category and then the other goods starting with the chocolates, followed by pens and finally umbrellas. This may have lead to more pens being chosen on AMT in the pens treatments. However, some evidence regarding the nature of participation seem to reject this possibility. First, the answers to the questionnaire show consideration of the different goods when making choices. Moreover, all goods were introduced on the instruction page for all treatments starting with the chocolates and followed by the pens and umbrellas. There were also only 3.5 alternatives per question on average, a small amount which makes it easy to consider all alternatives. Finally, if subjects were trying to save time and answer quickly they would find it faster to choose the last alternative especially in the questions with more than 4 alternatives (since the 'continue' button was placed at the bottom of the screen). To further examine the list effect and disentangle it from the reference effect we are currently in the process of running more sessions with a random appearance of alternatives on the screen.

4. Given the goods we used, the lab experiment is more prone to effects such as the time of day in which a session was conducted and weather (we ran sessions only on days in which there was no rain forecasted but we allowed for rain the day before or after). Alongside the small numbers used in the lab (19-31 subjects per treatment) this may have lead to significant amount of noise which outweighs the reference effects.

E Instructions and Screenshot

Here we bring the instructions from the lab treatment in which the endowment was the 3-Hershey's bars (The AMT instructions are almost indentical with the necessary changes). Below the instructions, figure E.1 shows a screenshot from one of the questions in the Godiva treatment held on AMT.

Instructions

Thank you for participating in this experiment. Shortly you will be asked to examine six items, one of which you will be taking home with you today along with a 10 dollars show up fee. The item you will earn depends on your choices and on chance.

The six items are as follows:

- 3 Godiva milk chocolate bars.
- 3 Hersheys milk chocolate bars.
- A black stylus pen by Zebra (touchscreen compatible).
- A silver stylus pen by Zebra (touchscreen compatible).
- A 42 manual black umbrella.
- A 38 automatic black umbrella.

We will refer to these items as 3-Godiva, 3-Hersheys, Black pen, Silver pen, 42 manual and 38 automatic. All items are worth roughly 10 dollars.

After we go through the instructions and you have had the chance to examine the items, I will hand each of you 3 Hersheys milk chocolate bars. These chocolate bars will then become yours.

You will then be asked to answer 15 multiple-choice questions. In each question your task will be to decide whether to keep your 3 Hersheys bars or switch to one of the other items listed in that question. Please mark your preferred choice for each question. Make sure to mark only one of the options in each question and please answer all 15 questions.

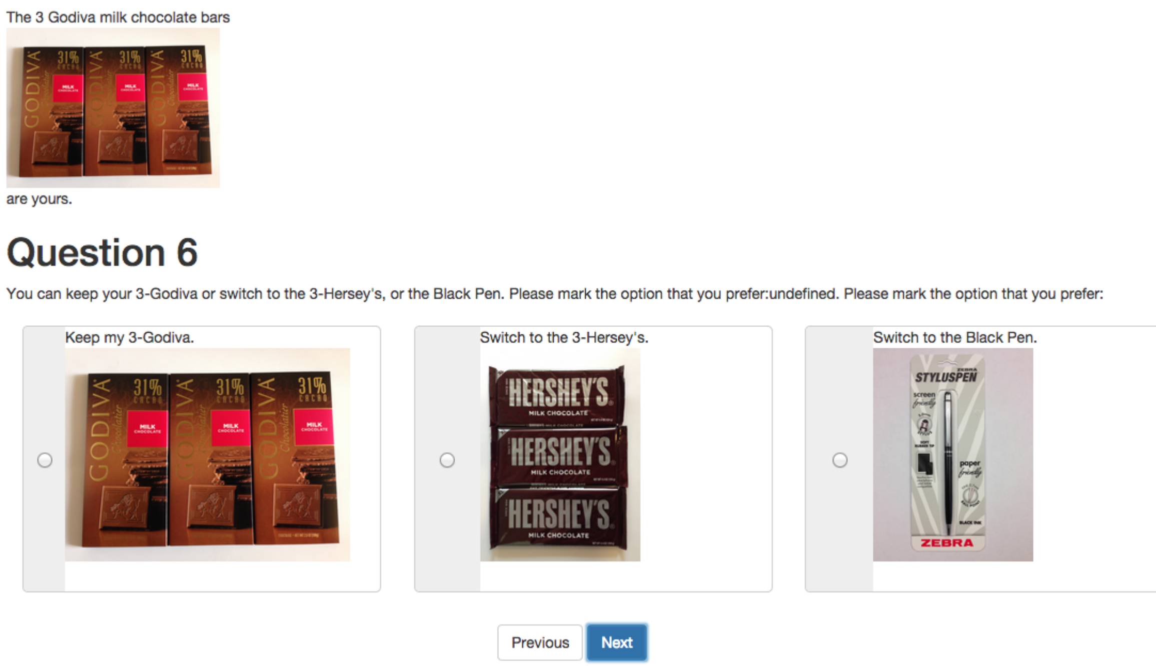
There are no right or wrong answers in this experiment; this study is interested in your preferences.

Payment

On the front desk we have 15 pieces of paper with the numbers 1-15 written on them. Before you start answering the questions, I will ask a volunteer to come up to help me crumple them into tiny paper balls, place them in a cup and give them a stir.

After the experiment is over, each one of you will come over to the front desk with his/her completed questions and the 3 Hersheys bars and pick a piece of paper from the cup. You will collect the item that you chose on the question number picked from the cup plus the 10 dollars show up fee. After you receive your payment please roll the piece of paper back into a tiny ball and place it back in the cup for the next person.

Figure E.1: Screenshot of question from AMT



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