Stochastic Choice and Familiarity: Inertia and The Mere Exposure Effect

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Abstract

In this paper we propose a first dynamic model of behavioral inertia. Using evidence from cognitive sciences, we model a decision maker that has a higher probability of choosing an alternative the more he has been *exposed* to it. The model allows us (i) to give a first explanation for some empirical evidence that shows that inertia in choices is dynamic, (ii) to give a more general description of the well-known phenomenon of the status-quo bias, (iii) to obtain the endowment effect, loss aversion and present bias as byproducts, and (iv) to quantify the behavioral inertia that affects choices. In particular, we show that it is possible to have accurate forecasts of the kind of heterogeneity we should expect to emerge due to the effect of exposure on inertia. Finally, we provide a choice theoretical foundation of the model and we discuss some possible extensions.
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1 Introduction

The opportunities we had and the choices we took shape our decisions today. This influence is much deeper and much more subtle than the simple acknowledgment that through experiences we learn. Past choices shape our decisions today because they become routinary, they become familiar. Since the seminal papers by Samuelson and Zeckhauser (1988) and by Kahneman et al. (1991) a lot of evidence has been accumulated highlighting the fact that people tend to stick to the status-quo.[1] *Inertia*, in the form of status-quo bias, endowment effect, present bias, etc., is a key component of human decision making and it has important economic effect that have been documented and studied. Nevertheless, it is still not clear what its source could be and thus, what are its implications trough time. What is clear though, is that inertia can have important dynamic effects. For example, Strahilevitz and Loewenstein (1998) find that the endowment effect is increasing with respect to the time of endowment. In this paper we provide a first dynamic model of behavioral inertia that can explain those findings and we use it to identify the kind of heterogeneity in behavior we should expect to emerge once differences in experiences and opportunities are taken into account.

We propose a possible cognitive source for such inertia known as *the mere exposure effect* that was firstly discovered by Zajonc (1968) and that has been recognized through many successive studies as an important behavioral regularity.[2] The mere exposure effect is the phenomenon by which people tend to develop a preference for things merely because they have been *exposed* to them, they are *familiar* with them. Although the concept of exposure might be more general, we adopt the simplified view that an individual is exposed to a product or an alternative if he has chosen it.[3] The main idea is that the more an individual is exposed to an alternative, i.e., the more he is familiar with it, the higher is the probability that he chooses such alternative due to the particular cognitive bias we are analyzing. That is, we propose a more general and dynamic notion of status-quo bias that allows us (i) to give a first explanation for the evidence presented in Strahilevitz and Loewenstein (1998), (ii) to obtain the endowment effect, loss aversion and present bias as byproducts, and (iii) to quantify the behavioral inertia that affects choices. This last feature in particular makes possible to give clear-cut predictions about the dynamics of this kind of inertia.

Section 2 presents a decision maker that chooses stochastically between the available alternatives at a given moment in time. In our framework, choice probabilities are given by a model similar to the one presented in Luce (1959). The key difference is that the utility of an alternative is not static. The utility of an alternative at any moment in time can be decomposed into two factors,

[1] See for example Harbaugh et al. (2001), Kempf and Ruenzi (2006) and Sprenger (2015).

[2] See for example Pliner (1982), Gordon and Holyoak (1983), Bornstein and D'Agostino (1992), Monahan et al. (2000), Harmon-Jones and Allen (2001), Zajonc (2001) and Huang and Hsieh (2013).

[3] In Section 4.1 we discuss the possibility of having a more general interpretation of exposure.

the basic utility of the alternative and the effect of exposure. That is, as previously explained, there is a dynamic relationship between choices and choice probabilities due to the mere exposure effect. In Section 3 we show that the model can have important economic implications. First, we show how this more general kind of status-quo bias implies the endowment effect, loss aversion and present bias in a dynamic framework. Second, we show that, in line with empirical evidence, the exposure effect implies that the endowment effect increases with exposure. Finally, as the main result of the section, we show that the model not only predicts the emergence of heterogeneous behavior from an homogeneous population due to the different choice paths followed by the different individuals, but it does so in a structured way. That is, it is possible to identify the distribution of choice probabilities that characterizes the heterogeneous behavior of the population at the limit. Interestingly enough, such distribution depends only on the basic utilities of the different alternatives and the distribution of menus. This implication of the model is of particular interest for the literature that analyzes the impact of the first years of life on successive social and economic outcomes through individual decisions, e.g. Heckman (2006), but also, potentially, to understand phenomena like the *home bias* in trade and finance. More generally, the result makes possible to comprehend and quantify the effect of experiences on individual decision making through the kind of behavioral inertia that is the focus of this paper.

All theoretical results of Section 3 depend on the knowledge of the process generating the observed choices. Thus, falsifiability of the model becomes an issue. This is why in Section 4 we propose four simple properties that fully characterize the model when we have data coming from an homogeneous population. The first of these properties is a generalization of the concept already introduced in Luce (1959) of independence of irrelevant alternatives (IIA) which states that the relative probability of choosing an alternative over another should not depend on the other alternatives in the set. The only change we impose is that the property has to be satisfied for any given level of exposure. The second property says that the effect of exposure should not be alternative specific. The third property we propose imposes that exposure cannot decrease the probability of choosing an alternative. This is the key property capturing the exposure effect. Finally, the fourth and more technical property, imposes that the effect of exposure cannot be marginally increasing. Section 4.1 then discusses the more general idea of exposure to the whole set of alternatives in a given menu, not just the ones chosen.

Section 5 concludes. All proofs are in the Appendix.

1.1 Related Literature

As previously said, this paper proposes a new and dynamic specification of the status-quo bias, based on the mere exposure effect. This differs from the literature in one important aspect, that is, the dynamic relationship between experiences, choices and inertia. In the main papers present in the literature that analyze the status-quo bias from a decision theoretic perspective, that is Masatlioglu and Ok (2005), Apesteguia and Ballester (2009), Masatlioglu and Ok (2014) and Ok et al. (2015), the analysis is static, the possible dynamics of the status-quo bias are not taken into account. Thus, our model can be seen as complementary with respect to the ones presented in the previously mentioned papers because we present a dynamic model of status-quo bias that allows us to explain some empirical regularities, like the fact that the endowment effect increases with the time of ownership as shown in Strahilevitz and Loewenstein (1998), that need a dynamic structure to be fully understood.

Moreover, from a more conceptual standpoint, the work presented here complements the others mentioned above in two other respects. First, as explained in Section 4.1, the exposure effect is something more general than the status-quo bias. That is, it can be seen as a bias that affects not only the status-quo but also all the alternatives which a decision maker has been exposed to. Second, our work is the first, to the best of our knowledge, to consider this kind of behavioral inertia in a stochastic choice model thus allowing for a formal analysis of these concepts in a probabilistic framework.[4]

Finally, the dynamic relationship between choices and inertia is something that is studied also in models of habit formation as, for example, the ones presented in the seminal papers by Pollak (1970) and by Becker and Murphy (1988). The main difference between our approach and the one used in the mentioned papers is that habits are not used as references. In fact, the usual models of habit formation use a utility function that depends on the distance between present consumption and last period consumption. That is, all alternative consumption plans are evaluated relative to the habit. If a consumption plan falls short of the habit utility is negatively affected. In our framework, habits are not references. They become prominent through exposure, that is, the probability of choosing them increases with exposure, they are not references that are used to evaluate other alternatives. Moreover, once we take into account the possibility of exposure to all the alternatives in the menu, as we do in Section 4.1, the conceptual difference between the two approaches becomes even more evident. In fact, when considering menu exposure, we abandon the idea that habits can emerge only through choices as the models in habit formation do.

2 Stochastic Choice and Exposure Effect

Let X be a finite set of alternatives. The decision maker (DM) chooses at every moment in time t from a *menu* (A_t) with $A_t \subseteq X$. That is, A_t is the set of alternatives that is available at time t and from which the DM has to make a choice. An alternative is any element of choice like consumption bundles, lotteries or even streams of consumption. We denote by $a_t \in A_t$ the chosen alternative at

[4]See Chew et al. (2015) for empirical evidence of reference dependent behavior in stochastic choice.

time t. With little abuse of the notation, we refer to the couple formed by the menu A_t and the chosen alternative a_t as *observation* t. We denote the collection of observations in the sequence $\{(A_t, a_t)\}_{t=1}^T$ as D, i.e. $D = \{1, ..., T\}$.

We model a DM that chooses randomly among alternatives in a menu. The probability of choosing an alternative depends on how relatively preferred is the alternative to the other ones in the menu but also on how much the DM has been exposed to the alternative. In particular, *ceteris paribus*, we model a DM that, by experiencing exposure bias, is more likely to choose an alternative the more he chose it in the past. Formally, the value of alternative $x \in X$ for a DM at time t is the sum of two components. One component, $u : X \to \mathbb{R}_{++}$, represents the utility the alternative x gives to the DM and we call $u(x)$ the *basic utility* or simply the *utility* of alternative x. The second component, $f : \mathbb{R}_+ \to \mathbb{R}_+$ with $f(0) = 0$, captures the exposure effect and we call it the *exposure function*. That is, the value of an alternative x at time t after having been chosen n_x times will be equal to $u(x) + f(n_x)$. We assume that f is non-decreasing and concave. This assumption is justified by some of the evidence in Zajonc (1968). Then we can formally define our model of stochastic choice that is based on the classical model presented in Luce (1959).

Definition 1 (Exposure Biased Luce Model (EBLM)) *p is an Exposure Biased Luce Model if there exist a basic utility u and an exposure function f such that $\forall A \subseteq X$:*

$$p_t(x|A) = \frac{u(x) + f(n_x)}{\sum_{y \in A} (u(y) + f(n_y))}$$

where n_x and n_y are the number of times that alternative x and alternative y have been chosen up until t.

Notice that an Exposure Biased Luce Model can be the standard Luce model whenever $f(r) = 0$ for all $r \in \mathbb{R}$.

An Exposure Biased Luce Model implies that the probability of choosing an alternative is increasing in the utility the alternative provides, but also in how much the DM has been exposed to it. This is a dynamic model. As underlined in the introduction, past experiences influence present behavior in a way that has clear economic relevance. This is what we analyze in the next section.

3 Exposure Effect, Inertia and Heterogeneity

In this section we discuss the implications of the model proposed. It is immediate to see that, as discussed in the introduction, the model provides a possible explanation for the kind of behavioral inertia studied since the seminal papers by Samuelson and Zeckhauser (1988) and by Kahneman et al. (1991). Through exposure, past choices become *more attractive* for our DM. That is, after having chosen something, it becomes more difficult for our DM to change his behavior. This can have very important economic and social consequences. Think for example of product fidelity or drugs. Our model predicts that the more people indulge in the habit of choosing a product or consuming drugs, the less likely it is they will change their habits. Experiences create routines that then are hard to overcome. To see some of these points more clearly, we propose some remarks that are direct consequences of the model. In order for the analysis to be more interesting, we consider the case in which f is strictly increasing. That is, we exclude the standard Luce Model.

To simplify the presentation of some of the remarks, we assume that the DM is endowed with some money $m \in \mathbb{R}$, and that his overall utility of consuming an alternative x having been chosen n times up until t while disposing of m units of money is equal to $u(x) + f(n) + m$. That is, the overall utility is quasilinear in money. Furthermore, we assume there exists an alternative $0 \in X$ that does not incur in the exposure effect and such that $u(0) < u(x), \forall x \in X \setminus \{0\}$. This alternative can be interpreted as *having nothing*, *having no alternative*. Given these assumptions, we can easily define the willingness to pay at time t (WTP_t^x) for an alternative x chosen n times up to t, as the amount of money for which a DM endowed only with m units of money will be indifferent between paying WTP_t^x to obtain the good, and paying nothing not obtaining the good; that is, $u(0) + m = u(x) + f(n) + m - \text{WTP}_t^x$, or $\text{WTP}_t^x = u(x) + f(n) - u(0)$. Similarly, we can define the willingness to accept at time t (WTA_t^x) for an alternative x that has been chosen n times up to t, as the amount of money for which a DM endowed with the good x and m units of money would be indifferent between getting WTA_t^x in order to give up the good, and staying with the good without receiving any amount of money; that is, $u(x) + f(n) + m = u(0) + m + \text{WTA}_t^x$, or $\text{WTA}_t^x = u(x) + f(n) - u(0)$. Notice that the argument of the exposure function can be different in the two expressions. Then, it is easy to see that, due to the exposure effect, there should be a gap between WTA and WTP of a good. In particular, the DM should experience the endowment effect as the next remark highlights.

Remark 1 *If a DM follows a EBLM then he experiences the endowment effect.*

The endowment effect, as previously stated, is usually defined as the difference between the willingness to accept once endowed with a good and the willingness to pay for such good if not endowed with it. Clearly, the exposure effect implies that once a DM is endowed with an alternative, such alternative becomes more relevant to him due to exposure. That is, after the DM is endowed with the alternative, it is more difficult for him to *leave it*. There is a plethora of evidence that people incur in the endowment effect, e.g. Harbaugh et al. (2001) and Kempf and Ruenzi (2006), here we provide a possible cognitive foundation for such behavioral bias. The exposure effect might be what drives the endowment effect. The second direct implication is more interesting, even if still straightforward, and it is related to the dynamic aspect of the model.

Remark 2 *If a DM follows a EBLM then the endowment effect increases with exposure.*

This result is a direct consequence the exposure effect increasing in the number of times an alternative has been chosen. Remarks 1 and 2 point to the findings of Strahilevitz and Loewenstein (1998). These authors empirically show that the endowment effect is an increasing function of the time an alternative is owned. That is, the gap between WTA and WTP for a good should be increasing in the time of ownership. In particular, they find that the endowment effect is not only a function of current ownership, as Remark 1 underlines, but also previous ownership can increase the valuation of an object, as stated in Remark 2. These implications can have interesting economic consequences. They state that the more an alternative is *familiar*, the more a DM has been exposed to it, the more it becomes *routinary* and so the more difficult it is for the DM to change his habits. These results suggest that, whenever from a social point of view it would be better to change some habit a particular individual has, *the sooner we intervene, the better*. This conclusion is in line with the literature developed by Heckman, regarding the best timing for policy interventions in order to improve the social and economic outcomes of the individuals that compose a society.[5] It can also be important for the understanding of the *home bias* in trade and finance. In fact, people might tend to choose more products or assets of their home country only because they have been more exposed to them.

The fact that the value of an alternative increases the more it is chosen, or in this context the longer the DM is endowed with it or experiences it, has clear implications also for the status-quo bias. In fact, the existence of the endowment effect can be seen, as it is usual in the literature, as the driving force of the status-quo bias. An interesting and straightforward implication of the exposure effect regards the dynamic behavior of the bias as the next remark underlines. To properly understand our contribution, the reader should refer to the ideas presented in Masatlioglu and Ok (2005), Apesteguia and Ballester (2009), Masatlioglu and Ok (2014) and Ok et al. (2015). One of the key features of these works is that they assume the existence of some alternatives that dominate the status-quo, that are the only alternatives for which a DM would leave the status-quo if he could choose. A consequence of the model we present here is that the set cannot increase the more a DM experiences the status-quo. The longer the period of time the DM stays with the status-quo, the more the value of the status-quo will have shifted upwards due to the exposure effect, hence the number of alternatives that dominate it cannot increase in time.

Remark 3 *If a DM follows a EBLM, the number of alternatives dominating a particular alternative x at least weakly decreases every time alternative x is chosen.*

[5]For a general survey of the literature, see Cunha et al. (2006). See also Sen (1997b) for a discussion over opportunities and economic inequality.

Another phenomenon that have always been connected to the endowment effect and the status-quo bias, is loss aversion. In particular, it has been used as a plausible explanation for this kind of biases. As we said, we here propose a different channel that might be driving this kind of inertia. We think that the exposure effect is a better explanation for the empirical evidence that has been gathered, for two main reasons. First, as underlined by Remark 2 it can explain some of the evidence that has been found in different experiments regarding the dynamics of the endowment effect, while loss aversion, being a static concept, cannot explain those findings without additional assumptions. Second, as Remark 4 highlights, the exposure effect can be seen as a primitive of loss aversion whenever the DM is unaware of the fact that he experiences it.[6] A DM described by a EBLM evaluates gains and losses differently due to the exposure effect. If we ask our DM whether he would prefer to gain alternative $x \in X$ or, once we endowed him with it, not lose it, *ceteris paribus*, his answer will be influenced by the presence of the exposure bias. Similarly to the driving mechanism behind Remark 1, once having the alternative, the DM experiences an exposure effect that makes the value of the alternative higher than its ex-ante value. Losses are evaluated with the value of the alternative after experiencing exposure while gains before experiencing it and without forecasting it. This difference is the driving force behind Remark 4. The DM will be more willing to avoid the loss than to obtain the gain.

Remark 4 *A naïve DM that follows a EBLM experiences loss aversion.*

As a final and more abstract remark, we would like to underline that, due to a reasoning similar to the one behind the previous remarks, a naïve DM described by a EBLM, should experience present bias as described in O'Donoghue and Rabin (1999), that is, the difference between the utility of today's and tomorrow's consumptions should be higher when the DM is experiencing today's consumption than when the DM is still not experiencing it. It is immediate to see that a DM affected by exposure effect who is not aware of it, should consider differently consumption at time t *before* being at t with respect to consumption at time t *once* being at t. The reasoning is similar to the one behind Remark 4. When evaluating consumption at time t and time $t+1$ from s, with $s < t$, a naïve DM, not forecasting the exposure effect, will provide a different evaluation than the one given at time t, once experiencing the exposure effect.

Remark 5 *A naïve DM that follows a EBLM experiences present bias.*

It is worthwhile to highlight the fact that all previous remarks do not depend on the stochasticity of choices assumed in the model. In fact, all remarks depend on the basic specification of the utility

[6]This assumption is in line with the evidence presented, among others, in Zajonc (1968), Zajonc (2001), and Hansen and Wänke (2009) that see the mere exposure effect as a consequence of an unconscious process.

of an alternative when the exposure effect is taken into account. Thus, they would be valid also in a deterministic choice model considering the same issues with the same basic structure.

We conclude the section with its main result. We said that experiences can have an effect on present choices that runs deeper than mere learning. The exposure effect is a powerful tool to substantiate this claim not only because it is well documented in cognitive sciences, as previously explained, but also because the structure that it implies can be extremely helpful to predict individual behavior and hence to have better policy designs. In fact, if the social objective is to eradicate some damaging behavior or to reinforce a positive habit, it is crucial to know the cognitive process that make habits and routines to emerge. Moreover, thanks to its simplicity, it is able to give sharp predictions. This tractability is evident in a EBLM. In particular we focus on a particular specification of the model for which the exposure effect is linear.

Definition 2 (Linear Exposure Biased Luce Model (Lin-EBLM)) *p is a Lin-EBLM if it is a EBLM and the exposure function f is defined as follows for any $n \in \mathbb{R}$:*

$$f(n) = kn,$$

with $k \in \mathbb{R}_+$.

Now, suppose we have an homogeneous population at $t = 0$, homogeneous in the sense that all the individuals composing it share the same basic utilities and exposure function. Imagine we observe the individuals choosing from the grand set X, what kind of heterogeneity should we expect to emerge in the behavior of the individuals composing the population? The answer to this question is given in the next proposition.[7]

Proposition 1 *An homogeneous population choosing from X following a Lin-EBLM will show heterogeneous behavior as t goes to infinity. The limiting distribution of choice probabilities will be a Dirichlet distribution with parameters equal to the utilities of the different alternatives divided by k. That is, for any alternative $x \in X$, the probability $p_t(x|X)$ as t goes to infinity, will be distributed following a Beta distribution with parameters equal to $u(x)/k$ and $\sum_{y \neq x} u(y)/k$.*

This proposition gives a clear cut answer to the question we previously posed that is crucial for the strand of research analyzing the impact of early life experience on economic decisions and thus outcomes.[8] The result is saying that if we want to intervene and reduce the possibility of a bad habit to endure, we have two possible routes to follow. One, that can be costly, is to change the

[7]The result can be generalized thanks to classical results in statistics to an homogeneous population facing a time invariant distribution of menus. We do not pursue this route because it would not change the main message of the proposition.

[8]See Heckman (2006).

alternatives to which the different individuals are exposed. That is, we should change the menus the different individuals face. This is in line with the literature on freedom of choice that analyzes the impact of menus on individual freedom, see for example Pattanaik and Xu (1990), Sen (1991), Sen (1997a), Sudgen (1998), Barbera et al. (2004), Ballester and De Miguel (2006) and Savaglio and Vannucci (2007). Our results add to this debate a dynamic implication of opportunities. Early life opportunities might have a big weight on our decisions, limiting our possibilities of evading bad habits. The second route is more difficult to follow in many circumstances, e.g. drugs, but it can sometimes be achieved with proper disincentives. That is, it is possible to intervene on the basic utilities directly. Anything that affects the basic utilities has an impact on the limiting distribution of behavior we should observe.

All the results in this section rely on the fact that the DM is described by a EBLM, but is it possible to falsify the model? If yes, what are the properties that describe it? These questions are addressed in the following section.

4 Characterization

What properties should a process generated by a EBLM satisfy? This question is the focus of the present section. We assume we observe the choice probabilities of a population sharing the same preferences over the alternatives in X. That is, suppose we observe many and different sequences of decision problems and choices generated by a continuous population of individuals sharing the same preferences. Let $\mathcal{D}$ be the set containing such sequences and $D \in \mathcal{D}$ be the collection of observations composing one of them. Let any $D \in \mathcal{D}$ have length $T > 2$. We assume that for any $D \in \mathcal{D}$ and for any $t \in D$, we observe the probabilities of choosing the different alternatives in A_t. Moreover, we assume that $\mathcal{D}$ contains the following sequences:

- for any $x, y \in X$ and any $n_x, n_y < T$, there exists a $D \in \mathcal{D}$ such that there is some $t \in D$ where x and y have been chosen n_x and n_y times before respectively and $A_t = \{x, y\}$.
- for any $x, y, z \in X$ and any $n_x, n_y, n_z < T$ there exists a $D \in \mathcal{D}$ such that there is some $t \in D$ where x, y and z have been chosen n_x, n_y and n_z times before respectively and $A_t = \{x, y, z\}$.

These requirements in our framework are equivalent to the standard assumption in decision theory that asks to observe choices from all menus of cardinality two and three. The main difference is that here we ask to observe such menus after any kind of history of choices. This is an important assumption that allows us to identify the values of the different alternatives from observed behavior. Notice however that the property is not as strong as it seems at first glance. In fact, it is equivalent to observing an infinite population choosing deterministically and the stochastic choice would be representing the frequency of choices. Now we are ready to state the four properties that characterize the whole model. The properties are intended for any $D, D' \in \mathcal{D}$ and any $n_x, n_y, n, n' \in \mathbb{Z}_+$.

Axiom 1 (Exposure IIA (EIIA)) *For any $x, y \in X$ having been chosen n_x and n_y times up until $t \in D$ and $t' \in D'$ respectively and for any $A \subseteq X$:*

$$\frac{p_t(x|\{x,y\})}{p_{t'}(y|\{x,y\})} = \frac{p_t(x|A)}{p_{t'}(y|A)}$$

This is just a more general version of the classical IIA presented in Luce (1959). It imposes that the relative likelihood of choosing an alternative over the other, given the number of times the alternatives have been chosen, should not be influenced by the other alternatives present in the set. Clearly a EBLM satisfies this axiom given that the relative likelihood of choosing an alternative over the other, given the bias, depends only on the ratio of their utilities and biases.

Axiom 2 (Anonymous Bias (AB)) *For any $x, y, \in X$ having been chosen n times up until $t \in D$ and $t' \in D'$ respectively, and for any $z \in X$ having been chosen n' times up until t and t', if $x = a_t$ and $y = a_{t'}$ then:*

$$\frac{p_t(x|\{x,z\})}{p_t(z|\{x,z\})} - \frac{p_{t+1}(x|\{x,z\})}{p_{t+1}(z|\{x,z\})} = \frac{p_{t'}(y|\{y,z\})}{p_{t'}(z|\{y,z\})} - \frac{p_{t'+1}(y|\{y,z\})}{p_{t'+1}(z|\{y,z\})}$$

This axiom imposes that the effect that choosing an alternative has on the relative likelihood of choosing it again cannot be alternative specific and does not depend on the particular sequence under study. Given the exposure function does not depend on the alternative that has been chosen or on the sequence, a EBLM clearly satisfies it.

Axiom 3 (Exposure Bias (EB)) *For any $x, y \in X$ and for any $t \in D$, if $x = a_t$ then:*

$$p_t(x|\{x,y\}) \leq p_{t+1}(x|\{x,y\})$$

This axiom is the key one capturing the idea behind the cognitive bias we are analyzing. The probability of choosing an alternative cannot be negatively affected by the fact that the alternative has been chosen in the past. Notice that this axiom excludes the possibility of becoming satiated of a good. Clearly, given the exposure function is non-decreasing, the axiom has to be satisfied by a EBLM.

Axiom 4 (Marginally Decreasing Bias (MDB)) *For any $x \in X$ having been chosen n times up until $t \in D$ and such that $x = a_t$:*

$$|p_t(x|\{x,y\}) - p_{t+1}(x|\{x,y\})|$$

is non-increasing in n.

This is a more technical axiom which imposes that the effect of choosing an alternative has on the likelihood of choosing it again is marginally non-increasing. Given the exposure function is concave a EBLM trivially satisfies such property.[9]

Theorem 1 *A dataset $\mathcal{D}$ satisfies EIIA, EB, AB and MDB if and only if there exist a function $u : X \to \mathbb{R}_{++}$ and a non-decreasing concave function $f : \mathbb{R}_+ \to \mathbb{R}_+$ with $f(0) = 0$ that define an Exposure Biased Luce Model.*

4.1 Discussion: Menu Exposure

In the introduction we briefly discussed the possibility of considering a more general kind of exposure, that is, the exposure effect affects all the alternatives in the menu, not only the chosen one. There is in fact evidence that the exposure effect is something more general and that has to do with the unconscious processing of environmental stimuli, thus making the idea of extending the effect to the whole set of alternatives in the menu a sensible one. This can be extremely important, for example, for marketing strategies that try to increase the exposure of a product in the market.

The framework we propose here can easily accommodate a more general exposure effect. This is in fact quite trivial. Only two changes need to be implemented. First, we need to change the interpretation of the exposure function as the following definition highlights.

Definition 3 (Exposure Biased Luce Model* (EBLM*)) *p is an Exposure Biased Luce Model* if there exist a function $u : X \to \mathbb{R}_{++}$ and a function $f : \mathbb{R}_+ \to \mathbb{R}_+$ such that $\forall A \subseteq X$:*

$$p_t(x|A) = \frac{u(x) + f(n_x)}{\sum_{y \in A}(u(y) + f(n_y))}$$

where n_x and n_y are the number of times that alternative x and alternative y have been present in a menu up until t and f non-decreasing and concave.

It is immediate to notice that the only difference between a EBLM and a EBLM* is in the argument of the exposure function. While a EBLM considers only the exposure a chosen alternative gets, a EBLM* generalizes the idea to all the alternatives of a menu. This implies that the characterization of a EBLM* would be almost identical to the one of a EBLM except for a second change that needs

[9]Notice that the properties are independent. In fact, it is easy to think about procedures that satisfy all properties except one. For example, think about a EBLM in which the exposure effect is negative. Such procedure would satisfy all properties except EB. Another example can be an EBLM where the basic utility value of an alternative x, i.e., $u(x)$, depends on the other alternatives in the menu. Such procedure would satisfy all properties except EIIA. Similarly an EBLM with a convex exposure effect would satisfy all properties except MDB. Finally, an EBLM with an alternative specific exposure function would satisfy all properties expect AB.

to be done. The specification of the data has to change in order to properly state the new axioms. Let the new dataset $\mathcal{D}^*$ be as follows:

- for any $x, y \in X$ and any $n_x, n_y < T$, there exists a $D \in \mathcal{D}^*$ such that there is some $t \in D$ where x and y have been present in the menu n_x and n_y times before respectively and $A_t = \{x, y\}$.
- for any $x, y, z \in X$ and any $n_x, n_y, n_z < T$ there exists a $D \in \mathcal{D}^*$ such that there is some $t \in D$ where x, y and z been present in the menu n_x, n_y and n_z times before respectively and $A_t = \{x, y, z\}$.

Now we are ready to present the parallel version of the axioms we previously presented. For all of them, the only thing that changes is that this time we consider menu exposure, not only choice exposure. Again, the properties are intended for any $D, D' \in \mathcal{D}^*$ and any $n_x, n_y, n, n' \in \mathbb{Z}_+$.

Axiom 5 (Exposure IIA* (EIIA*)) *For any $x, y \in X$ having been present in a menu n_x and n_y times up until $t \in D$ and $t' \in D'$ respectively, and for any $A \subseteq X$:*

$$\frac{p_t(x|\{x,y\})}{p_{t'}(y|\{x,y\})} = \frac{p_t(x|A)}{p_{t'}(y|A)}$$

Axiom 6 (Anonymous Bias* (AB*)) *For any $x, y, \in X$ having been present in the menu n times up until $t \in D$ and $t' \in D'$ respectively, and for any $z \in X$ having been present in the menu n' times up until t and t', if $x = a_t$ and $y = a_{t'}$ then:*

$$\frac{p_t(x|\{x,z\})}{p_t(z|\{x,z\})} - \frac{p_{t+1}(x|\{x,z\})}{p_{t+1}(z|\{x,z\})} = \frac{p_{t'}(y|\{y,z\})}{p_{t'}(z|\{y,z\})} - \frac{p_{t'+1}(y|\{y,z\})}{p_{t'+1}(z|\{y,z\})}$$

Axiom 7 (Exposure Bias* (EB*)) *For any $x, y \in X$ and for any $t \in D$, if $x = a_t$ then:*

$$p_t(x|\{x,y\}) \leq p_{t+1}(x|\{x,y\})$$

Axiom 8 (Marginally Decreasing Bias* (MDB*)) *For any $x \in X$ having been present in a menu n times up until t and such that $x = a_t$:*

$$|p_t(x|\{x,y\}) - p_{t+1}(x|\{x,y\})|$$

is non-increasing in n.

This means that the parallel version of Theorem 1 can be stated also for this new specification of the model. The proof is omitted.

Theorem 2 *A dataset $\mathcal{D}$ satisfies EIIA*, EB*, AB* and MDB* if and only if there exist a function $u : X \to \mathbb{R}_{++}$ and a non-decreasing concave function $f : \mathbb{R}_+ \to \mathbb{R}_+$ that define an Exposure Biased Luce Model*.*

5 Final Remarks

Experiences play a major role in shaping our decisions. In particular, routinary choices have a very prominent role in our day to day decision making. Our decisions tend to show inertia that seems difficult to overcome. The economic effects of this kind of inertia can be catastrophic if it pushes individuals to reiterate suboptimal decisions. Thus, understanding the source of inertial behavior is crucial to design better economic policies.

In this paper, we make two main contributions. First we propose a more general and dynamic cognitive specification of the well-known status-quo bias. We adopt the mere exposure effect, a cognitive phenomenon first documented in Zajonc (1968), to model a process in which the probability of an alternative being chosen cannot decrease the more it is chosen. We show that it implies the emergence of phenomena such as the endowment effect, loss aversion and present bias and we use it to build a tractable model that can be implemented in standard economic analysis. Second we show that with our model it is possible to substantiate the idea that experiences are important in decision making for a deeper reason than mere learning. In fact, the model allows us to predict the distribution of heterogeneous behaviors we should observe from otherwise homogeneous individuals that had different experiences during their lifetime, and thus, through the exposure effect, end up choosing differently. Finally, we also provide some conditions that make the model empirically falsifiable and testable.

The main strength of the model we propose is its tractability. It provides a simple way of modeling behavioral inertia that can be easily used in standard economic analysis without the need to change the methods usually adopted or depart too much from the standard framework of rational choice. The implications of the model are many and can be potentially important not only for discussions on early life opportunities but also to have a better understanding of the structure of dynamic competition among firms. If consumers are described by our model, then the *pioneering advantage* or *first-mover advantage* emerge with clarity and the model might help to design better policies to avoid dominant market position. Nevertheless, the model is not able to incorporate some ideas that might be sensible in some context, like the idea of satiation. In some circumstances, it is sensible to assume that the DM becomes satiated with an alternative the more he chooses it. That is, the probability of choosing an alternative should decrease the more the DM is exposed to it. This is exactly the opposite model with respect to the one we are proposing here. Nonetheless, it should be possible to accommodate such ideas just by changing the properties we propose in this paper. In particular EB would need to be changed and also some more technical assumptions would be needed to correctly specify the model, i.e., to avoid probabilities becoming negative. This a route we leave to future research.

To conclude, we think it is important to try to find the main cognitive process that might cause some of the biases that have been documented in the literature in the last years. We think that this paper might help to shed some new light on the kind of behavioral inertia that is widely accepted in economics nowadays. In particular, the novelty of the framework we propose is to take into consideration the inherently dynamic relationship between experiences, inertia and choices.

A Appendix

A.1 Proofs

Proof of Remark 1. Suppose the DM, at the moment t has m units of money and he has to decide whether to buy an alternative x that he has chosen n times up to t. Then his WTP_t^x will be equal to $u(x) + f(n) - u(0)$. Now suppose the DM chooses x. Then, in $t + 1$, the WTA_{t+1}^x of the DM will be equal to $u(x) + f(n + 1) - u(0)$. But then, given that $f(n + 1) > f(n)$ due to the exposure effect, we must have that $\text{WTA}_{t+1}^x > \text{WTP}_t^x$, that is, the DM experiences the endowment effect. ■

Proof of Remark 2. Suppose we have a sequence of choices made by the DM that has m units of money, in which he chose the alternative x n times up to t. Once the DM chooses x, his WTA_{t+1}^x will be equal to $u(x) + f(n) - u(0)$. This implies that the WTA is increasing with n due to the fact that f is increasing and the result follows. ■

Proof of Remark 3. This is a straight forward implication of the exposure effect. Suppose we have a sequence of choice of length t in which the DM chose n times alternative x. Define $\mathfrak{U}_x^t$ as the set containing the alternatives dominating x at the moment in time t, i.e. $\mathfrak{U}_x^t = \{x' \in X | u(x') + f(n_{x'}) > u(x) + f(n)\}$. Then, given f is increasing in its argument, *ceteris paribus*, the set of alternatives that dominates x cannot increase with exposure. ■

Proof of Remark 4. Suppose the DM chooses an alternative x in t that he has chosen n times up to t. Then the value in $t+1$ of this alternative for him will be $u(x)+f(n+1)$. Thus, if he loses it the difference in utility will be $u(0)-(u(x)+f(n+1))$. On the other hand, if he has to decide in t whether to take the alternative, the perceived value of the alternative is $u(x)+f(n)$ due to his unawareness regarding the exposure effect in $t+1$. Thus, the perceived gain when taking alternative x is $u(x)+f(n)-u(0)$. Clearly, given f is increasing, $|u(0)-(u(x)+f(n+1))| > |u(x)+f(n)-u(0)|$ and the result follows. ■

Proof of Remark 5. When at s, the difference between the utility of consumption at time t and the one of consumption at time $t + 1$ for a naiv̈e DM described by a EBLM will be $\Delta_s = |u(c_t) - u(c_{t+1})|$. On the other hand, once at t we have $\Delta_t = |u(c_t) + f(1) - u(c_{t+1})|$. Clearly, due to the exposure bias, $\Delta_s < \Delta_t$, and the remark follows. ■

Proof of Proposition 1. Notice that a Lin-EBLM defines a random process with reinforcement equivalent to the classical Pólya urn process presented in Eggenberger and Pólya (1923).

Definition 4 (Pólya Urn Process) *A Pólya Urn Process is a process following which at any t a ball is drawn from an urn containing only two colors, white and black. Whenever a ball of a given color is drawn, it is returned to the urn in addition to $k \in \mathbb{R}_+$ balls of the same color.*

Notice that the initial number of balls of each color does not have to be an integer, it can be any positive real number.

To see that a Lin-EBLM can be seen as a Pólya urn, let the alternatives be the different colors in the urn and the initial utility values of the alternatives be equivalent to the number of balls of each color in the urn. Then choices are draws and the exposure bias determines how many balls of each color are added in every draw. In their classical result Eggenberger and Pólya show that an urn containing balls of two colors, will converge to a Beta distribution with parameters equal to the initial numbers of the two kind of balls in the urn each divided by k.

Given this result, it is immediate to see that our process should converge to a Dirichlet distribution with parameters equal to the basic utilities of the different alternatives divided by k. In fact, notice that we can take any alternative x and define a fictitious alternative $\overline{x}$ representing all other alternatives. This would still define a Pólya urn with two colors, hence the result in Eggenberger and Pólya (1923) would directly apply. Given the generality of the reasoning, it must be that the final distribution of the process has Beta distributions as marginals, that is, the process must converge to a Dirichlet distribution with parameters equal to the utilities of the different alternatives divided by k. $\blacksquare$

Proof of Theorem 1. *Necessity*: In the text.

Sufficiency: We proceed following three steps that will allow us to construct the functions on which a EBLM is based. In the first step we are going to define a general utility function for every alternative that only depends on the number of times an alternative has been chosen. Then we are going to show that it is possible to separate such function into two components that will characterize the utility function and the exposure function that is not alternative specific and non decreasing in exposure. Finally, we will show that the exposure function has to be concave.

First, notice that EIIA implies that the relative probabilities of two distinct alternatives depend neither on the other alternatives in the set nor on the particular sequence the alternatives are in. Hence, given $\mathcal{D}$, we can apply the results in Luce (1959) and construct a utility function $v : \mathbb{Z}_+ \times X \to \mathbb{R}_{++}$ that assigns a real value to an alternative $x \in X$ that depends on the number of times the alternative has been chosen that is defined as follows. For any $x \in X$ having been chosen n_x times up until t, and for any $A \subseteq X$::

$$p_t(x|A) = \frac{v(n_x, x)}{\sum_{y \in A} v(n_y, y)}$$

That is, $v(n_x, x)$ will represent the utility of x after having been chosen n_x times. Such function is unique up to a scalar transformation.

Now, we want to show that v can be decomposed into a utility function $u : X \to \mathbb{R}_{++}$ that represents the preferences of the DM not influenced by exposure and another function $f : \mathbb{N} \to \mathbb{R}_+$ that is not alternative specific and that is non-decreasing in exposure. W.l.o.g., take $x, y \in X$ such that haven bee chosen 0 times up until $t \in D$ and n times up until $t' \in D'$ and a third alternative $z \in X$ that has been chosen n' times up until t and t'. First notice that EIIA implies the following equalities:

$$\frac{p_t(x|\{x,z\})}{p_t(z|\{x,z\})} = \frac{p_t(x|\{x,y,z\})}{p_t(z|\{x,,y,z\})}$$

$$\frac{p_{t'}(x|\{x,z\})}{p_{t'}(z|\{x,z\})} = \frac{p_{t'}(x|\{x,y,z\})}{p_{t'}(z|\{x,y,z\})}$$

$$\frac{p_t(y|\{y,z\})}{p_t(z|\{y,z\})} = \frac{p_t(y|\{x,y,z\})}{p_t(z|\{x,y,z\})}$$

$$\frac{p_{t'}(y|\{y,z\})}{p_{t'}(z|\{y,z\})} = \frac{p_{t'}(y|\{x,y,z\})}{p_{t'}(z|\{x,y,z\})}$$

Then AB, by induction, implies the following:

$$\frac{p_{t'}(x|\{x,y,z\})}{p_{t'}(z|\{x,y,z\})} - \frac{p_t(x|\{x,y,z\})}{p_t(z|\{x,y,z\})} = \frac{p_{t'}(y|\{x,y,z\})}{p_{t'}(z|\{x,y,z\})} - \frac{p_t(y|\{x,y,z\})}{p_t(z|\{x,y,z\})}$$

Using the representation we obtained by applying the classic result from Luce (1959), we can rewrite the previous equality as follows:

$$\frac{v(n,x)}{v(n',z)} - \frac{v(0,x)}{v(n',z)} = \frac{v(n,y)}{v(n',z)} - \frac{v(0,y)}{v(n',z)}$$

That is:

$$v(n,x) - v(0,x) = v(n,y) - v(0,y)$$

Given the generality of the argument, this is true for any $x, y \in X$ and for all $n \in \mathbb{Z}_+$. This implies that we can separate v into two components. We can let $u : X \to \mathbb{R}_{++}$ be equal to $v(0, \cdot)$ and define a function $\hat{f} : \mathbb{Z}_+ \to \mathbb{R}_+$ such that for all $n \in \mathbb{Z}_+$, $\hat{f}(n) = v(n,x) - v(0,x)$ for some $x \in X$. It is immediate to see that $\hat{f}(0) = 0$. Moreover, by Luce (1959), u as it is defined rationalizes the choice of the DM in the absence of the exposure effect.

Now let $f : \mathbb{R}_+ \to \mathbb{R}_+$ be the affine extension of $\hat{f}$. It is immediate to see that EB implies that f is non-decreasing. In fact, EB implies that $v(n+1, x) - v(n, x) \geq 0$ for any $x \in X$ and $n \in \mathbb{Z}_+$.

Finally, it is immediate to see that MDB implies that f is concave. In fact, by MDB and the definition of affine extension, for any $n \in \mathbb{R}_+$ we have $f(n+1) - f(n) \leq f(n) - f(n-1)$, that is, $f(n+1) + f(n-1) - 2f(n) \leq 0$ which implies that the function is concave. ■

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