An Experiment on Aspiration-Based Choice*

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Abstract

This paper experimentally studies the influence of aspirations on choice. Motivated by the theoretical model of Guney et al. (2015), we consider choice problems which may include unavailable alternatives. In a choice problem, an aspiration is the most desired alternative there (available or not). In our design, we endogenously derive both aspirations and a subjective similarity notion that operates between an aspiration and other alternatives. We find that (i) choice reversals are more likely when an unavailable aspiration alternative is added into the environment than when an unavailable non-aspiration alternative is added, (ii) an available option is more likely to be chosen when there is an unavailable aspiration that is similar to it compared to when there is no such option in the environment, (iii) choices are better explained by a similarity-based procedure when the similarity notion that is endogenously derived in a separate part of the experiment is used rather than the Euclidean metric.

Keywords: Experiment; Choice; Aspiration; Phantom; Similarity; Reversal

JEL classification: D010, D11, D12, C91

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1 Introduction

People possess aspirations regarding almost every aspect of life ranging from consumption (e.g. luxury products) to partner search (e.g. ideal mate). Moreover, as also pointed out in Hedgcock et al. (2009), preferred options might often be unavailable. This unavailability may stem from a variety of sources: in a standard consumer setting, a product might be simply unaffordable or sold out; in a political context, a candidate may exit the race; and in marketing, companies may pre-announce products which are not yet available on the market. The fact that aspirations may sometimes be unavailable does not prevent them from having an impact on agents' decisions. Our goal in this paper is to experimentally investigate this impact on choice behavior.

Consider the following anecdotal example to illustrate what we mean by an aspiration and how we think it may influence choices. Say, a customer enters a shoe store, looks at all the shoes set out in the store, and finds a pair she likes best. We think of that pair as her current aspiration since it is her ideal pair in the store and she would choose it absent any restrictions. But, what if her size is sold-out or the pair is unaffordable for her? In such a circumstance, the customer may then look for an available pair that is similar to her unavailable aspiration. There is no guarantee, however, that the most similar pair will be the same as the available pair that gives her the highest utility. Therefore, unattainable aspirations, by promoting a similarity-based choice behavior, may very well lead the decision maker to behave in a way that cannot be explained by the standard theory. Indeed, the marketing and psychology literatures present some *indirect* evidence for such effects. It is found that choice shares[1] of the two alternatives change significantly depending on whether or not a third alternative that is "highly desirable" but unavailable exists in the choice environment (Farquhar and Pratkanis (1992, 1993), Highhouse (1996), and Pettibone and Wedell (2000)). When such an option exists, the choice share of the alternative "similar" to it is observed to increase significantly.

In a choice environment where some of the observed alternatives are unavailable, we think of an aspiration as the alternative that the decision maker would choose, i.e. the agent's first best option, if all alternatives in that choice problem were available.[2] Thus, an agent's aspiration varies with the available and unavailable alternatives that she faces, as in the case of different aspirations in different shoes stores. Additionally, the aspiration in a choice environment is the agent's universally best alternative only when the universally best option is present in the choice environment, which typically is not the case.

Notice that different agents may form different aspirations in the same environment. However, studies in the psychology and marketing literatures typically work with "highly desirable" alternatives that are uniform across all agents rather than specific to each agent. For example, a highly desirable option might be considered as an alternative with the highest liking rating aver-

[1] The choice share of an alternative in a set is the percentage of agents who choose it from that set.

[2] When all alternatives are available, an agent's aspiration is the alternative that she chooses. In the case of unavailability, our definition of aspiration imposes no restriction on when a decision maker learns about the unavailability of alternatives. The shoe store example is consistent with our definition both when the set of unavailable shoes is revealed to the customer at the outset or later.

aged across all subjects (Min 2003) or an exogenously introduced alternative that asymmetrically dominates one of the two other options which have equal choice shares initially (Pettibone and Wedell (2000)). Neither method guarantees that the candidate option is an aspiration for *each individual*. This makes it impossible to distinguish whether the observed impact is due to the unavailable alternative being an aspiration or perhaps just due to the presence of an unavailable alternative.

Another issue in most studies in the literature is that the "similarity" (distance) between options is determined by an objective measure (e.g. the Euclidean distance), which depends on options' physical characteristics. Yet, in reality, the Euclidean distance may not coincide with a decision maker's notion of similarity or serve as an appropriate proxy. For example, Euclidean distance between pairs of a black leather and a brown suede shoes is not meaningful since color and material are attributes that cannot be naturally represented in the Euclidean space. Additionally, agents' perceptions of distance may be subjective and thus, the similarity between any two options may not be perceived the same by all as opposed to the literature where typically the same distance function is assumed to be employed by each subject.

Motivated by both real life circumstances and the indirect evidence in the literature, we study the effects of possibly unavailable aspirations on choice through an individual decision making experiment that is free of the issues above. Our aim is twofold. First, we explore whether unavailable aspirations really affect choices. Second, we examine whether unavailable aspirations act on choices through the channel of a subjective similarity notion. More specifically, using well-defined measures of endogenously determined aspirations and similarity notions, we aim to answer the following questions: (1) Do unavailable aspirations affect choices by leading to choice reversals and how do the effects of unavailable aspirations and unavailable options that are not aspirations compare? (2) How does the presence of an unavailable aspiration influence the odds that the most similar option is chosen? (3) Which of the subjective and Euclidean distance can better explain the tendency to choose the option closest to the unavailable aspiration?

To address these questions, we design an experiment that is composed of two parts. Part 1 contains choice tasks where either all options are available or some options are displayed with an "unavailable" tag and are unchoosable. In Part 2, we use a variation of the Becker-DeGroot-Marschak (1964) mechanism to derive, for each subject, a willingness to exchange price. We interpret this price as a subjective distance that reveals how similar an agent perceives her aspiration is to other options.

Our experimental results show that a significant number of choice reversals, i.e. an agent changing her choice, occur when an unavailable alternative deemed as an aspiration is introduced into the environment. Moreover, we find that the odds of choice reversal are significantly higher when the introduced unavailable option is an aspiration compared to the case when it is not. These two findings, taken together, provide evidence that unavailable aspirations influence agents' choice behavior. Additionally, we find that the odds that the alternative subjectively closest to the unavailable aspiration is chosen increase significantly when the unavailable aspiration is present in the environment relative to the case it is not. Furthermore, compared with the Euclidean distance function that is widely used in earlier studies, the subjective distance function we derive for each individual better explains the tendency to choose the option closest to the unavailable aspiration. The last two findings provide support for a subjective similarity-based choice behavior.

The role of preferred unavailable options is of substantial practical interest. As also pointed out in Farquhar and Pratkanis (1992), it is not difficult for firms or policy makers to introduce unavailable products that would act as aspirations for people. Such options may have a significant impact on choice behavior and thus may potentially be used by marketers and policy makers who may want to strategically introduce unavailable options to affect people's choice behavior. For the examples of the use of unavailable options as propaganda devices in various persuasion and decision making settings, see Farquhar and Pratkanis (1992).

The rest of the paper is organized as follows. Section 2 provides a quick literature review. Section 3 explains the theoretical background. Section 4 presents the experimental design. Section 5 explains hypotheses and how the design can distinguish among alternative theories. Section 6 gives the main results. Section 7 concludes. In Appendix I (Section 8), additional analyses for the main results and details about the main experiment's design are provided. In Appendix II (Section 9), two extensions are presented: (i) the timing of unavailability is varied, (ii) the setting of choice problems is extended so that either the number of attributes in alternatives or the number of (un)available alternatives is greater.

2 Related Literature

An alternative that exists in the choice environment but is unavailable at the time of choice is called a *phantom* in the literature. A phantom alternative is not necessarily highly desirable and effects of such phantoms on choice are analyzed in numerous experimental studies. For instance, Doyle et al. (1999) find that the attraction effect (Huber et al. (1982)) is still observed even when the asymmetrically dominated option is a phantom while Ge et al. (2009) show that the compromise effect (Simonson (1989)) continues to exist when the extreme option is unavailable. These effects differ from the aspirational effects studied in the present paper. Because an aspiration refers to a superior alternative that is chosen uniquely whenever available. In contrast, an extreme option is not necessarily an aspiration and when agents have monotonic preferences, an asymmetrically dominated option can never be an aspiration.

Another line of research studies the effects of phantom options that are highly desirable. Even though these phantoms are suggested to be "superior" alternatives, as discussed earlier, superiority for each subject is indeed no guarantee and also, subjective measures of similarity are not allowed. Our work differs from previous literature in that, taking its base from a theory, both aspirations and distance measures are formally defined and derived endogenously in our experiment for each agent through incentive compatible mechanisms. In contrast to most of the studies in the literature which use a between subject analysis and compare relative choice shares in the absence and presence of a reference alternative, we study these effects in a within subject analysis and look at choice reversals at an individual level. However, one aspect where our paper agrees with the earlier work is that alternatives in our choice problems can naturally be viewed as members of a standard Euclidean space.[3] Thus, we are able to compare the performance of the subjective distance functions with that of the Euclidean metric, which is frequently used in previous studies.

There is a strand of literature where the effects of aspirations have been experimentally studied in various contexts (such as risky choice and group decision making) under a quite different interpretation of aspirations (Simon (1955), Harnett (1967), Payne et al. (1980, 1981)). Informally, they define an aspiration to be a subjective threshold and any outcome below is considered to be a failure while any outcome above to be a success. This contrasts significantly with the current paper where we consider an aspiration in a given choice setting to be the alternative that yields the highest utility if the decision maker were to face no unavailability restrictions. Put differently, we consider aspiration more of an ideal that the decision maker is dreaming about rather than a threshold.

Finally, the theoretical implications of aspirations are also studied in other settings. For example, Bendor et al. (1995, 2001), Karandikar et al. (1998), Cho and Matsui (2005) study the effects of aspirations on players' strategy choices; Genicot and Ray (2014) incorporate aspirations in the study of economic issues like investment, mobility, inequality, and the poverty trap; and Guney et al. (2015) apply their aspiration-based choice model to study the difference between pre- and post-promotion consumption amounts of a good and conformity behavior in networks. These studies highlight the possible implications of aspirations in various settings and emphasize the need for a better understanding of aspirations experimentally as well.

3 Theoretical Background

According to the classical theory in economics, each agent has a utility function and when confronted with a set of available alternatives, she chooses the available alternative that maximizes her utility. However, violations of the classical theory have been observed in experimental studies and a reference point is one of the most frequent reason for such violations. It is known that an agent who chooses an alternative a over b in the absence of a reference point might choose b over a in the presence of a reference alternative. This cannot be explained by the standard theory. To explain such behavior, various reference-dependent choice theories have been proposed. Some of these theories consider a reference point in a general sense (Tverksy and Kahneman (1991), Köszegi and Rabin (2006)) while others study the effect of a specific reference point such as aspirations (Rubinstein and Zhou (1999), Guney et al. (2015)) and status quos (Masatlioglu and Ok (2005, 2014), Ok et al. (2014), Riella and Teper (2014)).

[3] The way alternatives are defined in Euclidean space slightly differs in earlier studies and the present one. A typical alternative in previous research is a good defined by a combination of several attributes mostly expressed as a numerical value (e.g. a car defined by its price as well as ride quality). Our study uses a bundle of several goods as a typical option (e.g. 4 bars of chocolate and 3 folders is a bundle).

Guney et al.'s (2015) aspiration-based choice (ABC) theory is the most closely related theoretical work. Following a revealed preference approach, they suggest a model of how aspirations arise and affect choices. Formally, they extend the basic choice theory setup by taking a choice problem to be a pair of sets (S, Y) with $S \subseteq Y$, where both sets are subsets of the grand space X. They offer the interpretation that Y is the collection of alternatives the decision maker observes in the environment and S is the set of alternatives that are available to her among them. Thus, confronted with a choice problem, this agent can choose alternatives from S only, i.e. $C(S, Y) \subseteq S$. In the earlier shoe store example, the set of all shoes in the world can be considered as X, the set of all shoes set out in the store as Y and the ones that are available in her size as S. Pairs of shoes that are set out in the store but not available for the agent to choose, that's $Y \backslash S$, are referred to as *phantoms*.

Imposing axioms on choices, Guney et al. (2015) characterize a choice procedure that is based on two endogenously derived parameters over the grand space: a (strict) preference relation $\succeq$ that reveals the agent's reference-free preference over any two alternatives and a distance function d that reflects how she perceives dissimilarity between any two alternatives. When faced with a choice problem (S, Y), the decision maker first forms her aspiration $a(Y)$ by maximizing her preference relation $\succeq$ over Y and then chooses the alternatives in S that are closest to her aspiration with respect to her distance function d. Thus,

$$C(S, Y) = \operatorname*{argmin}_{s \in S} d(s, a(Y)) \text{ for every choice problem } (S, Y).$$

ABC theory, recognizing that a decision maker's perception of similarity is personal, formulates a representation based upon a *subjective* distance notion. Guney et al. (2015) first derive a set of aspiration-dependent utility functions and then construct the distance function so that the distance between any two alternatives is ordinally equivalent to the difference between their aspiration-dependent utilities, given the aspiration. Formally, for any two alternatives x and b such that $b \succeq x$,

$$d(x, b) \approx U_b(b) - U_b(x)$$

where d is the distance function, U_b is the aspiration-dependent utility of an alternative when the agent has the aspiration b.[4]

The predictions of ABC theory are as follows: (i) the agent chooses her aspiration uniquely whenever it is available, i.e. $a(Y) \in S \Rightarrow C(S, Y) = a(Y)$, (ii) when the aspiration is unavailable, the agent chooses the available alternative that is closest to her aspiration (and this closest available alternative might be different than the available option with the highest utility), (iii) the subjectively derived distance better explains the choice data than an exogenously given distance function, (iv) the agent can exhibit choice reversals[5] upon the introduction of an unavailable option into the

[4] This theory guarantees the following property which is also very well-aligned with intuition: When an alternative is the aspiration, its aspiration-dependent utility is higher for itself than any other lower-ranked alternative, i.e. $U_b(b) \geq U_b(x)$ for any x and b such that b is preferred over x.

[5] Formally, a choice reversal is said to occur when $C(S, S) \neq C(S, Y)$ for some S, Y such that $S \subseteq Y$.

environment when that option serves as an aspiration but her choice must remain the same (hence, no reversals) when the added unavailable option is not an aspiration. In a weaker form, this prediction can be also formulated as the amount of choice reversals due to the introduction of an unavailable aspiration must be greater than the reversals due to the introduction of a non-aspiration alternative.

In a choice problem (S, Y), an agent's aspiration is drawn from Y and this is an important feature that disciplines the model. If the aspiration were formed more broadly by being drawn from a varying larger set that might include alternatives unobserved to an outsider (such as the shoes seen through advertisements or searches prior to visiting the shop Y in our earlier motivating example), then all predictive power of the above model would be lost because the "true" Y could vary significantly across choice problems. If aspirations were formed more narrowly by being drawn from the set S of feasible elements, then the model would impose too much discipline and reduce to the rational choice model.[6] By requiring the aspiration to be derived from the set Y, ABC theory aims to find a compromise which allows deviations from rationality while retaining predictive power to some extent.

Notice also that while ABC theory is a model of not fully rational agents, the reason need not be due to cognitive limitations. In fact, agents perform two optimization procedures (maximizing $\succeq$ and minimizing d). The interpretation of ABC theory is rather procedural; it suggests a way in which agents may make decisions when faced with desired unavailable alternatives.

Rubinstein and Zhou (1999) also study a distance minimization procedure which selects the closest alternative to an exogenously determined reference point. Given that their model allows for unavailable reference points and the reference option is chosen whenever it is available, the reference point in their model can also be interpreted as an aspiration. However, references in their model are exogenously given whereas Guney et al. (2015) recognizes the subjectivity of aspirations and derives them endogenously. In contrast to ABC model, Rubinstein and Zhou (1999) do not allow for the absence of a reference point. Moreover, they restrict the grand alternative space and the distance function to be Euclidean. While Guney et al.'s (2015) ABC theory allows for Euclidean space and distance function, it also allows for choice situations where alternatives cannot be naturally expressed as Euclidean and the distance notions in agents' minds are subjective and do not necessarily coincide with the Euclidean distance.

Another particular reference point frequently studied in the literature is a status quo (Masatlioglu and Ok (2005, 2014), Ok et al. (2014), Riella and Teper (2014)). There are two typical features of status quo-based choice theories in the literature: (i) a status quo is always assumed to be available and therefore choosable in a choice problem, (ii) the agent first rules out all alternatives that are inferior to the status quo and then makes a choice from the remaining set of options.

[6] Another possibility may be that Y consists of all alternatives that the agent has observed until her time of choice. Given our experimental design, this would imply that Y is equal to the grand set of alternatives in the experiment (plus alternatives previously observed outside the experiment). In this scenario, Y would not vary across choice problems and hence, the theory would again predict rational behavior. As will be seen, rational behavior is ruled our by our choice data.

In contrast to the availability assumption in these theories, aspirations in reality are frequently unattainable and therefore cannot be chosen. As modeled in Guney et al. (2015), aspirations lead to deviations from rationality only when *unavailable*. Furthermore, aspirations are by definition alternatives which are superior to all available alternatives and a procedure which requires all inferior options to be eliminated would result in choosing nothing whenever an aspiration is unavailable.

One of the most well-accepted theories of a general reference point is Tversky and Kahneman's (1999) loss aversion model. Unlike Guney et al. (2015), Tverksy and Kahneman (1991) concentrate on a more restricted choice domain, namely Euclidean space, and study reference points that are *exogenously given* and not necessarily the most desired options as in the case of aspirations. They model loss averse behavior where gains and losses are determined according to a reference point and losses loom larger than gains. Different from Guney et al. (2015), this theory does not allow for reference-free choice situations. Even though one can suggest designating a neutral reference point (such as $(0,0)$ in the Euclidean space) to represent a no reference situation, this results in situations that are incompatible with aspirations. As shown in Masatlioglu and Ok (2014), Tversky and Kahneman's (1991) general non-constant loss aversion model over a large enough domain must necessarily lead to a situation where an agent chooses an alternative a over b when there is no reference point, but chooses b over a when a is the reference point.[7] This behavior is against the idea of an "aspiration" which is a highly desirable alternative that is selected whenever it is available. In contrast, Tversky and Kahneman's (1991) constant loss aversion model does not suffer from the above behavior, but cannot explain some specific choice patterns in our experimental design that ABC theory can. Details on such patterns are provided in Section 5 where we introduce our hypotheses and ways to distinguish among alternative explanations, given our experimental design.

Finally, Köszegi and Rabin (2006) suggest a model of reference-dependent preferences. They consider agents with loss averse utility functions (Tverksy and Kahneman (1991)) and endogenously derived expectations serve as reference points there. In a single agent model, they define an equilibrium notion where the agent's rational expectations are consistent with the optimal behavior given the expectations. According to their model, gain-loss utility influences behavior in the presence of uncertainty but in deterministic environments behavior reduces to the rational choice. This is different from Guney et al. (2015) where aspirations can result in deviations from rationality in deterministic environments.

As we discussed earlier, aspirations in reality are formed by individuals themselves rather than being exogenously given. Hence, they are subjective. Aspirations of an individual in a choice situation need not be the same as the aspirations of another person in the same choice environment. This necessitates the endogenous derivation of aspirations if one aims to understand their effects. Second, in experimental studies, a distance or similarity notion is suggested as a channel through which aspirations might influence choices. An observation from real life suggests that these notions could be very different from objective measures and might vary from one person to another. Hence,

[7] A non-constant loss-averse utility refers to a utility function that is concave in the gain domain and convex in the loss domain whereas a constant loss-averse utility is linear in both the gain and loss domains.

a study aiming to test this similarity channel should derive the distance function endogenously. Given that Guney et al. (2015) is the only study combining such desired features, we take it as our starting point and base our experimental design on it.

Note that our purpose here is not to test each axiom of Guney et al.'s (2015) ABC theory separately. We rather explore the overall behavior jointly characterized by their axioms and focus on testing the implications which we believe are the most critical. More specifically, we are interested in whether unavailable aspirations can lead to choice reversals as allowed by their theory and whether choices can be viewed *as if* arising from the minimization of a subjective distance given that the reference points are the endogenously determined aspirations as modeled in ABC theory. One needs to be cautious here as we test an "as if" argument. We don't claim that subjects actually use the distance minimization procedure ABC model suggests. Indeed, subjects might have different distance notions or more broadly formed references in their minds, or they might even apply different procedures which happen to give rise to the choices we observe in the experiment. We rather say that a significant amount of choices observed in the experiment can be viewed *as if* agents use the aspiration choice procedure with the distance notion derived in Part 2 of the experiment. We also discuss why these choices cannot be viewed as arising from other related models, both theoretically (Section 5) and through our experimental data (Section 6).

4 Experimental Design

We conducted a computer-based experiment at the laboratory of Center for Social Sciences (C.E.S.S.) at New York University. Subjects were recruited from the general undergraduate population via e-mail solicitation. A total of 198 subjects participated in 12 experimental sessions where 7 of these sessions with a total of 99 students were for the main treatment and the rest was for the extension treatment which varied the timing of unavailability. Details of that extension treatment is provided in Appendix II. The experiment is composed of two parts which are completed by each subject in order. In the beginning of the experiment, the instructions for Part 1 were read aloud to ensure clarity. Next, subjects participated in Part 1 of the experiment. After everyone in a session had completed that part, instructions for Part 2 were read aloud. Then, subjects participated in Part 2 of the experiment and finally each participant received her payment in private. The entire process lasted approximately 55 minutes.

Each alternative in a decision task was a bundle of consumer goods such as postcards, key chains, folders. Before subjects started answering questions in Part 1, each consumer good that would be the part of a bundle in the experiment was publicly shown to all subjects.[8] A list of the specific bundles used in the experiment is provided in Appendix I. Within any specific task, the set of consumer goods used in bundles was fixed and only the amount of goods was varied across bundles. The cost of each bundle used in the experiment was approximately the same. On average,

[8]Here, subjects only knew the consumer goods that would be present, but not the exact bundles that they would face in the experiment.

subjects earned a combination of cash and consumer goods with a combined value of \$20. The agents' compensation was designed so that there was no strategic benefit to lying, i.e. choosing an unpreferred bundle, and this was also explained to the subjects in the instructions.

Part 1 is composed of choice tasks. In a choice task, either (1) all displayed alternatives are available, or (2) an unavailable alternative is also displayed in addition to the available options presented. Subjects are asked to choose one of the available options in each task. A task in category (1) refers to (Y, Y) type of choice problems in ABC theory and it is called a "binary" task if the cardinality of Y is two, a "trio" task if the cardinality of Y is three. For each trio task, there is one corresponding task in category (2) where all three alternatives in the trio task are still presented but one option is now displayed with an "unavailable" tag on it and is unchoosable. We call these tasks "two+one" to indicate that two available and one unavailable alternatives are presented in the task. These are the tasks of (S, Y) type with $S \subsetneq Y$ in ABC theory[9] where the available alternatives displayed in the task form the set S and all options displayed (including both the available and unavailable ones) form the set Y. The unavailable option in a task is predetermined and is either asymmetrically dominant, dominant, or compromise.[10] To prevent any psychological effect that might arise due to different reasons of unavailability (e.g. stock-out or sold-out), no reason for unavailability is mentioned to subjects. For binary tasks, there are no associated questions of type (2) since marking one alternative as unavailable would leave only one available option and hence no room for choice.

There are 10 binary, 15 trio, and 15 two+one tasks. In each round, a choice task is presented and subjects indicate their choices by clicking on the available bundle they like. Figures 1, 2, and 3 show screenshots of typical rounds.[11] The order of rounds and the order of alternatives in each task are randomized for each subject. However, to guarantee that trio and two+one tasks are not presented consecutively, randomization is done so that subjects encounter all trio tasks before the rounds of two+one tasks start to appear. If trio tasks were allowed to appear after their corresponding two+one tasks, then this could introduce status quo biases into the agent's choice problem as the alternatives she faces earlier are present later. The particular way we randomize prevents this potential problem.

Based on ABC theory, an agent's aspiration in a two+one task, i.e. (S, Y), is taken to be the alternative she chooses in the corresponding trio task, i.e. (Y, Y). For example, a subject's aspiration in Figure 3 is her choice from the corresponding tasks in Figure 2. Thus, if she chooses

[9] From now on, for ease of notation, we will not write the property $S \subsetneq Y$ in the text. However, whenever we mention a pair of sets denoted with different letters, we think that the first set is a strict subset of the second.

[10] We say a bundle a "dominates" another bundle b if a offers weakly more of every good and strictly more of at least one good compared to b. A bundle is "asymmetrically dominant" if it dominates exactly one of the other two bundles and "dominant" if it dominates both of the other bundles. Finally, a bundle is a "compromise" if it is a convex combination of the two other bundles and there are no dominance relations among the three of them. See Figure 6 in Appendix I for more specific information. Our analysis will control for these types.

[11] The task in Figure 1 is of (Y, Y) type where $Y = \{$5 Pens and 1 Folder, 1 Pen and 5 Folders$\}$. The task in Figure 2 is again of (Y, Y) type but this time $Y = \{$5 Pens and 1 Folder, 1 Pen and 5 Folders, 2 Pens and 4 Folders$\}$. The task in Figure 3 is of (S, Y) type where $Y = \{$5 Pens and 1 Folder, 1 Pen and 5 Folders, 2 Pens and 4 Folders$\}$ and $S = \{$5 Pens and 1 Folder, 1 Pen and 5 Folders$\}$.

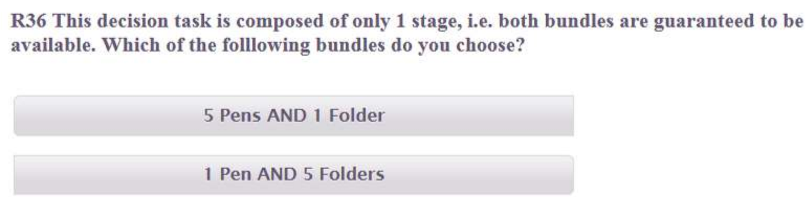

Figure 1: A Binary Task

Figure 2: A Trio Task

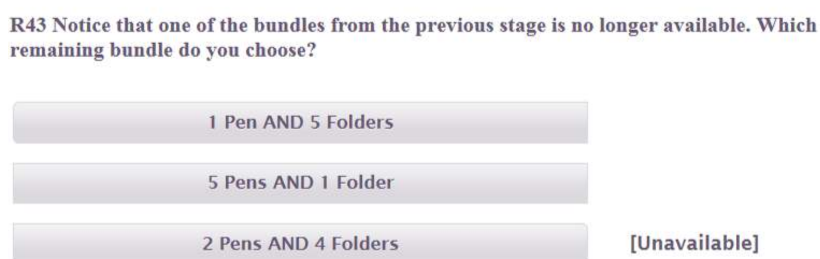

Figure 3: A Two+One Task

(2 Pens, 4 Folders) in Figure 2, then her aspiration is unavailable in the corresponding task given in Figure 3. Otherwise, if she were to choose (1 Pen and 5 Folders) or (5 Pens and 1 Folder) in Figure 2, then her aspiration is available in the corresponding two+one task given in Figure 3. We say "a choice reversal occurs" if a subject makes different choices from (S, Y) and (S, S). That is, in our terminology, a choice reversal may only occur between two choice problems with the same set of available alternatives. In our experiment, a reversal corresponds to choosing different options in a two+one task and its corresponding binary task that is obtained by removing the unavailable option in the two+one task from display completely and keeping its available options only. For example, a subject exhibits a choice reversal if she chooses different bundles from the tasks depicted in Figures 1 and 3.[12]

[12] There are other possible violations of rationality that may occur across *different* choice sets. In our experiment, a natural one is: if an alternative x is chosen in a trio task and a different alternative is made unavailable, creating a two+one task and x is no longer chosen there. That is, *choice reversals* may occur only between choice problems with exactly the same set of available alternatives, and *rationality violations* may occur when the set of available alternatives is changed as well.

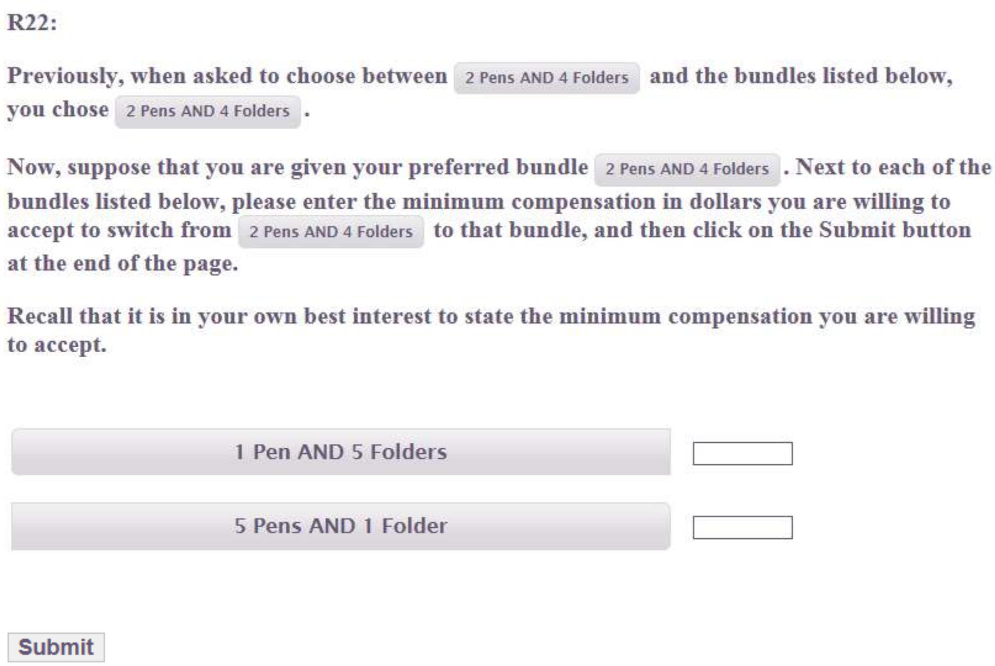

Figure 4: A Typical Round in Part 2

In order to test for similarity-based behavior, we need a proxy for similarity between an aspiration and other less preferred options. Recall from Section 3 that according to Guney et al. (2015), distances can be taken as $d(x, b) \approx U_b(b) - U_b(x)$. In the experiment, we derive this utility difference as a "willingness to exchange price", i.e. how much an agent needs to be compensated to switch from b to x when b is her aspiration. This utility difference need not be cardinally equal to the exchange price, but rather only needs to be ordinally equivalent. Therefore, we interpret a subject's minimum exchange price as her "subjective distance" between the two bundles. In particular, if an agent asks for \$5 to switch from b to x, but \$8 to switch from b to y, then we interpret b as subjectively more similar or closer to x than to y.

Thus, to measure the above utility difference, we use a modification of the Becker-DeGroot-Marschak mechanism in Part 2.[13] For each of the fifteen trio, i.e. (Y, Y), tasks in Part 1, there is a corresponding round in Part 2. Suppose that a subject has chosen bundle b in a trio task in Part 1 and so revealed that b is her aspiration among the bundles in that task. In this case, in the corresponding round in Part 2, this subject is provided with bundle b and asked to state the minimum (positive) price at which she would agree to change b for each of the other two bundles in the original trio task.[14] Figure 4 shows a typical screenshot of a round in Part 2 that is displayed

[13]Other types of valuation measures such as willingness to pay/accept are studied in the literature, e.g. Thaler (1980), Bateman et al (1997), Bateman et al. (2005).

[14]Our design guarantees the positivity of the willingness to exchange price because a subject is always provided with her favorite (aspiration) bundle and the price she declares is for changing this favorite bundle for a less preferred one. One may suggest that an endowment effect might be at play since the subject is provided with an alternative, specifically her aspiration. But, an endowment effect should only increase willingness to exchange prices and thus they should remain positive. As we focus on ordinal rankings, we only need that an aspiration leads to the same

to a subject who has chosen (2 Pens, 4 Folders) in the trio task of Part 1 depicted in Figure 2.

If agents are rational with quasilinear utility in money, then ascertaining agent's "subjective distance" between a pair of bundles should be equal to the difference (in dollar terms) between their reference-free utility levels. Therefore, when faced with an unavailable aspiration, we should expect rational agents to choose the closest alternative with respect to the derived subjective distance because this offers the highest available reference-free utility. However, as we know from the literature and also from the observed data in our experiment, frequently agents do not behave rationally and for irrational agents, the closest alternative need not be the same as the highest reference-free utility option. Thus, we seek to understand their choices through the lens of ABC theory.

As outlined above, Part 2 of the experiment provides a method of deriving distances as perceived by each subject. Note that there is nothing that forces these subjective distances derived in Part 2 to be coherent with agent's choices observed in Part 1. Moreover, the Euclidean distance naturally serves as an objective distance measure between bundles since each bundle is an element of the Euclidean space. Therefore, when testing for similarity-based choice behavior, it is possible to compare the relative performance of this objective distance function with that of the subjective distance measure derived in Part 2.

After Part 1 and 2 are both completed, each subject is paid a show-up fee of $5 and also given an additional prize that is determined as follows:

A decision task is randomly selected for each subject. If the selected decision task is from Part 1, then the subject is given the option she has chosen in that decision task. In case a decision task from Part 2 is selected, two objects are additionally determined randomly: (i) one bundle from among those the subject has faced in that task and (ii) a price p^* between 0 and 30. If the randomly selected bundle is the one that the subject has been provided with, then she receives that bundle. Otherwise, we use the Becker-DeGroot-Marschak method to determine the prize: If the minimum price the subject has stated in the experiment is less than or equal to p^*, then she receives the randomly selected bundle and $\$p^*$ as a prize. Otherwise, she keeps the provided bundle from that task as a prize.[15]

5 Hypotheses

Recall that in Section 3, we discussed ABC theory's predictions along with other related theoretical work, and in Section 4, we explained our experimental design. These two sections play an important role in forming the current section. Here, given the experimental design, we first present our experimental hypotheses based upon ABC theory's predictions (i)-(iv) from Section 3 and then discuss

relative rankings over other non-aspiration alternatives whether or not the aspiration is endowed.

[15]This price p^* can thus be understood as the market price to switch from the provided bundle to the randomly selected bundle. Note that Part 2 tasks may depend on the subjects' answers to Part 1, but given the above payment method, it is in the subjects' best interest to choose truthfully as truth-telling increases her odds of receiving her preferred alternative in two ways, whether the Part 1 task is selected or the corresponding Part 2 task is selected.

possible ways to distinguish among alternative explanations by other theories in the literature.

As we know from prediction (iv), ABC theory allows for choice reversals upon the introduction of an unavailable option into the environment only when that option serves as an aspiration. A weaker prediction is that the amount of choice reversals is greater when the unavailable option introduced to the environment is an aspiration compared to when it is not. Based on earlier experimental evidence on reference effects, one can expect to see reversals upon the introduction of a non-aspiration option (Huber et al. (1982)) and hence we form our first hypothesis based on this weaker prediction of ABC theory. In our experimental design, **Hypothesis 1** states that choices in a two+one task and the corresponding binary task are more likely to be different when the phantom option in the two+one task is an aspiration compared to when it is a non-aspiration.

Our second hypothesis is about the similarity channel through which aspirations can affect choices. As we know from ABC theory's prediction (ii), an unavailable aspiration leads one to choose the most similar available option which might be different than the available option with the highest utility. However, when all alternatives in a task are available, the agent maximizes her reference-free utility and thus chooses rationally (prediction (i)). Based on these, we form our second hypothesis which says that an available alternative is more likely to be selected when there is a phantom aspiration in the environment that is similar to it compared to when there is no unavailable option. In our experimental design, **Hypothesis 2** can be formulated as follows: the available alternative that is closest to the phantom aspiration in a two+one task is more likely to be selected from that two+one task compared to when it is presented in the corresponding binary task.

Our last hypothesis is directly derived from ABC theory's prediction (iii) that choices are better explained by a distance minimization procedure when a subjective distance is used rather than an exogenously given distance function. Since alternatives in our experimental design are bundles and thus members of the Euclidean space, a natural exogenously determined distance is the Euclidean distance. Hence, given our set-up, we formulate our **Hypothesis 3** as choices being better explained by a distance minimization procedure when the subjective distance derived in Part 2 of the experiment is used rather than the Euclidean distance.

In order to rule out the standard theory, it suffices to observe a significant number of choice reversals between two+one tasks and the corresponding binary tasks as different choices from the same set of available options cannot be explained by the standard theory. In addition, Hypotheses 1 and 2 - if satisfied- also provide further evidence against rational choice. Remember that alternatives in our experiment are deterministic and Köszegi and Rabin's (2006) model reduces to the classical theory in such environments. Hence, any outcome that rules out standard theory in our experiment also rules out Köszegi and Rabin's (2006) theory.

As explained before, one distinctive feature of Rubinstein and Zhou's (1999) procedure is that there always exists a reference point which is exogenously determined whereas ABC theory endogenously derives the reference point and also allows for reference-free choice situations. Therefore, in our experimental design, even though ABC theory can recognize the reference-free problems and identify the relevant reference in each choice situation, Rubinstein and Zhou's (1999) model is silent about reference point formation. Another distinctive feature of Rubinstein and Zhou (1999) is that their model is exogenously based upon the standard Euclidean metric, as opposed to the subjective distance that is used in ABC theory. In the data, we first look at the percentage of instances where the subjectively derived distance and the Euclidean distance disagree on the closest available option to an unavailable aspiration. If this percentage turns out to be significantly different from zero, these two distances can be distinguished and compared. Then, our Hypothesis 3 aims at comparing the explanatory powers of the particular subjective distance (derived according to ABC theory) and the objective Euclidean distance (used in Rubinstein and Zhou (1999)) when agents choose an available alternative in a two+one task where the reference point is considered to be the phantom aspiration as modeled in ABC theory.

Note that all our hypotheses are based on the effect of an unavailable option that is an aspiration. Given that status quo-based theories typically assume available reference points, these theories cannot explain Hypothesis 1 or 2. Indeed, to rule out status quo-based theories, it suffices to find significant differences even if the direction of findings are not as in the predicted directions in our hypotheses.

As explained in Section 3, Tversky and Kahneman's (1991) non-constant loss aversion model leads to situations where an agent chooses an alternative a over b when there is no reference point, but chooses b over a when a is the reference point. However, this is against both the idea of aspirations and prediction (i) of ABC theory which says that an aspiration alternative is selected when it is available. Hence, to distinguish between a non-constant loss aversion model and ABC theory, we focus on two+one tasks and look at the frequency with which aspirations are chosen when they are available. On the other hand, a constant loss aversion model does not have this feature of leaving an alternative when it becomes the reference, but it forbids certain choice patterns in our design which are permitted by the ABC theory. One such choice pattern is illustrated in Figure 5: the simultaneous choice of d over a when b is the reference; and a over d when c is the reference represents a violation of the constant loss aversion model while it is allowed by ABC theory. As a numerical example, consider the following two choice problems: (S, Y) and (S, Y') where $S = \{(1 \text{ Pen}, 5 \text{ Folders}), (5 \text{ Pens}, 1 \text{ Folder})\}$; $Y = S \cup \{(2 \text{ Pens}, 4 \text{ Folders})\}$; and $Y' = S \cup \{(4 \text{ Pens}, 2 \text{ Folders})\}$.[16] Having revealed that the bundles (2 Pens, 4 Folders) and (4 Pens, 2 Folders) are the reference points in (S, Y) and (S, Y') respectively, an agent with a constant loss averse utility does not choose (5 Pens, 1 Folder) from (S, Y) and (1 Pen, 5 Folders) from (S, Y') simultaneously. Notice that an agent who chooses randomly can produce any choice pattern and in particular, the probability of producing the above choice pattern is 25%. In addition to the choice pattern above, in our experimental design there are several other choice patterns which are permitted by ABC theory and forbidden by a constant loss aversion model. Due to the different forms of such choice patterns, the probability of a randomly choosing agent generating

[16]Here, $a = $ (1 Pen, 5 Folders), $b = $ (2 Pens, 4 Folders), $c = $ (4 Pens, 2 Folders), and $d = $ (5 Pens, 1 Folder).

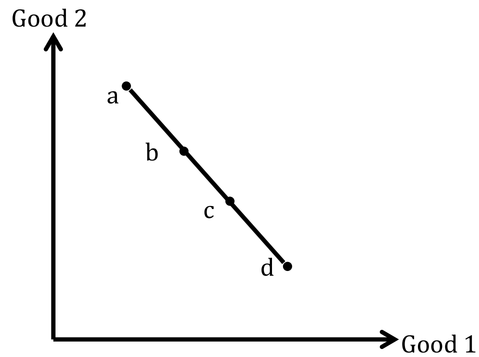

Figure 5: Four consumption bundles arranged linearly

these patterns may be different for each pattern.[17] Thus, in order to come up with an aggregate measure for violations of a constant loss aversion model, we take into account expectations. In the data, we find the the ratio of observed violations to the expected number of violations. This aggregate measure should be 0% if agents choose *as if* they have constant loss averse utility and should be 100% if agents choose randomly. ABC theory does not make a prediction for this ratio. In the results section, we examine this ratio and test whether it is significantly different from 0% and 100%.

Finally, in a choice experiment, one needs to be careful about agents exhibiting reversals due to mistakes or indifferences as well as agents choosing randomly. Our last purpose in this section is to explain how we can rule out these situations in our data.

As long as individuals' indifference between available options or mistakes are independent of whether an unavailable option is an aspiration or not, then there should not be a significantly different amount of choice reversals due to aspiration and non-aspiration phantoms. Thus, observation of a significant difference rules out mistakes or indifferences as explanations for observed behavior. This is true regardless of whether the direction is as in Hypothesis 1 or not.

According to random choice, agents are not influenced by reference points, but rather just choose randomly from a set of available alternatives. Therefore, an alternative must be equally likely to be selected in different choice problems as long as the set of available options is the same. In our design, one observation that would rule out random choice as an alternative explanation is that the presence of unavailable aspiration alternatives in a two+one task significantly changes the choice frequency of the available alternatives compared to the case where those alternatives are available in a binary task. This is related to Hypothesis 2 which predicts this effect with a certain direction although here the direction of the effect is not important for ruling out random choice.

[17]The other choice patterns are across two+one tasks which differ only in their phantom options. In these tasks, phantom options either (i) asymmetrically dominate the same available alternative or (ii) dominate all available alternatives. In either case, a constant loss averse agent should make the same selection from these two+one tasks if she takes the phantom alternative as her reference point. When there are two suchs tasks, then the probability of a violation of constant loss aversion by a randomly choosing agent is 50%. When there are three such tasks, then this probability is 75%.

6 Main Results

In all of the regression analyses conducted throughout the paper, data is clustered with respect to subject id. In the main part of the experiment, agents face five different types of bundles classified by the type of consumer goods available in each bundle (Section 8.2). To control for these different bundle types in the regression analysis, a dummy variable is used for each.[18] Similarly, in all the regression analyses, we also control for the type of phantom (dominance, asymmetric dominance, or compromise). The regression coefficients for any of these control variables are not presented in tables as they are not the focus of this study.

We first concentrate on two+one tasks and their corresponding binary tasks to study choice reversals due to the introduction of an unavailable option into the binary environment. The data reveals that agents exhibit a choice reversal 16.36% of the time when the unavailable option in a two+one task is deemed as an aspiration.[19] We bootstrap the mean of choice reversals with 1000 replications and clustering on subject id (with the null hypothesis being mean$= 0$) and find that the mean is significantly different than zero ($p = 0.000$). Alternatively, we count the percentage of reversals for each subject and use Wilcoxon signed-rank test to find that the median of reversals is significantly different from zero ($p = 0.0000$).

One might argue that the choice reversals we observe may be due to subjects' mistakes or indifference between the two available options. If this were the case, then we should expect that around 50% of the time agents exhibit a choice reversal, it would be towards the subjectively closest alternative and 50% of the time away from the subjectively closest alternative. But, the data reveals that the subjectively derived metric has a significant prediction power. Specifically, when agents exhibit a choice reversal, it is towards the alternative subjectively closest to the aspiration 77.12% of the time and this is significantly different from 50% ($p = 0.000$, bootstrapping the difference between the mean of reversals and 0.5). Alternatively, for each subject, we count the percentage of reversals that is towards the subjectively closest option and Wilcoxon signed-rank test shows that the median of these percentages is significantly different from 50% ($p = 0.0000$). Thus, while there may be some subjects who are (sometimes) indifferent or make mistakes, this argument cannot be the driving force behind the observation of choice reversals.

Notice that the observed choice reversals serve as a distinction between rational behavior and ABC theory. Reversals also rule out Köszegi and Rabin's (2006) preferred personal equilibrium notion that replicates the rational theory in deterministic environments.

In cases where the unavailable option in two+one tasks is not an aspiration alternative, we still observe choice reversals 8.54% of the time. This means that the unavailable alternative being an aspiration leads to an increase in choice reversals: from 8.54% to 16.36%. While the absolute increases may not seem that high, given the scale of choice reversals, this roughly corresponds to

[18] Results we obtained by regression analyses continue to hold if dummy variables for individual good type rather than for bundle type are introduced.

[19] These percentages are comparable in magnitude to the amount of reversals or change in choice shares found in other robust phenomena in the literature. For instance, Huber et al.'s (1982) percentages range between 4% and 13% and Simonson's (1989) were 17% on average.

Table 1: Logistic Regression for Result 1

Dependent Variable=REV	Specification
ASP	3.1529***
	(0.6537)
Number of Observations	1485
Pseudo R-squared	0.1165
*** Significant at 1% Robust standard error is in parenthesis Number corresponding to the explanatory variable is the odds ratio	

an increase of 91.56%. This increase in the odds of reversal due to a phantom being an aspiration is found to be even stronger when other variables such as types of bundles and phantoms are controlled for. Our next result provides such a more detailed analysis.

Result 1: The odds of a choice reversal are significantly greater when the phantom option is an aspiration compared to the case when it is not.

We concentrate on two+one tasks and their corresponding binary tasks. Remember we say "a choice reversal occurs" if different alternatives are chosen in these tasks. We run a logistic regression with REV as the dependent variable, ASP as the explanatory variable, and our other control variables. The variable REV takes 1 if there is a choice reversal and 0 otherwise; and ASP takes 1 if the phantom option in a task is an aspiration and 0 otherwise. Table 1 reports that an unavailable option being an aspiration (that's, ASP=1) raises (relative to ASP=0) the overall odds of choice reversal by 215.29% ($p = 0.000$).[20] When we drop observations where an agent's aspiration is either a dominated or an asymmetrically dominated alternative, the effect of a phantom being an aspiration becomes even stronger: it increases the odds of reversal by 307.07% ($p = 0.000$).[21]

A similar conclusion can be obtained by a non-parametric test as well. For each subject, we count the percentages of choice reversals when ASP=0 and ASP=1. We then apply Wilcoxon matched-pairs signed-rank test and reject the hypothesis that the two distributions are the same ($p = 0.0000$).

To emphasize from earlier, our data rejects both the rational model and Köszegi and Rabin's (2006) reference dependence model by the statistically significant frequency of choice reversals due to an unavailable aspiration. In addition, Result 1 also provides further evidence against these models. Furthermore, as long as agents' mistakes and indifferences are independent of whether or

[20] When the interaction of ASP with the type of phantom is included in the analysis, we find that the variable ASP does not inertact with the type of phantom option. Hence, the phantom option being an aspiration does not affect choices significantly differently depending upon whether the phantom option is dominant, asymmetrically dominant, or compromise. For details, see Appendix I.

[21] These dropped observations are already not included in the analysis of other results since their focus is the data where the phantom that is either a dominant, asymmetrically dominant, or compromise option is revealed to be an aspiration.

Table 2: Logistic Regression for Result 2

Dependent Variable=CLOS	Specification
Ph	1.3150***
	(0.0940)
Number of Observations	1870
Pseudo R-squared	0.0211
*** Significant at 1%	
Robust standard error is in parenthesis	
Number corresponding to the explanatory variable is the odds ratio	

not the unavailable alternative is an aspiration, Wilcoxon matched-pairs signed-rank test applied above accounts for such indifferences and mistakes. Hence, in addition to our earlier discussions, we can use the result of Wilcoxon matched-pairs signed-rank test also to rule out indifferences or mistakes as explanations for the observed choice behavior.

Our aim now is to understand whether agents choose the most similar option to their unavailable aspiration where similarity is determined using the subjective distance function we derive in the second part of the experiment. In our analysis, we concentrate on each two+one task and its corresponding binary task. For each subject, we include a pair of two+one and binary tasks into the analysis only when the phantom alternative in the two+one task is revealed to be an aspiration for the subject. In a two+one and the corresponding binary task, one of the available options will be closest to the unavailable aspiration and one will not. On average, the frequency of the option closest to the unavailable aspiration being chosen in two+one tasks is 83% while the frequency of the same option being chosen in the corresponding binary tasks is 79%. Hence, the presence of the unavailable aspiration in the environment increases the frequency that the similar option is being chosen.

We run a logistic regression to analyze the influence of an unavailable aspiration by comparing the odds that this closest alternative is chosen in the two+one task with the odds that it is chosen in the binary task. We use CLOS as the dependent variable and Ph as the independent variable. Ph takes 1 if there is a phantom in a task (i.e. the task is two+one) and 0 otherwise (i.e. the task is binary). CLOS takes a value of 1 if the subject chooses the option that is subjectively closest to her unavailable aspiration and 0 otherwise.

Result 2: The presence of an unavailable aspiration significantly raises the odds that the subjectively closest alternative to it is chosen relative to tasks with no unavailable aspiration.

According to Table 2, the odds that the most similar (subjectively closest) alternative is chosen is 31.50% higher in a two+one task where the unavailable aspiration is present in the environment compared to the case of a binary task where it is not present at all ($p = 0.000$).[22] As an example

[22]This result is sensitive to the types of phantom aspiration. When the interaction of Ph with the phantom type is

to understand this result, consider the following situation. For notational ease, let $S = \{b, c\}$ and $Y = \{a, b, c\}$. Suppose the agent chooses a from the choice problem (Y, Y), thereby revealing a as her most preferred element in Y. Thus, option a serves as an aspiration for the choice problem (S, Y). Moreover, in Part 2 of the experiment, assume her willingness to exchange prices reveal $d(a, b) < d(a, c)$. Then, the above result says that the odds that b is chosen from the two+one task (S, Y) are significantly greater than the odds that b is chosen from the binary task (S, S). Notice that this should not be the case either in rational theory or in a random utility model. As the feasible elements in (S, Y) and (S, S) are exactly the same and neither model admits reference effects, the choice frequencies from these two problems must be insignificantly different according to both models.

Running a non-parametric test also confirms a similar result. For each subject, we count the percentages of choosing the closest option in two+one tasks and in binary tasks. Then, we apply Wilcoxon matched-pairs signed-rank test and reject that the choice of the subjectively closest option in two+one tasks and in binary tasks come from the same distribution ($p = 0.0001$).

Previous literature testing for similarity-based decision making generally relies on the use of objective distances (e.g. Euclidean) to determine the similarity between alternatives. But, our data shows that 35.58% of the time, the subjective and Euclidean distances disagree on the closest option to an unavailable aspiration.[23] This divergence makes it possible to compare the performance of these two distance measures in representing agents' choice behavior as choosing the available alternative closest to the unavailable aspiration. Our next result addresses this.

Result 3: Choice in the presence of an unavailable aspiration is significantly better explained by a similarity-based behavior when similarity is determined using the subjective distance rather than the Euclidean one.

Concentrating on two+one tasks with aspiration phantoms, we find that 83.31% of choices can be explained by the minimization of the subjective distance to the the relevant aspiration phantom while 67.27% of choices can be explained by the minimization of the Euclidean distance. To conduct a significance analysis, we first define two dummy variables SUB and EUC. The variable SUB takes a value of 1 if the alternative closest to the unavailable aspiration with respect to the subjective

included, we find that the effect of Ph on CLOS is significant when the phantom is a dominant option and insignificant when the phantom is asymmetrically dominant or compromise. For details, see Appendix I.

[23] We say that two distance functions disagree if according to one distance measure x is closer to z than to y while according to the other measure x is closer to y than to z. Since the reflexivity property of any distance function requires that an alternative is the closest option to itself, similarity-based choice behavior expects that the aspiration alternative is chosen whenever available, regardless of the specific distance function used to determine similarity. Therefore, to find out how frequently the Euclidean and subjective distances disagree with each other, we concentrate on distances that are derived for only "critical" tasks: Two+one tasks where the aspiration of a subject is the unavailable option. We generate the variable DA (disagreement) to tell us, for each subject, the percentage of instances where the Euclidean and the subjective distance measure derived in Part 2 of the experiment disagree on the distance ordering of two bundles from a fixed unavailable aspiration bundle. DA has a mean 0.3558 and a standard deviation 0.1881, with a min 0 and max 1. Bootstrapping its mean with 1000 replications and clustering around subject id reveals that it is significantly different from zero ($p = 0.000$). Alternatively, Wilcoxon signed-rank test also shows that the median of DA is significantly different from zero ($p = 0.0000$).

distance is chosen from a task and 0 otherwise. Similarly, if a subject chooses the closest option with respect to the Euclidean distance, then the variable EUC takes 1 and otherwise it takes 0. The mean of SUB is 0.8331 while the mean of EUC is 0.6727. To test whether the difference between means of SUB and EUC is significant, we restrict attention to observations where SUB and EUC take different values. This gives us that the mean 0.721 for SUB (and 0.279 for EUC). Bootstrapping the difference between the mean of SUB and 0.5 with a replication of 1000 times and clustering around subject id, we find that the mean of SUB is significantly greater than 0.5 ($p = 0.000$). This implies that choices observed in the first part of the experiment are significantly better explained via similarity-based decision making when similarity is determined according to the subjective distances derived in Part 2 rather than the Euclidean distance.[24]

Alternatively, without excluding any observations, a similar analysis now follows. Since each of SUB and EUC variables is observed for each subject more than once, we summarize each of these variables by a percentage for each subject. As a result, for each subject there is now a unique SUB and a unique EUC value between 0 and 1, telling us the percentage of her choices that are closest to her unavailable aspirations according to the subjective and Euclidean distances, respectively. We then use Wilcoxon matched-pairs signed-rank and reject the hypothesis that SUB and EUC come from the same distribution ($p = 0.0000$).

One might think that going for the next best option is not surprising since the subjective distance is simply derived through prices in our experiment. As already explained in Section 4, for rational agents, choosing the closest alternative with respect to the derived subjective distance is also consistent with the classical theory because this closest option offers the highest available reference-free utility. However, for irrational agents, the closest alternative need not be the same as the highest reference-free utility option. Hence, when an agent's behavior cannot be explained by the classical theory, she is not naturally expected to choose the closest option with respect to her subjective distance.

Our data reveals the following on this matter. When we concentrate on seemingly rational choices from two+one tasks, i.e. choices that are not reversed in the corresponding binary tasks, 15.47% of these cannot be explained by the minimization of the subjectively derived distance. This is in contrast to what is expected by the classical theory. Moreover, we see a significant amount of irrationality in our data and when we concentrate on choices from two+one tasks which are reversed in the corresponding binary tasks and hence do not abide by rationality, the amount that cannot be explained by the minimization of the subjectively derived distance increases to 22.87%. If explaining choices through the endogenously derived distance were to be a trivial issue, then the amount of choices that cannot be explained by the subjective distance should not be significant in any case. Furthermore, the amount of choices that can (or cannot) be explained by the minimum subjective distance also would not significantly change depending on whether or not choices exhibit reversals because one would expect the distance to explain choices all the time. However, as seen from the data above, this is not the case. Both frequencies are significantly different from zero and

[24] The type of the phantom does not have an impact on this result. For details, see Appendix I.

the change from 15.47% to 22.87% is also significant. Therefore, the explanation of choices through the minimization of the endogenously derived distance cannot be a trivial issue. Note that even though there are still choices that cannot be explained by the minimum subjective distance to an unavailable aspiration, Results 2 and 3 show that an unavailable aspiration plays a significant role in leading people to go for the option that is subjectively most similar to it.

As explained before, Rubinstein and Zhou (1999) consider choice problems with exogenous reference points and therefore is silent about what the reference point in a choice task is in our experimental set-up. If we assume that the aspirations derived in our experiment serve as reference points in Rubinstein and Zhou's (1999) work, then their theory predicts that agents choose the alternative that minimizes the Euclidean distance to those aspirations. According to our Result 3, observed choices are better explained by the minimization of the particular subjective distance derived in Part 2 of the experiment than by the Euclidean distance.

As discussed in Section 5, Tversky and Kahneman's (1991) non-constant loss aversion theory over a large enough domain must lead to a situation where an agent chooses an alternative a over b when there is no reference point, but chooses b over a when a is the reference point. This is against our findings in the experiment where the aspiration alternative is generally selected when it is available (90.49% of the time).[25] Regarding Tversky and Kahneman's (1991) constant loss aversion model, there are specific choice tasks in our design which cannot be accommodated by a constant loss aversion model but are permitted by the ABC theory. As explained in detail in Section 5, when aggregating violations of a constant loss aversion model across several choice tasks, we take into account expectations and find the overall ratio of observed violations to the expected number of violations if an agent chooses randomly. This ratio should be 0% if agents follow a constant loss aversion model and should be 100% if agents choose randomly. In our data, this ratio is 16.89% and a Wilcoxon signed-rank test shows that it is significantly different from both 0 ($p = 0.0000$) and 100 ($p = 0.0000$).[26]

Finally, our results cannot be explained by status quo-based theories either. Typically, such theories assume that the status quo is available for choice (Masatlioglu and Ok (2005, 2014)) whereas in our experiment it is unavailable alternatives that influence choice. Furthermore, in our experiment, aspirations are alternatives which have been revealed to be superior to all available alternatives. This provides another reason why choice with aspirations cannot be understood through standard status quo models as in such models the status quo alternative rules out all inferior alternatives.

[25] This percentage refers to the overall frequency of the aspiration alternative being chosen in the relevant two+one task where a non-aspiration alternative is made unavailable. This also corresponds to testing one of the axioms used to characterize ABC theory: For any three nested sets $T \subseteq S \subseteq Y$, if $C(S,Y) \cap T \neq \emptyset$, then $C(T,Y) = C(S,Y) \cap T$. To test this axiom using our design, we take $T = \{x, y\}$ and $S = Y = \{x, y, z\}$ where $C(Y,Y) = \{x\}$. We find that in such situations $C(T,Y) = \{x\}$, 90.49% of the time.

[26] Additionally, the probability of an agent producing a violation when choosing randomly with non-uniform probabilities is lower. Thus, the ratio of 16.89% represents a lower bound.

7 Conclusion

This paper studies the effects of unavailable aspirations on choice using an experimental design that is incentive compatible. It introduces a new experimental methodology to deduce the relevant endogenously formed aspiration in each choice situation and its distance from other options as perceived by each individual. This novelty gives us the opportunity (1) to distinguish between the effects of a phantom option when it is an aspiration and when it is not, (2) to understand how the presence of an unavailable aspiration affects the choice of the subjectively closest alternative relative to cases where the unavailable aspiration is not present, and (3) to compare the performance of the Euclidean distance with that of a subjective distance when testing for similarity-based decision making.

Even though the mere presence of a phantom alternative in the environment can lead a decision maker to exhibit a choice reversal, the odds of reversal are found to increase significantly when the phantom is has the additional power of being an aspiration. This result is important because it shows that the effect of aspirations are stronger than that of non-aspiration alternatives (Punchline: "Among unavailable alternatives, aspirations affect choice more"). We also find support for similarity-based decision making. The choice of an available option is observed to be more likely when there is a similar and unavailable aspiration in the environment compared to when there is no such option in the environment. This result conveys a channel, namely that of similarity, through which aspirations can affect choices (Punchline: "Unavailable aspirations affect choice by similarity"). Moreover, the subjective distance measure is found to perform better than the objective Euclidean distance in explaining similarity-based behavior, providing a distinction between ABC Theory and Rubinstein and Zhou (1999) (Punchline: "Subjective distances better explain choices than the Euclidean distance"). As opposed to the disagreeing evidence in the literature on how the timing when unavailability is revealed affects the choice of similar alternatives, our extension treatment which is explained in Appendix II shows that this timing impact disappears when aspirations are deduced endogenously from choices and a subjective distance measure is used for each decision maker to reflect similarities between her aspirations and other options.

This paper finds unavailable aspirations may affect choices and provides a method to deduce both aspirations and subjective distances. These have the potential to be useful for both marketers and policy makers. For instance, a firm may profitably introduce highly desired and unavailable alternatives (due to prices, limited supply, age restrictions, etc.) to sway consumers and a government may also wish to do so to sway behavior as in the Presidential Fitness Challenge for school-age students.[27] Studying such paternalistic policies and measuring their impact through field studies is an interesting area to explore. Another promising avenue of research may be to extend the model to a dynamic setting to experimentally study the evolution of aspirations and the impact of this dynamic process.

[27]See https://www.presidentschallenge.org/challenge/physical/benchmarks.shtml. This challenge sets a desirable fitness level across different tasks which is unavailable for most students, but which may serve to sway students to acheive higher fitness levels.

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8 Appendix I: Additional Analysis for the Main Experiment

8.1 The Types of Phantom Bundles

Consider two bundles x and y such that each is composed of quantities of good 1 and good 2 where x has more of good 2 and y has more of good 1. According to the figure below, an alternative in the blue region asymmetrically dominates x, an alternative in the green region asymmetrically dominates y, an alternative in the gray region dominates both x and y, and finally an alternative on the red line is a compromise (intermediate) option.

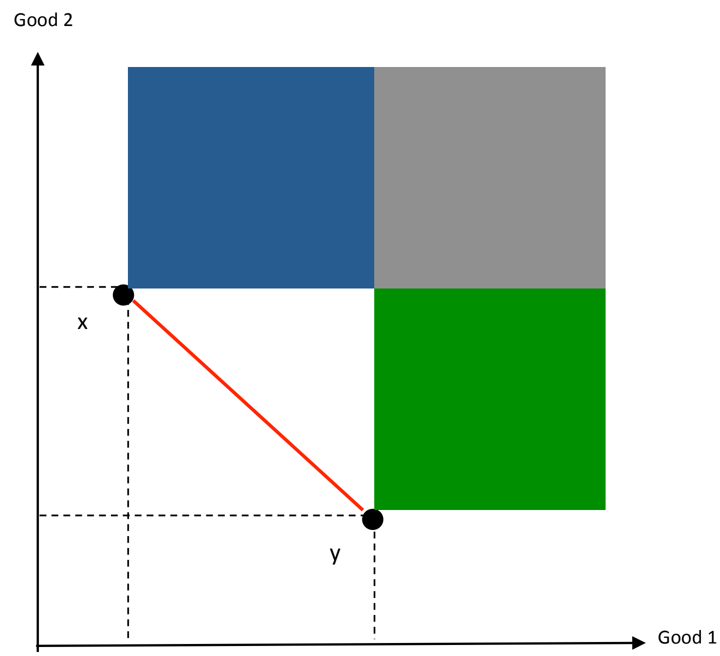

Figure 6: Dominant, Asymmetrically Dominant, and Compromise Options

In the main experiment, there were 15 tasks with a phantom option. The phantom bundle was asymmetrically dominant in 5 tasks, dominant in 6 tasks, and compromise in 4 tasks.

In Section 6, the effect of phantom types on our results is provided in several footnotes. The aim here is to give details on these effects. For the following analysis, defining two variables is useful: the variable AD takes 1 if the phantom option is asymmetrically dominant and 0 otherwise whereas the variable COMP takes 1 if the phantom option is compromise and 0 otherwise. Note that since the variables AD and COMP together define uniquely whether a phantom is dominant or not, we don't include a dummy variable for dominant phantoms which will serve as a baseline while interpreting the regression results. In all the regression analyses conducted throughout the paper, the variables AD and COMP are already included to control for their main effects. The current appendix further includes their interactions with other variables to understand whether our results differ depending upon the type of a phantom.

Table A.1: Updated Result 1: Including the Interactions with the Types of Phantoms

Dependent Variable=REV	Specification
ASP	5.1599**
	(3.8381)
ASP*AD	0.8118
	(0.6480)
ASP*COMP	0.3104
	(0.2540)
Number of Observations	1485
Pseudo R-squared	0.1215
*** Significant at 1%, ** Significant at 5%, * Significant at 10% Robust standard error is in parenthesis Number corresponding to the explanatory variable is the odds ratio	

According to Result 1 in Section 6, the odds of a choice reversal are significantly greater when the phantom option is an aspiration compared to when it is not. In order to see whether the effect of phantom being an aspiration differs depending upon the type of phantom, we include into the regression analysis (shown in Table 1) the interaction variables ASP*AD and ASP*COMP where the variable ASP is as defined there and the variables AD and COMP are as defined in the previous paragraph. The result of the new regression analysis is shown in the Table A.1 where all coefficients corresponding to independent variables are odds ratios. We find that ASP does not interact with AD and COMP ($p = 0.794$ and $p = 0.153$, respectively). Therefore, a phantom being an aspiration affects choice reversals in the same way regardless of whether the phantom option is dominant, asymmetrically dominant, or compromise.

Result 2 of the main analysis says that an available alternative is more likely to be chosen from a two+one task where the phantom aspiration is closest to it compared to when it is presented in the corresponding binary task. This result is affected by phantom type. Adding the interaction variables Ph*AD and Ph*COMP into the original regression in Section 6 gives that Ph interacts both with AD and COMP ($p = 0.027$ and $p = 0.000$, respectively). See Table A.2. When the phantom aspiration is a dominant alternative, its presence increases the odds of choosing the closest option by 61.67% ($p = 0.000$) but the effect of a phantom aspiration on the choice of closest option is insignificant when it is asymmetrically dominant or compromise ($p = 0.243$ and 0.188, respectively).[28]

Finally, according to Result 3, observed choices are better explained by a distance minimization procedure when the subjective distance derived in the second part of the experiment is used compared to when the Euclidean distance is used. The phantom type has no effect on this finding. To see this, we run a logistic regression where the variable SUB is the dependent variable and the

[28]Note that since the baseline is the dominant type, Ph in Table A.2 shows the effect of the presence of a phantom aspiration when it is a dominant alternative.

Table A.2: Updated Result 2: Including the Interactions with the Types of Phantoms

Dependent Variable=CLOS	Specification
Ph	1.6167***
	(0.1792)
Ph*AD	0.6967**
	(0.1140)
Ph*COMP	0.5003***
	(0.0981)
Number of Observations	1870
Pseudo R-squared	0.0238
*** Significant at 1%, ** Significant at 5%, * Significant at 10% Robust standard error is in parenthesis Number corresponding to the explanatory variable is the odds ratio	

variables AD and COMP are the independent variables. SUB takes 1 if a choice in a two+one task is explained better by the subjective distance and 0 if it is better explained by the Euclidean distance.[29] AD and COMP are defined as before. This reveals that p-values for AD and COMP are 0.125 and 0.531, respectively (Table A.3) and hence, the type of phantom does not matter for the superior performance of the subjective distance over the Euclidean distance.

Table A.3: Updated Result 3: Regression Analysis Including the Types of Phantoms

Dependent Variable=SUB	Specification
AD	0.6543
	(0.1808)
COMP	1.2159
	(0.3795)
Number of Observations	338
Pseudo R-squared	0.0070
*** Significant at 1%, ** Significant at 5%, * Significant at 10% Robust standard error is in parenthesis Number corresponding to the explanatory variable is the odds ratio	

[29]We concentrate on choices that can be explained by exactly one of the subjective and Euclidean distances.

8.2 Details about the Design of the Main Experiment

Bundles in the Main Experiment

Here, we present the set of bundles subjects faced in each task in the main experiment. A bundle with an "X" sign next to it means that it was presented as a phantom option in that task in Part 1.

Compromise Tasks:

- (1 Pen, 5 Folders); (2 Pens, 4 Folders); (5 Pens, 1 Folder)
- (1 Pen, 5 Folders); (2 Pens, 4 Folders) X ; (5 Pens, 1 Folder)
- (1 Pen, 5 Folders); (4 Pens, 2 Folders); (5 Pens, 1 Folder)
- (1 Pen, 5 Folders); (4 Pens, 2 Folders) X ; (5 Pens, 1 Folder)
- (1 Pen, 5 Folders); (5 Pens, 1 Folder)
- (2 Postcards, 10 Stamps); (4 Postcards, 8 Stamps); (10 Postcards, 2 Stamps)
- (2 Postcards, 10 Stamps); (4 Postcards, 8 Stamps) X ; (10 Postcards, 2 Stamps)
- (2 Postcards, 10 Stamps); (8 Postcards, 4 Stamps); (10 Postcards, 2 Stamps)
- (2 Postcards, 10 Stamps); (8 Postcards, 4 Stamps) X ; (10 Postcards, 2 Stamps)
- (2 Postcards, 10 Stamps); (10 Postcards, 2 Stamps)

Asymmetric Dominance Tasks:

- (1 Key Chain, 3 Folders); (3 Key Chains, 1 Folder); (4 Key Chains, 1 Folder)
- (1 Key Chain, 3 Folders); (3 Key Chains, 1 Folder); (4 Key Chains, 1 Folder) X
- (1 Key Chain, 3 Folders); (3 Key Chains, 1 Folder); (6 Key Chains, 1 Folder)
- (1 Key Chain, 3 Folders); (3 Key Chains, 1 Folder); (6 Key Chains, 1 Folder) X
- (3 Key Chains, 1 Folder); (1 Key Chain, 3 Folders); (1 Key Chain, 4 Folders)
- (3 Key Chains, 1 Folder); (1 Key Chain, 3 Folders); (1 Key Chain, 4 Folders) X
- (3 Key Chains, 1 Folder); (1 Key Chain, 3 Folders); (1 Key Chain, 6 Folders)
- (3 Key Chains, 1 Folder); (1 Key Chain, 3 Folders); (1 Key Chain, 6 Folders) X
- (1 Key Chain, 3 Folders); (3 Key Chains, 1 Folder)

- (1 Key Chain, 3 Folders); (4 Key Chains, 1 Folder)
- (1 Key Chain, 3 Folders); (6 Key Chains, 1 Folder)
- (1 Key Chain, 4 Folders); (3 Key Chains, 1 Folder)
- (1 Key Chain, 6 Folders); (3 Key Chains, 1 Folder)
- (1 Pack of Gum, 5 Pens); (9 Packs of Gum, 5 Pens); (10 Packs of Gum, 1 Pen)
- (1 Pack of Gum, 5 Pens); (9 Packs of Gum, 5 Pens) X ; (10 Packs of Gum, 1 Pen)
- (1 Pack of Gum, 5 Pens); (10 Packs of Gum, 1 Pen)

Dominance Tasks:

- (1 Bar of Chocolate, 2 Stickers); (2 Bars of Chocolate, 1 Sticker); (2 Bars of Chocolate, 4 stickers)
- (1 Bar of Chocolate, 2 Stickers); (2 Bars of Chocolate, 1 Sticker); (2 Bars of Chocolate, 4 stickers) X
- (1 Bar of Chocolate, 2 Stickers); (2 Bars of Chocolate, 1 Sticker); (2 Bars of Chocolate, 2 stickers)
- (1 Bar of Chocolate, 2 Stickers); (2 Bars of Chocolate, 1 Sticker); (2 Bars of Chocolate, 2 stickers) X
- (1 Bar of Chocolate, 2 Stickers); (2 Bars of Chocolate, 1 Sticker); (4 Bars of Chocolate, 2 stickers)
- (1 Bar of Chocolate, 2 Stickers); (2 Bars of Chocolate, 1 Sticker); (4 Bars of Chocolate, 2 stickers) X
- (1 Bar of Chocolate, 2 Stickers); (2 Bars of Chocolate, 1 Sticker)
- (2 Pens, 2 Packs of Gum); (1 Pen, 4 Packs of Gum); (4 Pens, 4 Packs of Gum)
- (2 Pens, 2 Packs of Gum); (1 Pen, 4 Packs of Gum); (4 Pens, 4 Packs of Gum) X
- (2 Pens, 2 Packs of Gum); (1 Pen, 4 Packs of Gum); (3 Pens, 6 Packs of Gum)
- (2 Pens, 2 Packs of Gum); (1 Pen, 4 Packs of Gum); (3 Pens, 6 Packs of Gum) X
- (2 Pens, 2 Packs of Gum); (1 Pen, 4 Packs of Gum); (2 Pens, 8 Packs of Gum)
- (2 Pens, 2 Packs of Gum); (1 Pen, 4 Packs of Gum); (2 Pens, 8 Packs of Gum) X
- (2 Pens, 2 Packs of Gum); (1 Pen, 4 Packs of Gum)

Instructions for the Main Treatment (Treatment "Earlier")

This is an experiment in decision making. Thank you for agreeing to participate. Please make sure your mobile phones are turned off to avoid interruptions during the experiment.

Your participation in this experiment is voluntary but we hope that you will also find the experiment interesting. You will be compensated for your participation; you will earn a combination of cash and consumer goods. Your final payoff will include a show-up fee of $5 and the rest will partly depend on the choices you have made and partly on chance.

The experiment will be conducted on the computer screen in front of you. Please do not talk or try to communicate with other participants during the experiment.

Please follow the instructions carefully. If you have any questions while the experiment is described, please raise your hand and your question will be answered so everyone can hear. The problems are not designed to test you. We are only interested in your personal opinion.

The experiment consists of two parts: Part I and Part II. Each part is composed of a series of decision tasks. At the end of the experiment, one of the decision tasks will be selected randomly and payment will be made accordingly. Each decision task is equally likely to be selected. Since you do not know which question will be picked, you need to answer all questions in both parts.

The published results of our research will not identify any individual or the choice he or she made in any way. All records will be linked to an anonymous subject ID only.

At the end of the experiment, we will call you, one at a time, to pay you in private.

We will now discuss the instructions and payment method for tasks from Part I, and then you will participate in the first part of the experiment. After everyone has completed the first part of the experiment, we will then discuss the instructions and payment method for Part II of the experiment which you will then take.

PART I: In each decision task, you will be presented with several bundles of consumer goods and asked to choose your most preferred bundle among the available bundles presented. To select a bundle, click on the bundle you prefer and then click submit. Once you submit, you cannot go back and change your choice in that decision task.

There are no right or wrong answers. We are only interested in the choices you would make in each given situation. The only right answer is what you would really choose. It is in your best interest to answer each question truthfully.

Payment Method:

If the decision task randomly selected at the end of the experiment is from part I, then- in addition to your show-up fee of $5- you will be given the option you chose in that particular decision task.

IT BENEFITS YOU TO CHOOSE YOUR MOST PREFERRED OPTION IN EACH DECISION TASK because you don't know which decision task will be randomly picked at the end of the experiment. Recall that any decision task is equally likely to be selected.

Are there any questions?

If there are no questions, please press Continue button and proceed to the first part of the experiment.

When you finish, please wait for our announcement to start Part 2, which will be started after everyone has completed the first part of the experiment.

PART II: Each decision task will consist of a set of bundles and you will be provided with one of them. For every other bundle in that task, you will be asked to state the minimum compensation in dollars that you would be willing to accept to change from the provided bundle to that bundle.

Here is an example:

Previously, when asked to choose between bundle A and the bundles listed below, you chose bundle A. Now, suppose that you are given bundle A. Next to each of the bundles listed below, please enter the minimum compensation (in dollars) you are willing to accept to switch from A to that bundle, and then click on the Submit button at the end of the page.

B —-

C —-

Notice that, since you will always be provided with your most preferred bundles, the minimum compensations you will enter should be greater than 0. Minimum compensations can be expressed in decimals. For example, 7.45 represents $7 and 45 cents. If your minimum compensation is a whole number, then you do not need to specify the number of cents, you may simply enter that whole dollar amount.

Again in this part, there are no right or wrong answers. We are only interested in your personal opinion.

PAYMENT METHOD:

If the decision task randomly selected at the end of the experiment is from Part II, then- in addition to your $5 show-up fee- you will be paid according to the following rule:

One of the bundles in that randomly selected decision task will be chosen.

If the selected bundle in the task is the one you are provided with, then you will get that bundle. Otherwise: A market price p* will be chosen randomly between $0.01 and $30. If p* is larger than or equal to the minimum amount you have stated, then you will leave the option you were provided with, get the other option instead and also be paid p*. Otherwise, you will keep the option you own.

Example:

Suppose that the minimum amount that you are willing to accept to switch from bundle A to bundle B is $3. Then, it is in your best interest to state 3 as your minimum switching price because of the following reason:

Suppose that you entered the price $6 instead. In this case, if $5 is drawn as the random switching price at the end of the experiment, you will receive bundle A because the price drawn was less than the price you specified. However, in truth you were willing to switch for $3, and hence would have preferred to switch from A to B and received $5. On the other hand, suppose that you entered the price \$1 instead of your true price of \$3. In this case, imagine that \$2 is drawn as the random switching price at the end of the experiment. In this event, you will receive bundle B and \$2, a combination that is worse to you than receiving bundle A because your true minimum switching price was \$3.

Therefore, it is not in your interest to lie upwards or downwards, but rather IT BENEFITS YOU TO STATE YOUR TRUE MINIMUM COMPENSATION IN EVERY TASK.

Are there any questions? If not, please press Continue button and proceed to Part 2.

When you finish, please raise your hand so that the experimenter can make your payment.

9 Appendix II: Extensions

9.1 Description and Results

Here, we extend our design in two different directions. In the first extension, we conduct a treatment where we vary the timing of unavailability. In the second one, we extend the setting of choice problems to analyze how the greater number of (un)available options in a task or attributes in a bundle affect our findings.

9.1.1 The Timing of Unavailability

The experimental literature finds disagreeing evidence regarding the effect of a highly desirable phantom option, depending upon when its unavailability is revealed. Hedgcock et al. (2009) show that a highly desirable phantom is more likely to induce a decision maker to choose a similar alternative if unavailability is revealed later rather than earlier whereas Min (2003) finds the opposite. To analyze how the timing of revelation of unavailability affects our findings, we introduce a new treatment and compare its results with our benchmark findings.

We call our benchmark in Section 4 Treatment *Earlier* (E). There, a subject learns about unavailability as soon as she faces a round. Hence, unavailability - if there is any - is revealed early within a round, namely at the outset of a round. We introduce a timing variation by changing how trio and two+one tasks are presented. In the new treatment, called *Later* (L), trio and two+one tasks are tied together, each being a stage of the same round: in the first stage, a subject is asked to make a choice from a trio task and in the second stage, she is asked to choose from the corresponding two+one task where one pre-determined alternative in the trio task is now labeled as unavailable. Here, unavailability is revealed *later* within a round, namely in the second stage of that round. Figures 7 and 8 show a typical 2-stage round in this treatment. In Treatment L, binary tasks are still presented as single-stage tasks as in the benchmark treatment.

Every round in Treatment E corresponds to a (round, stage)-pair in Treatment L. For example, Figures 7 and 8 in Treatment L correspond to Figures 2 and 3 in Treatment E, respectively. Therefore, the specific bundles used in Treatment L is the same as the bundles used in Treatment E. There are 10 binary (one-stage) rounds and 15 two-stage rounds in Treatment L; the order of bundles in a task and the order of rounds are also randomized.

To better understand the timing setting, consider the following example. A customer visits a cinema and waits on line to purchase a movie ticket. At one chain of cinemas, the list of current movies is displayed with sold out movies marked as unavailable. This is an example of the one-stage rounds that an agent faces in the Treatment E. On the other hand, at a different chain of cinemas, the list of current movies does not have the “sold-out” feature. Rather, when the agent reaches the ticket booth and talks to the seller, the seller may inform her that some movies are sold out. This is an example of a two-stage round faced in the Treatment L.

In Treatment L, all findings but one are the same as in our benchmark results. Specifically, a logistic regression analysis reveals that the introduction of an unavailable option into the environment

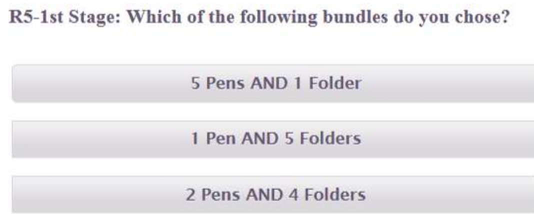

Figure 7: First Stage of a Two-Stage Round in Treatment L (Trio Task)

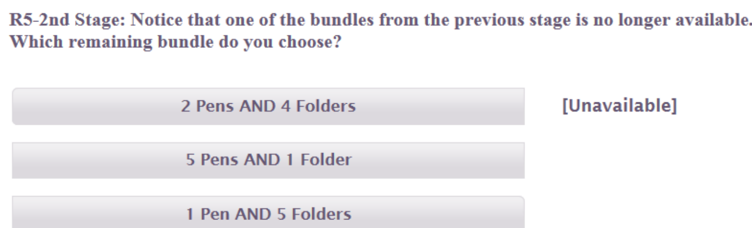

Figure 8: Second Stage that follows Figure 7 (Two+One Task)

leads to choice reversals in Treatment L that are not statistically different than those in Treatment E, regardless of whether the phantom option is aspiration ($p = 0.108$) or not ($p = 0.637$).[30] Consequently, the increase in the odds of reversal due to phantom option being an aspiration (relative to the case it is not) is not statistically different in both treatments ($p = 0.181$).[31] As for the similarity-based decision making in Treatment L, choices in the presence of an unavailable aspiration are also better explained by a distance minimization procedure when the subjective distance is used rather than the Euclidean one and moreover, a logistic regression analysis reveals that the magnitude of the subjective distance's superior performance over the Euclidean is not statistically different in both treatments ($p = 0.751$).[32]

The only result that does not survive in Treatment L is the counterpart of Result 2 in the benchmark analysis. Unlike Treatment E's Result 2, in Treatment L the odds of choosing the closest option are not statistically different in two+one tasks and their corresponding binary tasks

[30] We pool the data for both treatments and run one logistic regression on the data where the unavailable option is known to be an aspiration and one on the data where the phantom option is not an aspiration. The regression has REV (defined as before) as the dependent variable; treatL as the explanatory variable which takes 1 if the treatment is L and 0 otherwise; and our control variables (types of bundles and phantoms). $p-$values reported in the text indicate that the treatment has no significant effect on reversals.

[31] The reported p-value corresponds to the interaction between the explanatory variables ASP and treatL (defined as before) in the logistic regression with REV as the dependent variable; ASP and treatL as the explanatory variables; and our control variables. All these variables are defined as before. In the pooled data, the odds of choice reversal are now found to be 180% ($p = 0.000$) greater when the unavailable option is an aspiration compared to the case when it is not, regardless of the treatment.

[32] Dropping the observations for which both SUB and EUC (defined as before) take the same value and pooling the observations in both treatments, we run a logistic regression with SUB as the dependent variable; treatL as the explanatory variable; and other control variables. p-value reported in the text indicates that treatment's effect is not significant.

($p = 0.923$).[33] The joint analysis of both treatments via a logistic regression reveals the following interesting finding as well. In two+one tasks, the timing of when unavailability is revealed has no significant effect on the odds of choosing the alternative that is subjectively closest to the unavailable aspiration ($p = 0.953$).[34] As opposed to marketing and psychology literatures that find disagreeing evidence regarding whether an earlier or a later declaration of unavailability increases the odds that the most similar (with respect to an objective distance function) option is chosen, our result shows that the timing effect vanishes when we derive subjective aspirations and distances.

9.1.2 Form of Choice Tasks

We now briefly discuss how the results change if there is an increase in either: (1) the number of available options in a task, (2) the number of phantom options in a task, or (3) the number of attributes used to define each alternative. All of the tasks in this extension were embedded in Treatments E and L. Hence, no separate treatment was conducted for the extensions regarding the form of choice tasks. We study each of the three factors one at a time. We call a task "quad" if four bundles are displayed and they are all available. We call a task "x+y" if the task has x number of available bundles and y number of unavailable bundles. The unavailable option in a three+one task or one of the unavailable options in a two+two task is an aspiration there if it is chosen from the corresponding quad task where all four alternatives are available. As in the main analysis, in all the regression analyses, we use clustering with respect to subject id and also control for types of bundles and phantom alternatives.

To analyze the case of a greater number of available options in a task, we concentrate on trio, quad, and three+one tasks. Reversals in these tasks are defined analogously to those in the main section. Here, we say "a choice reversal occurs" if different alternatives are chosen in a three+one task and the corresponding trio task which is obtained by removing the unavailable option in the three+one task from display. Similar to our main results, in this particular extension, we find significant choice reversals both when the phantom is an aspiration (20.3%, $p = 0.000$, bootstrapping) and when it is not (12.7%, $p = 0.022$, bootstrapping).[35] Moreover, the increase in choice reversals due to the phantom option being an aspiration is significant ($p = 0.000$) and the magnitude of this increase is robust to variation in the number of available alternatives in a task, i.e.

[33] We apply the same regression in Result 2 to the data obtained for Treatment L and the reported p-value indicates that the effect of the variable Ph is not significant.

[34] We pool the data and run a logistic regression with CLOS as the dependent variable; Ph and treatL as the explanatory variables; and our control variables. The above reported p-value indicates that treatment has no significant effect on choosing the closest option in tasks with phantom options, i.e. when Ph=1.

[35] A logistic regression analysis shows that the effect of timing treatment on reversal is insignificant both when the phantom is aspration ($p = 0.411$) and when it is not ($p = 0.956$). Therefore, we calculate the percentage of reversals using the data for both Treatments L and E. In the text, we report $p-$values obtained by bootstrapping analyses, but note that Wilcoxon signed-rank test also gives similar results.

benchmark vs. extension tasks ($p = 0.388$).[36] As for the test of similarity-based[37] decision making, we concentrate on phantoms that are aspirations and using a regression analysis, we find that in this particular extension, the presence of a phantom in the environment increases the odds that the alternative subjectively closest to it is chosen ($p = 0.060$), regardless of the timing treatment.[38] Finally, independent of the timing treatment, a greater number of available alternatives significantly raises the odds that the option which is Euclidean-wise closest to the unavailable aspiration is chosen ($p = 0.025$).[39] Bootstrapping analyses show that, unlike the benchmark case, there is no longer a significant difference between performances of the subjective and euclidean distances in either treatment when we concentrate on three+one tasks ($p = 0.724$ in Treatment E and $p = 0.162$ in Treatment Later).

Next, we analyze how the presence of two phantoms (where one is an aspiration and the other is not) affects choices. Even though a significant number (6.25%, $p = 0.001$, bootstrapping) of choices between the two available options still reverse when these options are presented in a binary versus two+two task, the odds of reversal decrease significantly with the addition of the second phantom in the environment ($p = 0.000$), regardless of the timing when unavailability is revealed.[40]

[36]To see this, we pool the relevant data and run a logistic regression with dependent variable REV; independent variables ASP, treatL, AvailAlt as well as their interactions; and our other control variables. Consider two+one tasks and the corresponding binary tasks which are obtained by removing the unavailable option in two+one task from display. From three+one tasks, similarly obtain the corresponding trio tasks. Variable REV takes 1 whenever a subject chooses different alternatives in a two+one and the corresponding binary task or in a three+one and the corresponding trio task. REV takes 0 otherwise. AvailAlt takes 1 if choices from trio and three+one tasks are compared, 0 if the comparison is made for binary and two+one tasks. ASP takes 1 if the unavailable option in three+one or two+one task is an aspiration and 0 otherwise. This analysis finds no significant 2- or 3-way interactions between treatL, AvailAlt, and ASP. We find that an unavailable option being an aspiration significantly raises the odds of reversal ($p = 0.000$), regardless of the timing treatment and the number of available alternatives in the task. Furthermore, the odds of reversal when AvailAlt=1 and when AvailAlt=0 are not significantly different ($p = 0.893$), independent of the timing treatment and whether an unavailable option is an aspiration or not.

[37]We measure the similarity between alternatives in this extension in the same way as before, more specifically via applying our "willingness to exchange price" method to quad tasks.

[38]We concentrate on trio and three+one tasks in this extension and run a logistic regression with the dependent variable CLOS; the explanatory variables treatL and Ph (and their interactions); and our other control variables. CLOS takes 1 if a subject chooses the option that is subjectively closest to her unavailable aspiration and 0 otherwise. Ph takes 1 if the task is three+one and 0 if it is a trio task. The variable treatL takes 1 if the data belongs to Treatment L and 0 otherwise. The variable treatL is found to not interact with the variable Ph ($p = 0.626$). Dropping that insignificant interaction term, we find that Ph being 1 (relative to being 0) increases the odds of choosing the alternative subjectively closest to the aspiration ($p = 0.060$).

[39]To see this, we run a logistic regression on the pooled data with dependent variable EUC; independent variables AvailAlt, treatL, as well as their interaction; and other control variables. EUC takes 1 if a subject chooses the Euclidean-wise closest option to her unavailable aspiration in a two+one or three+one task and 0 otherwise. AvailAlt takes 1 if a task is three+one and 0 if it is a two+one task. AvailAlt and treatL are found to not interact ($p = 0.811$).

[40]This result is obtained via a logistic regression with the dependent variable REV; independent variables treatL, TwoPh as well as the interaction of the latter two variables; and other control variables. The variable REV takes 1 whenever the alternative chosen in a two+two or two+one task is different than the one chosen in the corresponding binary task which is obtained by removing the unavailable option(s) in those tasks from display, and 0 otherwise. TwoPh takes 1 if a binary and two+two tasks are being compared for reversal and 0 if a binary and two+one task are being compared. An observation from a task with phantoms is included in this analysis only if one of the phantoms there is revealed as an aspiration. Analysis shows that TwoPh does not interact with treatL. Regardless of the timing treatment, a task being two+two (rather than two+one) significantly lowers the odds of reversing the choice from the corresponding binary task ($p = 0.000$). Also, the effect of treatL on choice reversal between binary and two+two tasks is not significant ($p = 0.108$).

On the other hand, support for similarity-based choice behavior (with respect to the subjective distance function) is found to be stronger in the case of two phantoms than in the case of a unique aspiration phantom. Introduction of the second (non-aspiration) phantom option into an environment where there already exists an unavailable aspiration significantly increases the odds that the alternative subjectively closest to the unavailable aspiration is chosen ($p = 0.025$).[41] Despite this, in choice environments with two unavailable options, the difference between the performance of the subjective and Euclidean distances in explaining observed choices by means of similarity-based behavior vanishes. The reason found in the data is similar to the observation we discuss in the previous extension: a logistic regression analysis shows that, independent of the timing treatment, the odds that the alternative which is Euclidean-wise closest to the unavailable aspiration is chosen also increases significantly with the addition of a non-aspiration phantom to the environment ($p = 0.003$).[42]

Finally, we examine the sensitivity of our main results by considering binary, trio, and two+one tasks where each bundle is composed of three types of goods. Unlike in the main design, any two+one task in the present extension is created by conditionally making the choice of each subject from a trio task to be unavailable. Therefore, the unavailable alternative in each two+one task faced by any subject is always her aspiration and subjects with different aspirations face different two+one tasks. As before, regardless of timing, a significant number of choice reversals are observed when an unavailable aspiration is introduced into a binary task environment (15.78%, $p = 0.000$, bootstrapping). As for the test of similarity-based decision making, the analysis of the present extension case yields results that are either significantly stronger or not significantly different than the benchmark ones. For instance, the effect of an unavailable aspiration's presence on the choice of the subjectively closest option is found to not differ depending on the alternatives being a combination of two or three types of consumer goods.[43] In addition, as in the benchmark case, the performance of the subjective distance measure in this extension is again better than that of the Euclidean distance in explaining observed choices via similarity-based behavior.[44] A logistic

[41] Pooling the relevant observations, we run a logistic regression with the dependent variable CLOS and independent variables TwoPH and treatL as well as their interactions. For any task with phantom option(s), CLOS takes 1 if the alternative subjectively closest to the unavailable aspiration is chosen and 0 otherwise. TwoPh takes 1 if the task is two+two and it takes 0 if the task is two+one. The results show that treatL and TwoPh do not interact with each other ($p = 0.476$). Furthermore, treatL has no significant impact on CLOS ($p = 0.967$).

[42] To reach this result, we pool the relevant data and run a logistic regression with the dependent variable EUC; independent variables TwoPH and treatL and their interaction; and other control variables. Independent variables are defined as before. EUC takes 1 if a subject chooses the Euclideanwise-closest alternative in a task with one or two phantoms and 0 otherwise. We find that TwoPH does not interact with treatL ($p = 0.691$)

[43] We run a logistic regression with the dependent variable CLOS; independent variables Ph, ThAttr, treatL as well as their interactions; and other control variables. CLOS, treatL, and Ph are defined as before and ThAttr is defined as follows: It takes 1 if in a task each bundle is composed of three types of goods and it takes 0 if only two types are good are used. The analysis shows that ThAttr does not have a significant impact on the interaction that exists between Ph and treatL($p = 0.630$). Moreover, ThAttr has no 2-way interaction with either of Ph ($p = 161$) or treatL ($p = 0.111$). Dropping insignificant 2- and 3-way interactions, we conclude that, also in this extension, the odds that the subjectively closest option is chosen increase significantly with the presence of the unavailable aspiration in Treatment E ($p = 0.000$) while the odds do not change significantly in Treatment L ($p = 0.471$). Moreover, ThAttr has no significant influence on the choice of the subjectively closest option ($p = 0.473$).

[44] Of observed choices in two+one tasks with three types of goods in bundles, in Treatment E 85.85% and 35.85%

regression analysis reveals that, in Treatment E, the odds that the subjective distance function performs better than the Euclidean one are significantly higher when three- instead of two- types of goods are used to define each bundle ($p = 0.000$) whereas in Treatment L, the magnitude of the subjective distance's superior performance over the Euclidean does not significantly differ depending on whether two or three types of goods are used to express each bundle ($p = 0.447$).[45]

9.2 Procedural Details of the Extensions

Questions regarding the second extension where we change the form of choice tasks (the number of available options, unavailable options, and the number of types of goods in a bundle) were embedded in Treatments E and L.

For the extension where we change the timing of unavailability, a separate treatment called Treatment "Later" was run. Below is the instructions for that treatment.

Instructions for Treatment "Later"

This is an experiment in decision making. Thank you for agreeing to participate. Please make sure your mobile phones are turned off to avoid interruptions during the experiment.

Your participation in this experiment is voluntary but we hope that you will also find the experiment interesting. You will be compensated for your participation; you will earn a combination of cash and consumer goods. Your final payoff will include a show-up fee of $5 and the rest will depend on the choices you have made and on chance.

The experiment will be conducted on the computer screen in front of you. Please do not talk or try to communicate with other participants during the experiment.

Please follow the instructions carefully. If you have any questions while the experiment is described, please raise your hand and your question will be answered so everyone can hear. The problems are not designed to test you. We are only interested in your personal opinion.

The experiment consists of two parts: Part I and Part II. Each part is composed of a series of decision tasks. At the end of the experiment, one of the decision tasks will be selected randomly and payment will be made accordingly. Each decision task is equally likely to be selected. Since you do not know which decision task will be picked, you need to answer all questions in both parts.

The published results of our research will not identify any individual or the choice he or she made in any way. All records will be linked to an anonymous subject ID only.

We will now discuss the instructions and payment method for tasks from Part I, and then you will participate in the first part of the experiment. After everyone has completed the first part of

can be explained by the subjective and Euclidean distance, respectively, while in Treatment L respective percentages are 79.54% and 57.57%. The superiority of the subjective distance over the Euclidean one is significant both in Treatment E ($p = 0.000$, bootstrapping) and in Treatment L ($p = 0.000$, bootstrapping).

[45]We define the variables EUC and SUB as in the main analysis and drop observations both take the same value. Then, we pool the relevant data and a logistic regression with SUB as the dependent variable; ThAttr and treatL as the independent variables (and their interaction); and also other control variables. Variables ThAttr and treatL are found to interact ($p = 0.002$).

the experiment, we will then discuss the instructions and payment method for the second part of the experiment which you will then take.

PART I: Each decision task consists of two stages:

- In the FIRST stage of a decision task, you will be presented with several bundles of consumer goods and asked to choose your most preferred bundle among those. To select a bundle, click on the bundle you prefer and then click submit. Once you submit, you cannot go back and change your choice in that decision task.

- In the SECOND stage, you will be presented with the same set of bundles as in the first stage, but this time some of those bundles might be unavailable. Bundles that are unavailable will no longer be clickable, and you will be asked to choose your most preferred bundle among the available ones in this new situation. To select a bundle, click on the bundle you prefer and then click submit. Once you submit, you cannot go back and change your choice in that decision task.

There are no right or wrong answers. We are only interested in the choices you would make in each given situation. The only right answer is what you would really choose. It is in your best interest to answer each question truthfully.

Payment Method:

If the decision task randomly selected at the end of the experiment is from Part I, then one of the two stages of that decision task will be selected randomly as well and, in addition to your show-up fee of $5, you will be given the option you have chosen in that stage. Please note that both stages of any decision task are equally likely to be selected.

Example:

R1 - 1st stage: Which of the following bundles do you choose?

A

B

C

D

R1 - 2nd Stage: Notice that two of the bundles from the previous stage are now unavailable. Which remaining bundle do you choose?

A

B (Unavailable)

C

D (Unavailable)

IT BENEFITS YOU TO CHOOSE YOUR MOST PREFERRED OPTION IN EACH DECISION TASK AND IN EACH STAGE because you don't know:

1) which bundles will become unavailable in the second stage of a decision task

2) which decision task and which of its stages will be randomly picked at the end of the experiment. Recall that any decision task and any stage is equally likely to be selected.

Are there any questions?

If there are no questions, please press Continue button and proceed to the first part of the experiment.

When you finish, please wait for our announcement to start Part 2, which will be started after everyone has completed the first part of the experiment.

PART II: Each decision task will consist of a set of bundles and you will be provided with one of them. For every other bundle in that task, you will be asked to state the minimum compensation in dollars that you would be willing to accept to change from the provided bundle to that bundle.

Here is an example:

Previously, when asked to choose between bundle A and the bundles listed below, you chose bundle A. Now, suppose that you are given bundle A. Next to each of the bundles listed below, please enter the minimum compensation (in dollars) you are willing to accept to switch from A to that bundle, and then click on the Submit button at the end of the page.

B —-

C —-

Notice that, since you will always be provided with your most preferred bundles, the minimum compensations you will enter should be greater than 0. Minimum compensations can be expressed in decimals. For example, 7.45 represents $7 and 45 cents. If your minimum compensation is a whole number, then you do not need to specify the number of cents, you may simply enter that whole dollar amount.

Again in this part, there are no right or wrong answers. We are only interested in your personal opinion.

PAYMENT METHOD:

If the decision task randomly selected at the end of the experiment is from Part II, then- in addition to your $5 show-up fee- you will be paid according to the following rule:

One of the bundles in that randomly selected decision task will be chosen.

If the selected bundle in the task is the one you are provided with, then you will get that bundle. Otherwise: A market price p* will be chosen randomly between $0.01 and $30. If p* is larger than or equal to the minimum amount you have stated, then you will leave the option you were provided with, get the other option instead and also be paid p*. Otherwise, you will keep the option you own.

Example:

Suppose that the minimum amount that you are willing to accept to switch from bundle A to bundle B is $3. Then, it is in your best interest to state 3 as your minimum switching price because of the following reason:

Suppose that you entered the price $6 instead. In this case, if $5 is drawn as the random switching price at the end of the experiment, you will receive bundle A because the price drawn was less than the price you specified. However, in truth you were willing to switch for $3, and hence would have preferred to switch from A to B and received $5. On the other hand, suppose that you entered the price \$1 instead of your true price of \$3. In this case, imagine that \$2 is drawn as the random switching price at the end of the experiment. In this event, you will receive bundle B and \$2, a combination that is worse to you than receiving bundle A because your true minimum switching price was \$3.

Therefore, it is not in your interest to lie upwards or downwards, but rather IT BENEFITS YOU TO STATE YOUR TRUE MINIMUM COMPENSATION IN EVERY TASK.

Are there any questions? If not, please press Continue button and proceed to Part 2.

When you finish, please raise your hand so that the experimenter can make your payment.