Leaving the store empty-handed: Testing explanations for the too much choice effect using decision field theory.

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Abstract

Economic theories of choice suggest that more options are better, and people should prefer choosing from among more options to find their most valued alternative. But in an intriguing counter-example, Iyengar and Lepper (2000) observed that while people were attracted to more options while shopping, the larger set size increased the likelihood that they would leave the store empty-handed. Surprisingly, this too much choice effect has not been consistently observed in situations where it would be expected (e.g., Chernev, 2003; Scheibehenne, 2008). This paper describes boundary conditions for the too much choice effect that were determined by evaluating three different psychological explanations within a unified theoretical framework, decision field theory (Busemeyer & Townsend, 1993). The effect of environmental structure on choice was also tested by varying the distribution of quality in the option sets between low variance (roughly uniform) and high variance (exponential distribution). Based on these simulations, two explanations were identified that differentially predicted the too much choice effect: avoiding choice when the most-preferred option changes too often, or when time runs out. Moreover, the magnitude of the too much choice effect depended on the distribution of option quality. These mechanism-environment structure combinations can help explain why the too much choice effect is observed some – but not all – of the time.

KEYWORDS: choice overload, assortment variety, decision simulation, too much choice, decision field theory.

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People tend to prefer more options and seek them out. Economic models of choice and intuition suggest that having more options is preferable because it increases the chance of finding one's most preferred option. But is having more options always better? In an intriguing counter-example, Iyengar and Lepper (2000) found that people shopping at a grocery store were more likely to purchase jam when confronted with a sample display of 6 exotic jams rather than a display of 24. This happened even though more people stopped at the 24 jam display. Contrary to expectations based on the traditional economic models, more options increased the likelihood that people would leave the store empty-handed. This is commonly referred to as the too much choice (TMC) effect and was replicated in several other choice situations, including selecting among essay topics, chocolates to eat, and retirement accounts (Iyengar & Lepper, 2000; Iyengar, Huberman, & Jiang, 2004).

However, the TMC effect has not been consistently observed in situations where it would be expected (Chernev, 2003; Scheibehenne, 2008). Why might this effect appear in some situations but not others, and perhaps for some individuals but not others? To find out, two objectives are pursued in this paper. The first goal is to test three psychological mechanisms that could produce the TMC effect. Given the conflicting existing empirical results, the second goal is to identify some plausible boundary conditions for when the effect may and may not occur in order to guide future research. Both goals are addressed by modeling choice among different numbers of options using the unified framework of decision field theory (Busemeyer & Townsend, 1993). The rest of this section provides details on three psychological mechanisms that could plausibly generate the TMC effect, environment-based boundary conditions, and decision field theory-based models.

Psychological explanations of the TMC effect

Iyengar and Lepper (2000) explained the TMC effect by stating that an overabundance of choice is demotivating, causing people either to give up on making a choice or to make a choice with which they end up less satisfied. Consistent with this explanation, Schwartz (2004) argued that even though option set size is commonly thought to be correlated with happiness and satisfaction, the two are actually negatively correlated. While demotivation is an appealing explanation, motivation level was not manipulated or measured in Iyengar and Lepper's (2000) experiment, and a demotivation-based explanation requires an external theory of motivation to explain the data.

There are many possible explanations for the TMC effect that do not rely upon motivation. For example, increasing the number of options could alter a person's decision strategy, how they perceive the options, or the likelihood that two option features conflict. In any of these examples, the decision maker may also become demotivated, but this is not necessary to produce the TMC effect; in fact, demotivation could then be a product of the effect rather than the cause.

In this paper, three simple psychological explanations for the TMC phenomenon are examined. They are that people leave the store empty-handed more when facing many options because a) it is more difficult to determine their most preferred option (e.g. favorite jam) or their preference keeps vacillating; b) they reach their personally and implicitly determined time limit for making this type of choice, or c) they decide that there are better things they can do with their time/calories/money. Although many other reasonable alternatives exist (see e.g. Haynes, this issue, for a mechanism based on regret, and Anderson, 2003, for others), it is important to start with the simplest possible explanations first and see whether they are sufficient to account for the effect. Each of the three proposed explanations will be expanded upon in turn.

Preference change

The first explanation for the TMC effect is based upon the literature on conflict in choice (Tversky & Shafir, 1992; Dhar, 1997) and the concept of dynamic preferences (Busemeyer & Townsend, 1993). Specifically, if the best options are too difficult to differentiate (i.e., seem too similar), then people may switch back and forth between their most-preferred options. After a certain number of "switches," people may consider the choice too difficult to make and consequently decide not to choose. For example, vacillation could occur between two options when the first has a high value on one feature but low on another feature and the second has the reverse, causing conflict between them (Tversky & Shafir, 1992a). In that case, people may seek to avoid these tradeoffs by not choosing either option (Luce, Payne, & Bettman, 1998).

Decreasing the discriminability within an option set could also increase vacillation. One manner of reducing discriminability would be to provide decision makers with ranges of feature values as opposed to actual point values (Dhar & Simonson, 2003). Regardless of the cause of the vacillation (similarity, conflict, noise), if the preference switching occurs too frequently, people might interpret this phenomenological experience as an indicator that they do not have a clear preference, and so give up without making a choice. And as the number of options increases, people may be more likely to vacillate and give up, creating the TMC effect. This is despite the fact that multiple worthwhile options should, from a classical economic perspective, make the choice of a satisfactory option easier.

Time out

The second simple explanation of the TMC effect is time-based. If the decision is taking too long relative to the payoff magnitude, then people may also leave empty-handed. Humans are adaptive decision makers who sometimes consider opportunity costs associated with a given decision and consequently alter their choice behavior (Hendrick, Mills, & Kiesler, 1968; Payne, Bettman, & Johnson, 1988; Yates, 2003). For instance, individuals may give themselves a fixed amount of time in which to make a decision, an allotment which can also depend on the type of decision and its importance. According to this mechanism, if a person cannot decide before this fixed amount of time has elapsed, he or she will stop trying and move on. Consequently , an individual who requires a lot of information before making a choice but has only a small amount of time in which to do so would probably think it best to exit the choice process altogether. Because a larger set of options would typically take longer to consider, more purchasing could occur in a smaller option set when the allotted time for the decision is equivalent in both situations—again resulting in the TMC effect.

No-choice option

The third explanation relies on the notion that not choosing could be deemed an option itself. If not choosing is identified as a distinct option, then it can be selected just like any of the other (real) options, meaning that the decision maker chooses not to choose. For instance, a decision maker may be thinking that if he buys jam he will not have enough money (or hunger or interest) to purchase something he would prefer more. As a result, when considering jams, he might actively think about a no-choice option which represents all the other things he could do with that amount of money. This explanation has precedence in the consumer preference literature (Busemeyer, Johnson, & Jessup, 2006). Furthermore, many experiments involving non-forced choice present individuals with just such a no-choice option (Tversky & Shafir, 1992a; Tversky & Shafir, 1992b; Dhar & Simonson, 2003). Here, the TMC effect would emerge if the no-choice option is more attractive in a larger than a smaller option set.

Environmental factors influencing the TMC effect

As adaptive decision makers, people are also sensitive to the environmental context of their choices (Gigerenzer & Todd, 1999; Payne, Bettman, & Johnson, 1988): They not only use information from the environment when choosing but may also implicitly or explicitly select a decision strategy based on the environment structure and task demands. Consequently, the environment represents an important element in considering the TMC phenomenon. Including different environmental conditions may provide additional insight into why the TMC effect is observed in some studies and not others. Hence, in addition to the three specific psychological mechanisms for the TMC phenomenon, each explanation was evaluated in the context of two distribution types.

There exist a wide range of reasonably expected distribution types for sets of options. While it might seem most natural to consider option sets that are normally (i.e., Gaussian) distributed – as these might more closely approximate the real-world distribution of options in the marketplace – the desire to define boundary conditions for the TMC effect suggests that two extreme distribution types should be considered: uniform and exponential. Distributions similar to these extremes may be encountered by decision makers in different environments; J-shaped distributions, such as the exponential, are commonly observed in nature (Hertwig, Hoffrage, & Martignon, 1999; Stewart, Chater, & Brown, 2006; Zipf, 1949).

In a uniform distribution, for any given option there is likely to be another in the set that is similar to it in value. In contrast, an exponential distribution has one dominant option which is clearly superior to the others. If the TMC effect depends on *difficulty in discriminating* the single most highly valued option, then it is more likely to emerge from a uniform distribution. With an exponential distribution, discriminating the most attractive option should not be difficult, and instead the challenge may arise when first *searching* for the best option(s).

Decision field theory

Whether the different psychological mechanisms would produce the TMC effect in particular environments was evaluated using a unified theoretical framework, decision field theory (Busemeyer & Townsend, 1993). Unlike static theories of choice, decision field theory is a random walk model of forced choice that predicts both choice probabilities and response times for options. Decision field theory makes explicit assumptions about how people accumulate information, build preferences over time, and use decision thresholds to reach a choice. For example, in decision field theory, attention stochastically alternates between features in real time, updating the dynamic preference value for each option according to how much that option's particular value on that feature dimension is preferred. Preference values accumulate until the preference for one option reaches a preset decision boundary, at which point that option is chosen. As a result of the dynamic nature of preference accumulation and stochastic feature-attention switching, models derived within decision field theory can predict changing choices over time even when options are unchanging (see Appendix for computational formulas).

Figure 1 illustrates the choice process. Here, three possible options (A, B, and C) are considered. A person samples information about each option stochastically, and based on that information each of these options accumulates relative preference across time. The first option to reach the preset decision boundary is chosen; in the example shown, preference for option B surpasses the threshold set at 2 on the vertical axis at approximately time step 6800 and is selected. The decision boundary (sometimes called aspiration level or decision threshold) represents the amount of preference (or evidence, for inferences) that must be accrued for a choice to be made. Consequently, a higher decision boundary requires that more preference accumulates before an option is chosen; this also typically takes more time.

A high decision boundary could be utilized when making important decisions. On the other hand, a very low decision boundary enables a choice to be made very quickly, but usually at the cost of increased likelihood of making a poor decision. Thus, a low decision boundary might be used when making decisions under time pressure or decisions of little importance. Different decision boundaries used to make the same decision can also result in different options being chosen. For example, if the decision boundary were lowered to .75 in Figure 1, option A would instead be chosen, at approximately time step 2000.

Decision field theory and derivative models have been applied to explain a variety of effects in the decision making literature, including decisions under uncertainty (Busemeyer & Townsend, 1993), multi-attribute choice (Diederich, 1997), multi-alternative choice (Roe, Busemeyer, & Townsend, 2001), preference reversals (Johnson & Busemeyer, 2005), experiential and descriptive choice discrepancies (Jessup, Bishara, & Busemeyer, in press), and have also recently been applied to the marketing domain (Busemeyer, Barkan, Mehta, & Chatervedi, 2007). Of particular relevance for the present investigation, Busemeyer et al. (2006) showed that decision field theory could account for particular behaviors involving context effects when a no-choice option was available.[1] Dhar and Simonson (2003) had previously demonstrated that allowing individuals the option of not choosing differentially affected some well-established context effects, increasing the attraction effect and decreasing the compromise effect. By simply including a no-choice option, decision field theory predicted this same pattern of results.

Extending decision field theory to account for non-forced choice

Decision field theory and its derivative models have unique features that increase their applicability to modeling the conditions in which the TMC effect might arise. First, models built within decision field theory can incorporate competition. As preference states evolve across time, a comparison can be made at each time step between the preferences for different options to determine which is most preferred. Because preferences for options accumulate across time as a random walk in decision field theory, it is possible that at one moment in time a certain option will be most preferred, but at the next moment a competing option is most preferred. These competitive dynamics enable a decision field theory-based model to implement the previously described preference change explanation for not choosing. This can be done by adding a threshold representing the number of preference changes an individual could tolerate before deciding that the choice was too difficult to make. Figure 2 presents an example of the preference change instantiation, with a tolerance threshold value of 7 switches. If this tolerance boundary is reached before the preference for any option hits the decision boundary, the choice process is ended (denoted by the gray shaded area) and no option is selected. In Figure 2, the preference change tolerance threshold is reached around time step 2250. The same tolerance for preference changes in two different-sized option sets could result in the TMC effect.

Second, decision field theory describes preference as a process that evolves over time, allowing models to predict differential choice behavior, depending on the time at which the choice was made. As a result, decision field theory-based models can also implement the previously described time out explanation for not choosing. This is accomplished by incorporating a time-based stopping boundary, representing a personally-determined time threshold at which an individual chooses not to choose. Figure 3 presents an example of the time out instantiation with a time boundary at 4000 time steps. If the time boundary is reached before any option hits the decision boundary, as in the case in this figure, the individual will exit the decision process and not choose anything. When the time boundary is short, few choices will be made. In contrast, a large enough time boundary (e.g., infinite) would always result in a choice being made. The same time-based stopping boundary in two different sized sets of options could potentially produce a TMC effect.

The typical static and deterministic mathematical models utilized by economists and consumer behavior researchers are not able to test these aforementioned two potential explanations (preference change and time out) for the TMC effect. However, they can implement the no-choice explanation which adds in not choosing as a separate option with particular values specified for all of the features. Decision field theory-based models can also test such an explanation by building in the no-choice option with a preference state of its own, as demonstrated by Figure 4. In this example, the no-choice option reaches the decision boundary before any other option, at approximately time step 5100, resulting in the individual choosing not to choose. The TMC effect could emerge if this no-choice option is chosen more frequently when a larger rather than a smaller option set is encountered.

Decision field theory thus offers the possibility of testing multiple psychologically plausible explanations for the TMC effect within a unified theoretical framework. Moreover, some of these explanations are not readily testable within other existing decision frameworks stemming from traditional models of choice.

METHODS

Each explanation for the TMC effect was implemented in a decision field theory-derived model and choice behavior was then simulated. The preference change explanation was implemented by counting the number of times a different option took the lead (i.e., became most preferred) and comparing this value with a preset preference change tolerance threshold. If the number of preference changes reached the tolerance threshold before any option reached the decision boundary, the simulated decision maker chose not to choose. To implement the time out explanation, a time boundary was added which, if reached before any option hit the decision boundary, caused the simulated individual to exit the decision process and not choose anything. The no-choice option explanation was implemented by adding “not choosing” as an extra option which competed against all the available options. Because this method required that the no-choice option have specific values on the features, a simplifying assumption was to give it values equal to the mean for each feature (Busemeyer et al., 2006). However, in the present simulations, this option’s mean value was varied from 1.75 units below the mean (i.e., “unattractive”) to 3 units above the mean (i.e., “extremely attractive”) allowing it a better opportunity to produce the TMC effect. The feature values for this option were then created in the same manner as were the real options (described below).

Simulation details

To test for the presence of the TMC effect with various decision mechanisms, parameter settings, and environment structures, each mechanism/environment combination was simulated many times on small choice sets with 6 options and large choice sets with 24 options (in accordance with the values used by Iyengar and Lepper, 200, study 1), and the frequency of choosing was compared between sets.[2] The TMC effect occurred when more choices were made in the 6 option set than the 24 option set.

In each simulation, two parameters were varied over a wide range of values: the decision boundary and the model-specific additional parameter (i.e., preference change tolerance, time boundary, or no-choice option value). Additionally, to assess the role of the environment in the presence or absence of the TMC effect, each of the proposed decision mechanisms were evaluated for all parameter values in the two distribution environments, uniform and exponential.

The uniform distribution was created by drawing a random number, for each option, from a uniform distribution within the interval [-0.25, 0.25], and adding it to 2; this represented the preference value for that option. Next, for each option a second random number was drawn from the same uniform distribution which was then both added to and subtracted from the overall preference value, resulting in two feature values for each option.

The exponential distribution was created by assigning each option a value obtained by squaring a random number drawn from a normal distribution with a mean of 1 and standard deviation of 1, resulting in a distribution with a mean value of 2. Next, for each option a second random number was drawn from a normal distribution with a mean of 0 and standard deviation of 1 and then both added to and subtracted from the option's main value, resulting in two feature values for each option.

Twenty values were used for each of the two model parameters resulting in a 400 cell matrix of parameter combinations. For each of the 2 option set sizes, 30 different value distributions were generated and 1,000 decision trials were simulated for each cell of each distribution. This resulted in 24,000,000 simulations (400 x 30 x 1,000 x 2) for each model with each distribution. The option sets were prepared in the same manner as in Iyengar and Lepper's (2000) jam study. First, 28 options were created with a random distribution (uniform or exponential) of two feature values and then the four highest valued options (determined by the mean for an option across both features) were removed (as Iyengar and Lepper did), thus producing a large option set with 24 options. Next, the remaining top two, middle two, and bottom two options were used for the small option set with 6 options (also as Iyengar and Lepper did). The variable of interest is the difference between the frequency of not choosing in the large option set and the small option set, holding the distribution of option values, decision boundary, and model-specific additional parameter constant. The TMC effect occurred when not choosing in the large option set exceeded not choosing in the small option set. Of interest for each mechanism/environment combination is the extent of the parameter space over which the TMC effect occured, and how strongly. From this, possible boundary conditions for the TMC effect could be inferred.

RESULTS

The simulations were conducted over a wide range of parameter values so as to obtain a more informative picture of the prevalence of the TMC effect. Across this broad range, there are many parameter combinations for which either choices are always made or never made in *both* option set sizes. In these floor and ceiling cases, of course, the TMC effect does not occur. The TMC effect also does not occur for those parameter settings where equal amounts of choice and no-choice are made from the two option set sizes. But, when *does* it occur?

The results for the three models are shown in Figures 5-7 and descriptive statistics regarding the occurrence of the TMC effect are given in Table 1. In the figures, the TMC effect is present when the value on the vertical axis is negative (representing the proportion of decisions in which an option is selected from among 24 options minus the proportion of decisions in which an option is selected from among 6 options). The two horizontal axes represent the value of the decision boundary (i.e., threshold to which an option's preference must accumulate for it to be chosen) and the model-specific additional parameter.

For the preference change mechanism (Figure 5), when option values are uniform distributed the TMC effect occurs in 61% of the parameter space tested. Across the region where the effect occurred, the median difference in the probability of making a choice between the two option set sizes was .12. When option attractiveness comes from an exponential distribution, so that a few highly attractive options may exist, the TMC effect is reduced both in occurrence—arising in only 25% of the parameter space—and magnitude, median difference = .07. The effect was found only when tolerance for the number of lead changes is very small (e.g., 1-5).

An examination of Figure 5 reveals that the model produces reasonable predictions, despite results that may initially appear contradictory. For example, individuals with a low tolerance for preference changes (e.g., 1-5) and low decision boundary (also 1-5) appear to complete their choices more often in the large set when the best options can be highly similar (uniform distribution) than when clear winners exist (exponential distribution). At face value, this seems unrealistic, as one should expect the presence of clear winners to increase the amount of choosing. However, this apparent contradiction vanishes when realizing that each graph plots the relative, rather than absolute, amount of choosing—that is, the difference in choice rates between the two option set sizes. Thus, while the absolute choice probability in the aforementioned range of parameter values for both the 6 and 24 option sets is greater when in the exponential distribution environment (both have median choice rates of > .99) than in the uniform distribution (medians of .79 and .91, respectively), the small option set was more affected by the distribution type than the large option set, producing the observed results (i.e., relatively more choosing for the 24 option set in the uniform compared to the exponential environment).

The time out mechanism leads to a strong TMC effect over a narrow band of parameter values when option values are uniformly distributed (Figure 6a). The value of the decision boundary and number of time steps which produced the maximum TMC effect for that number of time steps was correlated (r = .97), with a regression coefficient of .29. The TMC effect occurs, usually less strongly, in 49% of the tested parameter space overall, with the median size of the effect at around .20. However, with the exponential distribution (Figure 6b), the effect is much stronger (median = .64) and occurs in the vast majority (84%) of the tested parameter space; only when decision or time boundaries are very low does the effect fail to emerge.

A close look at the plots in Figure 6 demonstrates that again the model produces reasonable predictions, despite apparent contradictions. For example, it appears counterintuitive to observe a TMC effect when individuals set a high decision boundary and have a long time deadline when a few distinctly best options are present but not when good options can be highly similar. Again, the absolute choice probabilities reveal that the time out deadline is almost always reached and choice probability hits 0 for both option sets in the uniform environment (median purchasing rate across the entire parameter space for the 24-option set = 0). However, in the exponential environment, an option is selected on almost every trial in the small option set whereas the choice process in the large option set again usually reaches the time boundary and chooses nothing, though not as often as in the uniform case (median purchasing rate across entire parameter space for 24 option set = .12).

The no-choice model does not lead to the occurrence of the TMC effect, regardless of distribution type (see Figure 7 and Table 1). Instead, and in accordance with classical economic theory, this is the only model that regularly predicts greater choice from the large option set than from the small option set. In the uniform distribution (Figure 7a), this “more choice is better” effect occurs most when the value of the no-choice option is roughly equivalent to the mean value of the other options. This makes intuitive sense: when the value of the no-choice option is below the mean value of the other options, the no-choice option is rarely chosen in either option size set, so the choice difference is 0. But as the no-choice option’s value approaches and surpasses the mean value of the other options, simulated individuals presented with the small option set detect this no-choice option more easily than those presented with the large option set and so “choose not to choose” more often, leading to the maximal “more choice is better” effect. However, as the relative value of the no-choice option continues to increase, both simulated individuals choosing from the small option set and the large option set will notice its higher value and begin always choosing it, leading to no choice difference between the set sizes and making the “more choice is better” effect disappear. In the exponential distribution (Figure 7b), the “more choice is better” effect occurs most strongly when the no-choice alternative is highly attractive and the threshold for deciding is low.

To summarize, the TMC effect can be expected to occur, if choosers are using the preference change mechanism, more commonly and strongly when good options are similarly attractive (as in the pattern created by the uniform distribution) than when there are distinctly best options (as in the pattern created by exponential distribution). The use of the time out mechanism predicts a reversed situation, where the effect is larger and more frequent with distinctly best options than with similarly good options. The no-choice option mechanism does not noticeably produce the TMC effect except by chance.

DISCUSSION

Based on these simulations, two psychological mechanisms were identified that differentially predicted the TMC effect: preference change and time out. Furthermore, the emergence of the effect via these mechanisms depends on the distribution of option values in the environment.

Evaluation of mechanisms and environments

The preference change explanation is consistent with the idea that people use their phenomenological experiences to inform their choices (Schwarz, 1990; Kahneman & Tversky, 1973). For example, people may interpret vacillations between preferred options as an indicator that they do not have a strong preference, and consequently not choose any option. The preference change mechanism predicted a larger and more extensive TMC effect when good options were similarly attractive (i.e., uniform value distribution) relative to when a distinct best option is present (exponential distribution). Thus, this mechanism is sensitive to the environmental distribution. The present results suggest that if participants in Iyengar and Lepper's (2000) jam study were using this mechanism, then the jams they encountered probably appeared to them to be of similar value. As not making a choice is similar to decision deferral, the simulation results are also consistent with Dhar's (1997) empirical findings that preference uncertainty is related to deferral rates. Taking this together with research indicating that large assortment or information variety leads to greater confusion in choice (Gourville & Soman, 2005; Huffman & Kahn, 1998; Lee & Lee, 2004), one could conclude that larger, more confusing assortments – which reduce discriminability among the good options and thus make it difficult to determine which option is the best – may lead to greater choice deferral (and hence the TMC effect) via the preference change mechanism.

The present results also indicate that people may exhibit the TMC effect if they are concerned with the amount of time needed to make a decision. If there is insufficient time to acquire the necessary amount of information for making a choice (i.e., to reach the decision boundary), then the individual may instead exit the choice process without choosing anything. Interestingly, this time out explanation predicts the TMC effect for both uniform and exponential distributions of option values when the time-out threshold is low, suggesting that if people have a very short time tolerance for a decision (as could be the case in shopping decisions such as Iyengar and Lepper's jam study) the distribution of options may not be important. This prediction corresponds with findings that people take into account the amount of time that they have spent on a problem as an indicator of decision readiness (Veinott, Yates, Gonzalez, & Verosky, 2002). However, the mean and median magnitudes of the TMC effect generated by this mechanism were substantially larger when the options were exponentially rather uniformly distributed, presumably because people in the 24 option exponential case are more likely to hit their time boundary before they can identify the best of the options.

Finally, the no-choice option mechanism did not predict the TMC effect for either environmental condition tested. This model comes closest to traditional explanations of non-forced choice tasks in the judgment and decision making literature which predict that more choice is better.

Using decision field theory allowed the evaluation of multiple choice mechanisms and their interaction with different environments. As Iyengar and Lepper (2000) point out, the distribution of options is important, but they did not vary distributions in their experiments. The present results confirm the importance of taking into account the distribution of options along with choice mechanisms to see how their interaction affects the prevalence and magnitude of the TMC effect. Option value distribution, along with the number of options in the different sizes of option sets (Shah & Wolford, 2007), appears to be a boundary condition for the effect.

Understanding the mechanism/environment interaction allows new experimental predictions to be made when there is knowledge about decision makers, their behavior, and/or the tasks they face. For instance, if one observes the TMC effect among a group of decision makers and knows what environment structure they faced, one can predict the most likely decision mechanism used, and then run further tasks to test this prediction. If instead one knew both the decision mechanism used and the environment structure faced, then one could infer from the simulation results here the possible range of decision-mechanism parameters that individuals were employing, depending on whether or not they evinced the TMC effect.

Limitations and future directions

There are of course a number of limitations to the present investigation. First, each psychological mechanism was evaluated in isolation whereas it is possible that individuals use multiple strategies simultaneously. For instance, people may be sensitive to preference uncertainty, time, and missed opportunities when making a decision, yet the attention they pay to each constraint may depend on the current decision context. However, for reasons of clarity and parsimony, each explanation was evaluated here separately so as to determine whether it alone can generate the effect of interest. Second, it is plausible that choice and deferral may involve a two-step process (e.g., first deciding whether to choose or not, and then, if choosing, to decide on an option). However, because time-course data for the TMC effect has not yet been reported, the likelihood of such an explanation could not be evaluated. Moreover, a two-step decision process would probably generate behavioral patterns similar to the no-choice option mechanism (which it resembles). Third, these simulations assumed that people use the same choice processes for 6 options as for 24 options (e.g., acquiring information, processing each option). While this is not necessarily realistic, modifying the models to allow for differential processing would build in additional assumptions which may or may not be accurate. Thus, the parsimonious modeling approach with minimal assumptions was utilized; this was still useful for observing whether or not different mechanisms could predict the TMC effect without the aid of many additional assumptions. Fourth, only two environments were considered even though a multitude of possible environments exist. As previously stated, a goal of this examination was to identify boundary conditions, and the uniform and exponential distributions are two extreme distribution types. Nonetheless, the simulations were also run using normally distributed option-value sets with uncorrelated feature values, but the magnitude and location of the TMC effect was circumscribed between the results from the uniform and exponential environments, the two extreme distribution types, and so did not provide any additional insights beyond the current findings.

There are also several interesting directions for future research. First, although two different mechanisms were identified which might engender the TMC effect, there are other plausible explanations to explore (Anderson, 2003) which could also be compared within the decision field theory framework. Second, these results indicate that individual differences in tolerance for time spent making a decision or for preference uncertainty play a substantial role. For example, the time out boundary could vary depending on the decision context (e.g., jams or jobs), but could also vary according to character traits, as in the case of maximizers and satisficers (Schwartz et al., 2002). The effect of these individual differences on the emergence of the TMC effect should be tested in different choice domains.

Third, as mentioned in the previous section, these simulation results provide testable empirical predictions for each explanation, enabling a more directed approach towards understanding the TMC effect. For instance, the results from the time out explanation predict that a large TMC effect emerges when the time out and decision boundaries are medium to large for exponentially but not uniformly distributed option sets. This can be tested by manipulating these parameters in experiment participants: It may be possible to force the decision boundary upwards by requiring individuals to achieve a “target” quality level for each purchase. Similarly, the time out boundary can be manipulated by requiring an option to be selected within a pre-specified amount of time. In this case, the decision field theory model predicts that the TMC effect should appear in the exponentially distributed case over a wider range of the parameter space (i.e., quality of the target to be achieved and time allotted for the decision) than in the uniform case. Other such tests for various mechanism/environment pairs can also be devised.

CONCLUSION

Iyengar and Lepper (2000) creatively identified an intriguing choice phenomenon: decreasing choice in the face of too many options. The fact that the TMC effect is not always observed makes understanding the phenomenon more challenging. The present simulations suggest that future research focusing on environmental factors (e.g., distribution of options, assortment variety), cognitive strategies, individual differences, and their interactions will lead to a better understanding of this phenomenon. Ironically, what leads people to the store may also drive some of them away empty-handed. While too much choice may indeed be demotivating, that is not the end of the story. Evaluating the TMC effect within the context of decision field theory allowed for the examination of the complex relationship between choice strategies and the distribution of available options. By providing a process explanation for the TMC effect, it becomes possible to elucidate how the effect emerges as well as when.

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Appendix

The formulation for decision field theory presented here can be found in Roe et al. (2001). Preferences in decision field theory are accumulated according to the following equation:

$$P(t + h) = S \cdot P(t) + V(t + h) \tag{1}$$

The term on the left represents accumulated preference for options at time step t plus a time increment h. This preference vector is composed of preference at time t multiplied by a distance-dependent feedback matrix S, the product of which is added to the valence for an option at time $t + h$.

The valence for each option at time t is calculated according to:

$$V(t) = C \cdot M \cdot w(t) + \varepsilon(t) \tag{2}$$

In equation (2), C is a contrast matrix which scales the inputs from the product of the ensuing terms. M represents the motivational value for each option on each dimension (i.e., feature). The stochastic attention weight vector w indicates which feature is receiving attention at time t, and ε is a normally distributed error term with a mean of zero.

In the present work, the values for all terms on the diagonal of the S matrix were fixed at .95, to allow for a small amount of memory decay across all options, and .05 on the off-diagonals, to allow for a small amount of equally distributed distance-dependent inhibition. In equation (2), the $w(t)$ vector was set to [.51, .49] to provide a slight difference in the attention paid to each feature.

Footnotes

[1]This represents the first time that decision field theory was extended to a non-forced choice situation. Previously, Roe et al. (2001) demonstrated that adding a minimum preference boundary allowed decision field theory to discard some options from consideration in a manner akin to the elimination by aspects heuristic (Tversky, 1972). However, the minimum preference boundary never allowed all options to be discarded, so ultimately a choice still had to be made.

[2]Decision field theory was initially designed for very small option sets that were not differentiated in processing time. To make the 24 option set take longer to process than the 6 option set, processing time in the 24 option case was reduced to ¼ the speed of the 6 option set (i.e., now each momentary evaluation takes 1 time step in the small option set but 4 time steps in the large option set). This results in processing taking the same amount of time for each option and different amounts for each set, as one might expect during sequential option assessment. An alternate approach might involve assuming that 6 randomly selected options are evaluated at each time step. This would likely produce similar, but different, results.

Table 1

Descriptive Statistics for the Too Much Choice Effect

Mechanism	Environment	Max	Mean	Med	SD	MaxN	Prop	PropEq	PropN
Preference Change	Uniform	0.29	0.13	0.12	0.08	0.16	0.61	0.25	0.14
	Exponential	0.20	0.08	0.07	0.06	0.07	0.25	0.74	0.01
Time Out	Uniform	1.00	0.30	0.20	0.28	0.00	0.49	0.51	0.00
	Exponential	1.00	0.56	0.64	0.31	0.00	0.84	0.16	0.00
No-choice	Uniform	0.00	—	—	—	0.30	0.00	0.53	0.48
	Exponential	0.00	—	—	—	0.14	0.00	0.30	0.70

Note. Values refer to the difference between the probability of choosing in the 24 option set and 6 option set. (Unsigned differences are reported here, in contrast to the signed differences plotted in the figures.) When choosing was greater in the 6 option set, the too much choice (TMC) effect occurred. Max = Maximum TMC effect; Mean = mean TMC effect, given that it occurred; Med = median TMC effect, given that it occurred; SD = standard deviation of the distribution of the TMC effect, given that it occurred; MaxN = Maximum choice difference over cases where there was no TMC effect (i.e. where there was more choice among 24 options than among 6); Prop = proportion of the parameter space tested in which there was a TMC effect; PropEq = proportion of the parameter space tested in which equal rates of choice occurred in both the large and small option sets (a window of ±.005 was provided around 0, such that differences in rates of choice which fell within this range were considered equal amounts of choice); PropN = proportion of the parameter space tested in which more choice occurred in the large option set than the small option set; "—" indicates cases where there was no value.

Figure Captions

Figure 1. Process illustration of decision field theory. The vertical axis represents the preference state (i.e., accumulated preference) and the horizontal axis represents decision time in arbitrary units. In this example showing three options (A, B, & C), preference for each option accumulates across time and the first option to reach the decision boundary (black horizontal line at y=2) is chosen. Here, option B is chosen at approximately time step 6800. If the decision boundary were reduced to .75, then option A would instead be chosen at approximately time step 2000. The gray shaded area denotes that the choice process has been exited.

Figure 2. Preference change mechanism implemented in decision field theory. The vertical axis represents the preference state (i.e., accumulated preference) and the horizontal axis represents decision time in arbitrary units. For every time step on which a different option becomes most preferred (denoted by the circles), the preference change counter is incremented. If this counter value reaches the tolerance threshold for preference changes before an option reaches the decision boundary, then the process will stop and no option will be selected. Here, the tolerance threshold was set to a value of 7 and reached at approximately time step 2250. The gray shaded area denotes that the choice process has been exited.

Figure 3. Time out mechanism implemented in decision field theory. The vertical axis represents the preference state (i.e., accumulated preference) and the horizontal axis represents decision time in arbitrary units. If the time boundary (vertical line at approximately 4000 time units) is reached before an option reaches the decision boundary then the process will stop and no option will be selected. Here, the process ended without any option being selected. The gray shaded area denotes that the choice process has been exited.

Figure 4. No-choice as an extra option implemented in decision field theory. The vertical axis represents the preference state (i.e., accumulated preference) and the horizontal axis represents decision time in arbitrary units. A fourth option is added, representing ‘not choosing.’ If this option reaches the decision boundary before any other option, then the process will stop and no option will be selected. Here, the no-choice option was the first to reach the decision boundary (at approximately time step 5100), causing the process to end and resulting in no choice being made. The gray shaded area denotes that the choice process has been exited.

Figure 5. Preference change model: The occurrence of the TMC effect, for a) uniform and b) exponential distribution of option values. The vertical axis presents the magnitude of the TMC effect from the simulations, given the preference change tolerance and decision boundary parameters (shown on the horizontal axes). The TMC effect occurs when the value on the vertical axis is negative. In order to minimize occlusion of the effect of interest, the alignment of the axes may differ between graphs. Each cell represents 60,000 simulated decisions.

Figure 6. Time out model: The occurrence of the TMC effect, for a) uniform and b) exponential distribution of option values. The vertical axis presents the magnitude of the TMC effect from the simulations, given the time boundary and decision boundary parameters (shown on the horizontal axes). The TMC effect occurs when the value on the vertical axis is negative. In order to minimize occlusion of the effect of interest, the alignment of the axes may differ between graphs. Each cell represents 60,000 simulated decisions.

Figure 7. No-choice model: The occurrence of the TMC effect, for a) uniform and b) exponential distribution of option values. The vertical axis presents the magnitude of the TMC effect from the simulations, given the value of the no-choice option, relative to the mean of the of the option set, and decision boundary parameters (shown on the horizontal axes). The TMC effect occurs when the

value on the vertical axis is negative. In order to minimize occlusion of the effect of interest, the alignment of the axes may differ between graphs. Each cell represents 60,000 simulated decisions.

Figure 1

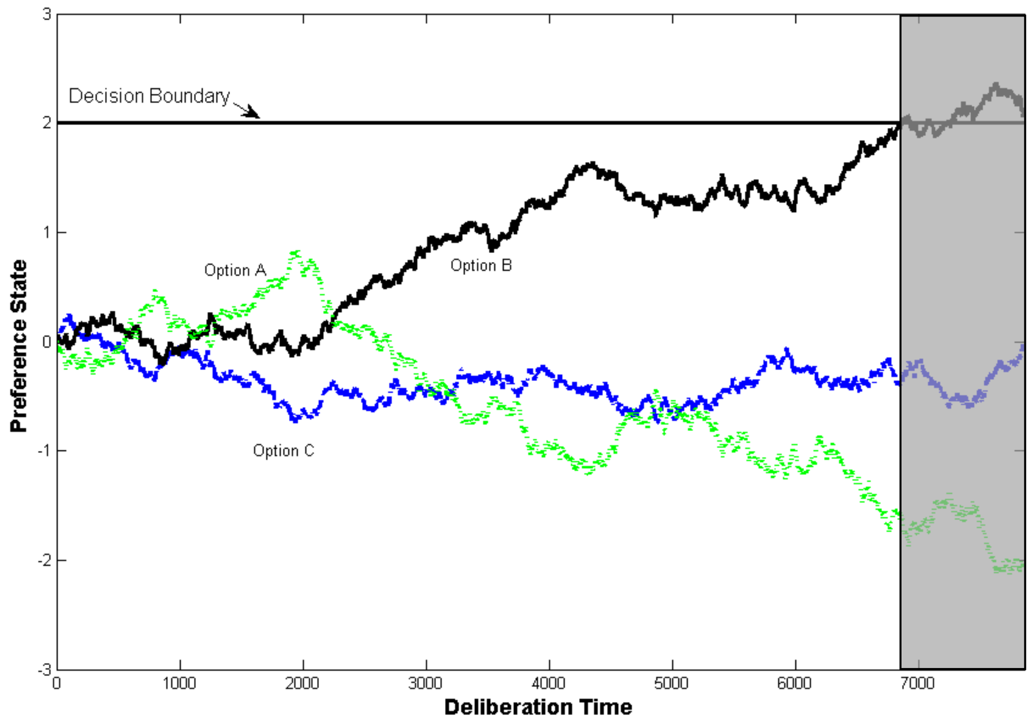

Decision Boundary
Option A
Option B
Option C
Preference State
Deliberation Time
3
2
1
0
-1
-2
-3
0
1000
2000
3000
4000
5000
6000
7000

Figure 2

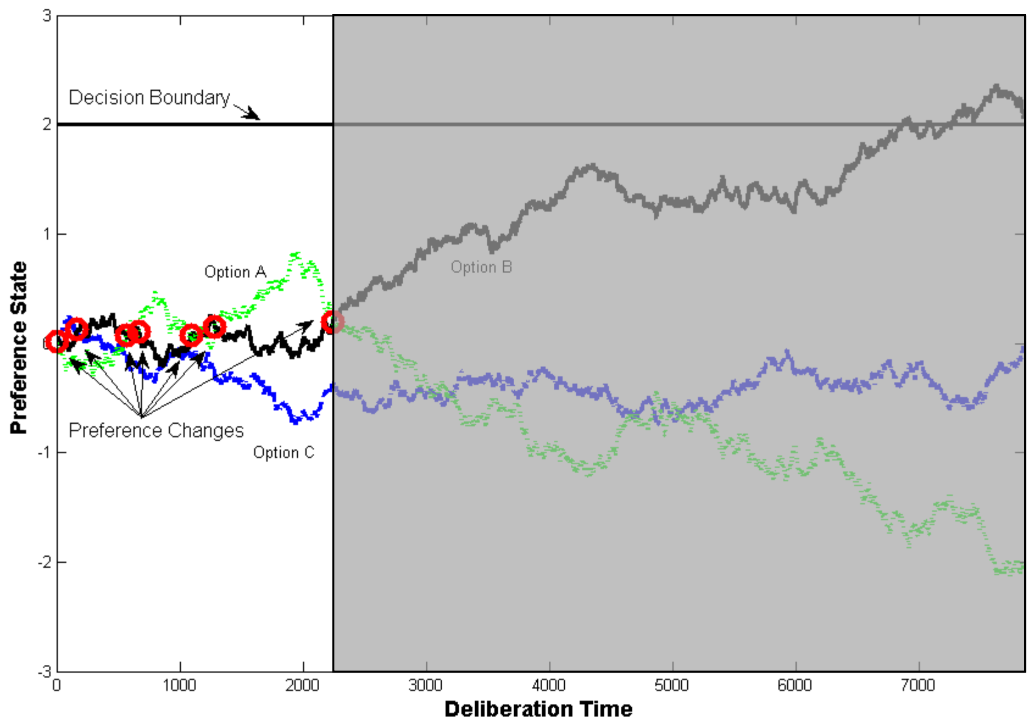

Decision Boundary
Option A
Option B
Option C
Preference Changes
Preference State
Deliberation Time
3
2
1
0
-1
-2
-3
0
1000
2000
3000
4000
5000
6000
7000

Figure 3

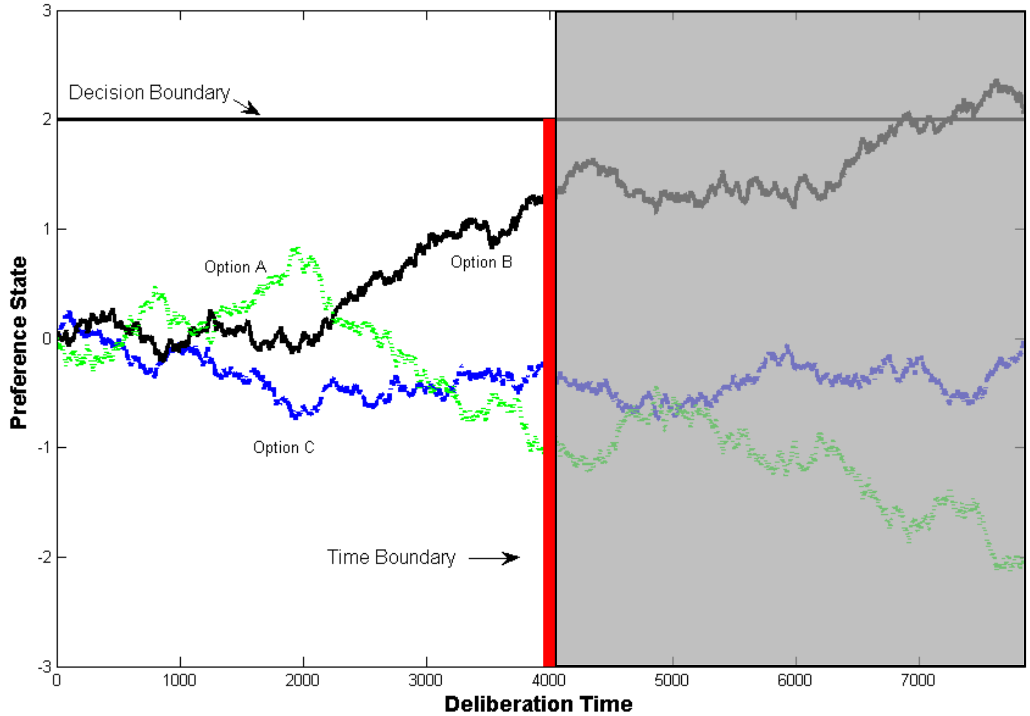

Decision Boundary
Option A
Option B
Option C
Time Boundary
Preference State
Deliberation Time
3
2
1
0
-1
-2
-3
0
1000
2000
3000
4000
5000
6000
7000

Figure 4

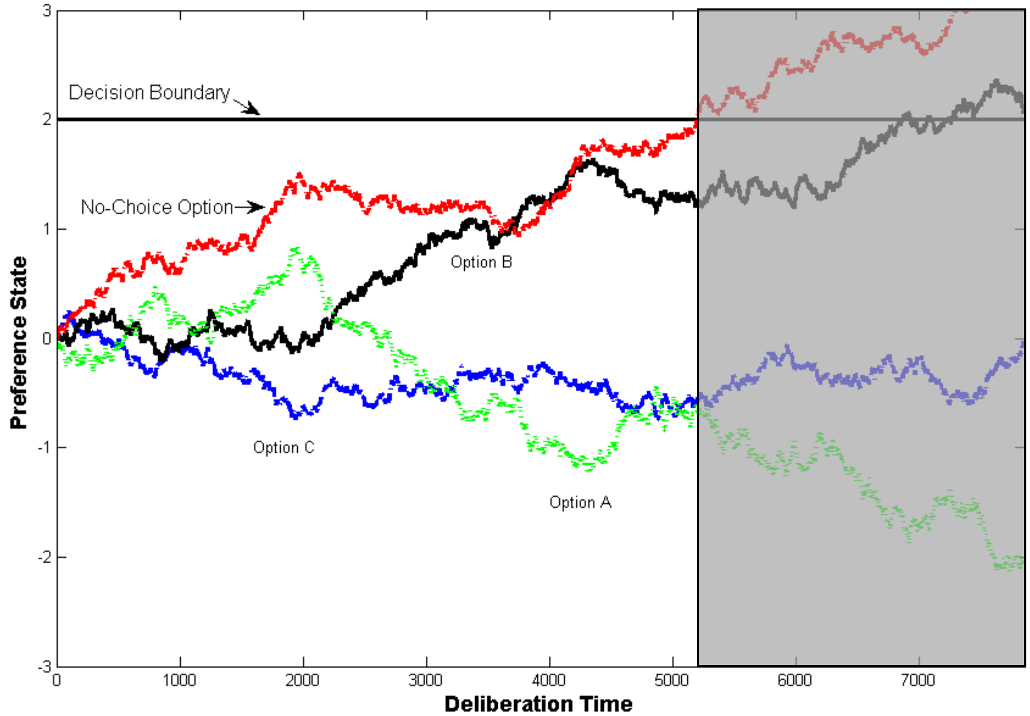

Decision Boundary
No-Choice Option
Option B
Option C
Option A
Preference State
Deliberation Time
3
2
1
0
-1
-2
-3
0
1000
2000
3000
4000
5000
6000
7000

Figure 5

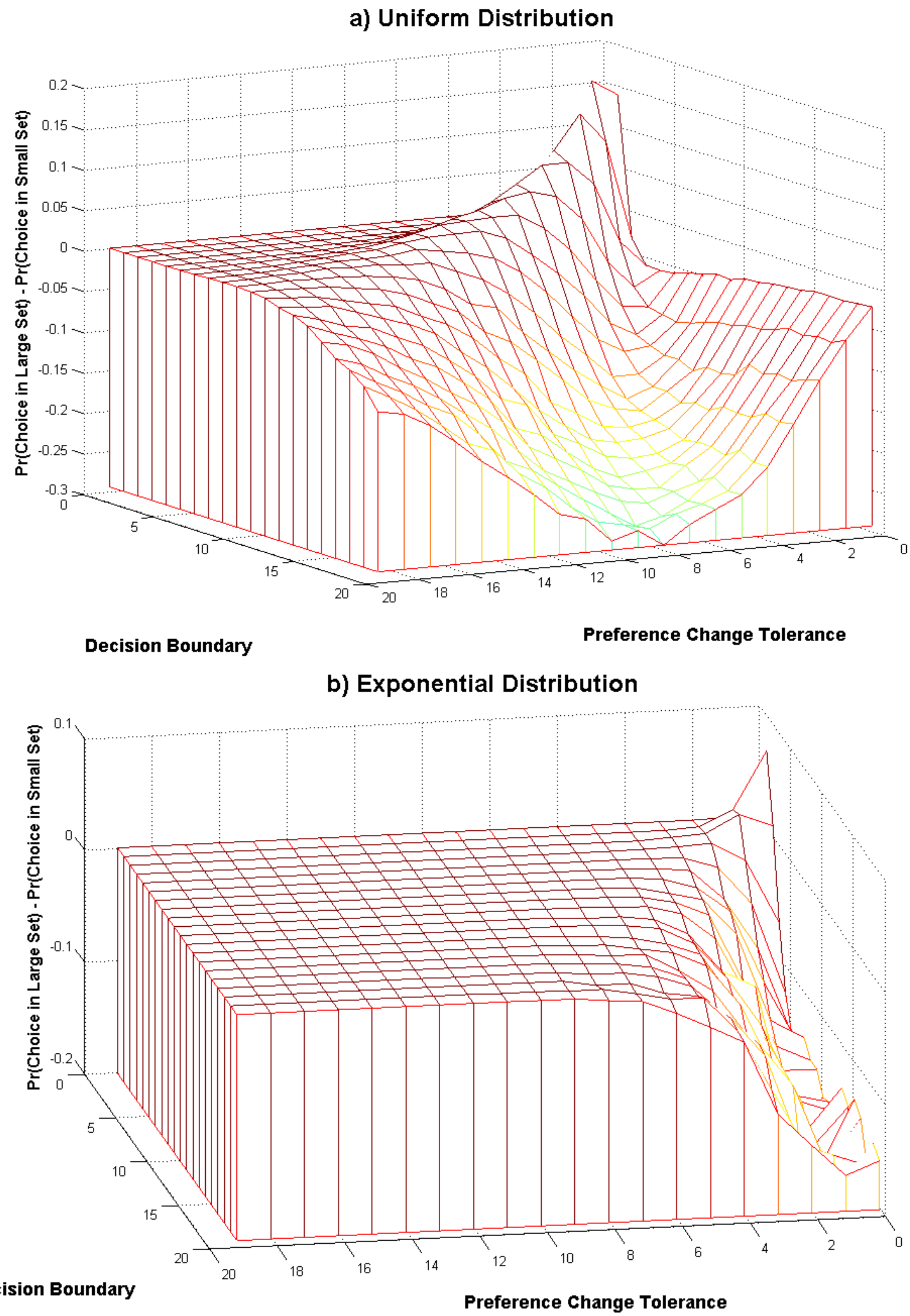
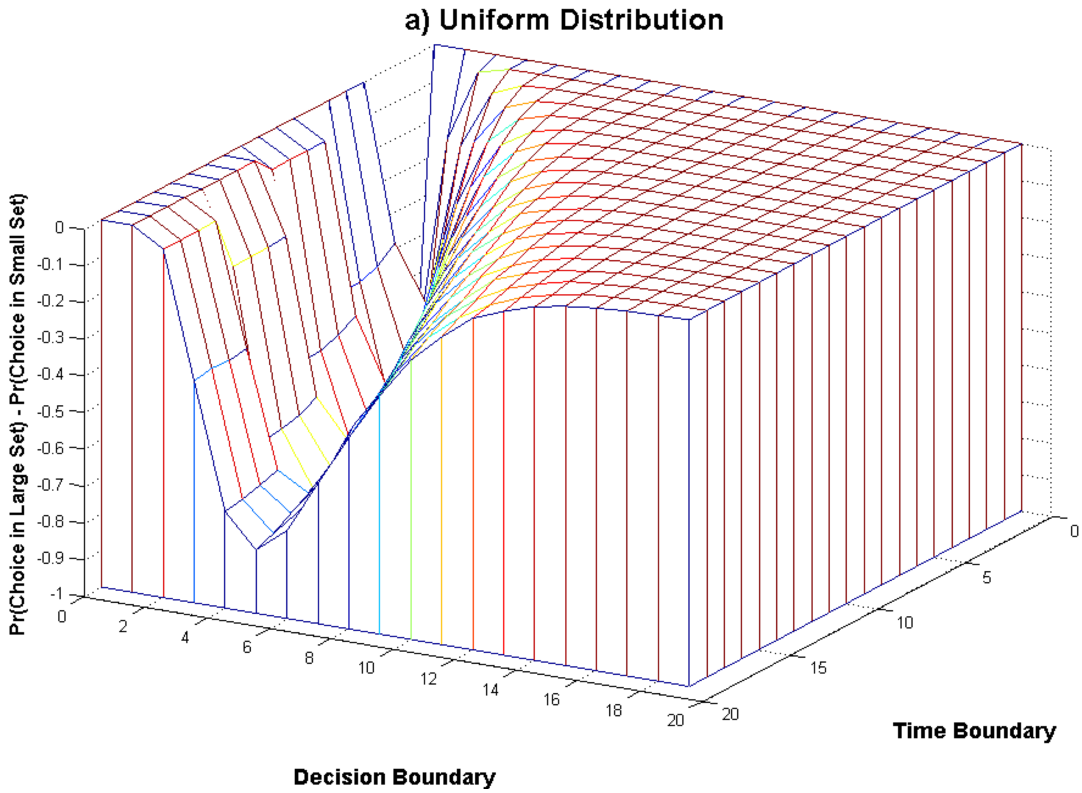

a) Uniform Distribution
Pr(Choice in Large Set) - Pr(Choice in Small Set)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
0
5
10
15
20
20
18
16
14
12
10
8
6
4
2
0
Decision Boundary
Preference Change Tolerance
b) Exponential Distribution
Pr(Choice in Large Set) - Pr(Choice in Small Set)
0.1
0
-0.1
-0.2
0
5
10
15
20
20
18
16
14
12
10
8
6
4
2
0
Decision Boundary
Preference Change Tolerance

Figure 6


a) Uniform Distribution
Pr(Choice in Large Set) - Pr(Choice in Small Set)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
0 2 4 6 8 10 12 14 16 18 20
0 5 10 15 20
Time Boundary
Decision Boundary

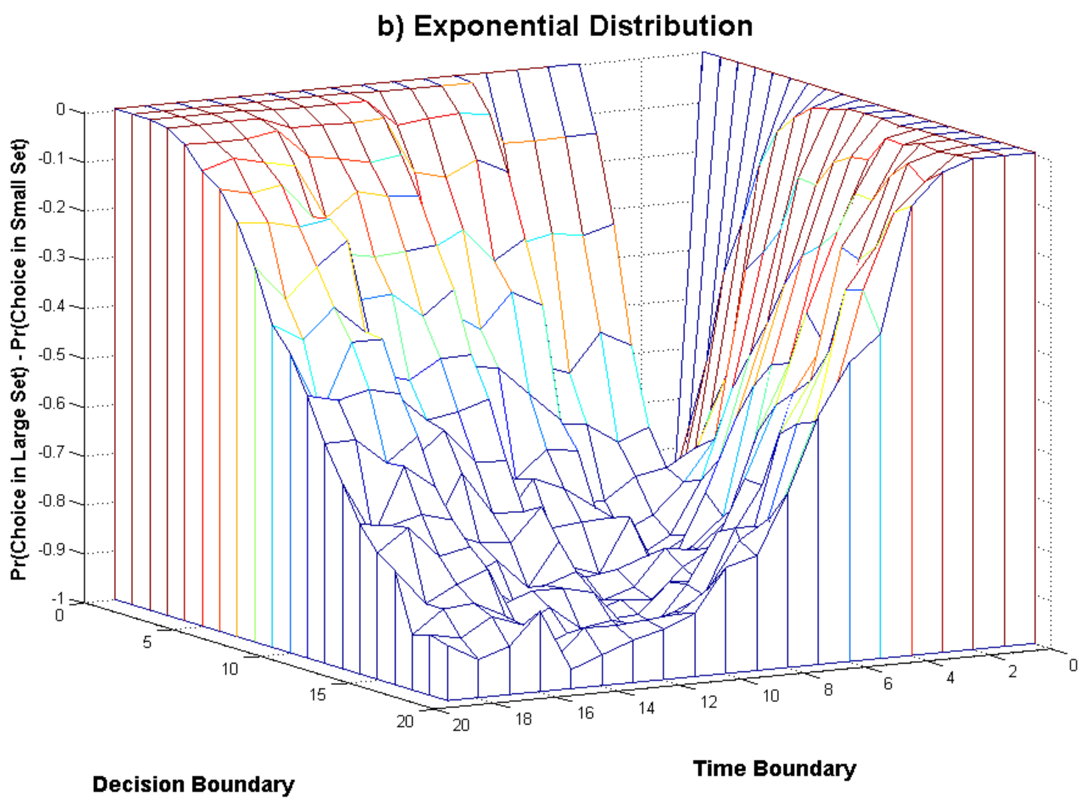
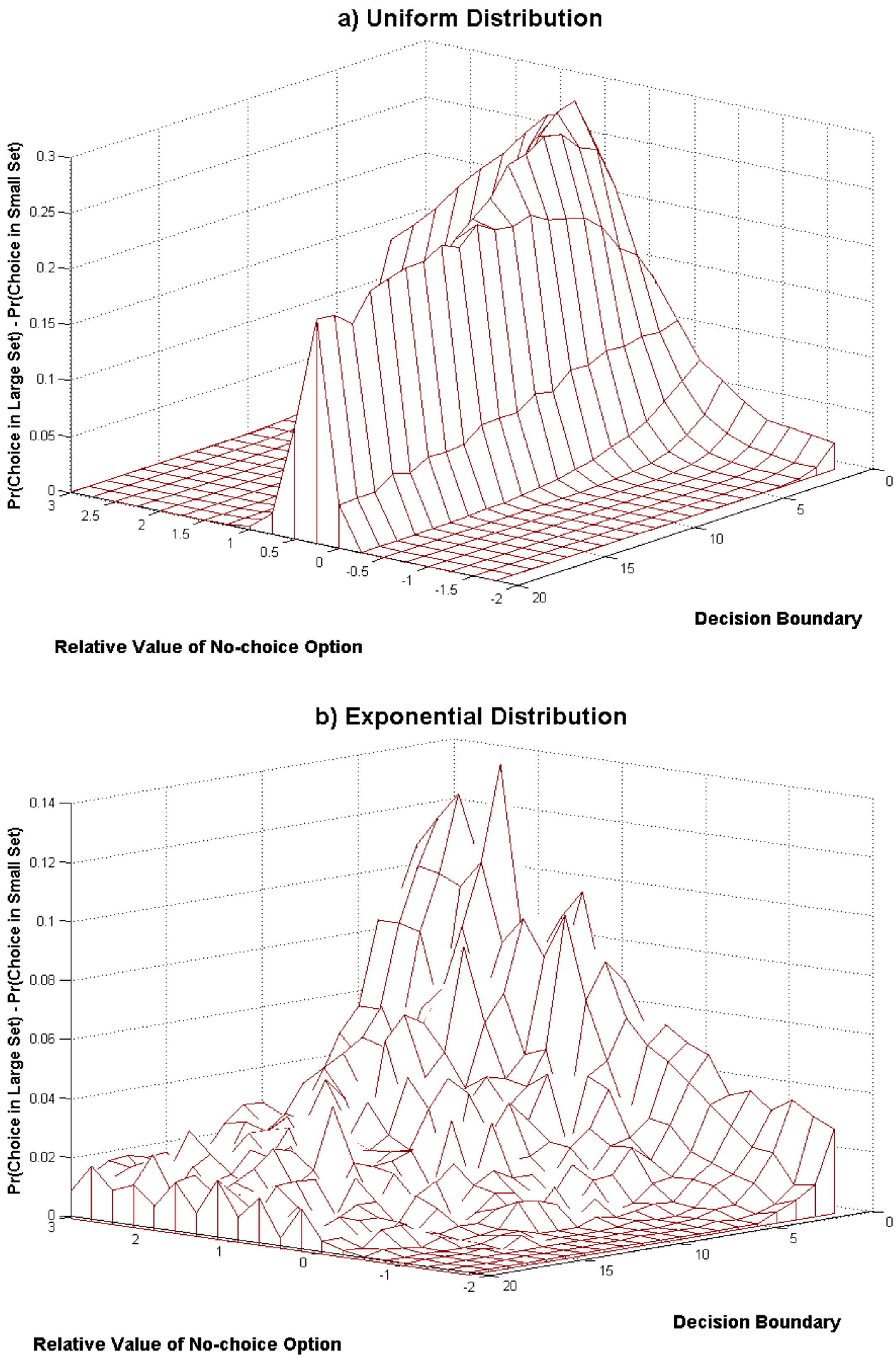

b) Exponential Distribution
Pr(Choice in Large Set) - Pr(Choice in Small Set)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
0 5 10 15 20
20 18 16 14 12 10 8 6 4 2 0
Decision Boundary
Time Boundary

Figure 7


a) Uniform Distribution
Pr(Choice in Large Set) - Pr(Choice in Small Set)
0.3
0.25
0.2
0.15
0.1
0.05
0
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
20
15
10
5
0
Decision Boundary
Relative Value of No-choice Option
b) Exponential Distribution
Pr(Choice in Large Set) - Pr(Choice in Small Set)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
3
2
1
0
-1
-2
20
15
10
5
0
Decision Boundary
Relative Value of No-choice Option