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Seeking Subjective Dominance in Multidimensional Space: An Explanation of the Asymmetric Dominance Effect

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An important example of the influence of context on elicited values and choice is the effect of *asymmetrically dominated alternatives,* first studied by Huber, Payne, and Puto (1982). A theory of dynamic choice reconstruction is presented to account for this effect. The theory is based on ideas of dominance seeking, in which the decision maker actively looks for ways to simplify the task. Results of three experiments showed that the relationship of an irrelevant alternative to others in the choice set influences the weights of the different dimensions as well as the values of the different items. The results support the claim that values depend on local relationships in a way that is consistent with the theory. © 1995 Academic Press, Inc.

When judging options in a choice set, one would hope that the preference ranking of any two will not depend on the presence or absence of additional alternatives. Independence from irrelevant alternatives is a desirable quality for any normative theory because, only when it holds does there exist a single preference ordering. Consider the following example: A person sitting in a restaurant, looking at the dessert menu chooses to have the crême brulée over the tiramisu. Upon learning that the special dessert of the day is an orange sherbet, he then changes his mind and orders the tiramisu. Although the indifference of preference-order to additional alternatives is desirable, it does not always hold. The present research is aimed at theorizing about why it fails. The main idea to be explored has to do with how local context influences the way alternatives in the choice set are evaluated: more specifically, we are concerned with the role of a third, irrelevant, alternative in influencing the relative preference ordering of the two other alternatives in the choice set.

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The notions that are considered important in this paper are the relationship and similarity of the irrelevant alternative to either of the other alternatives in the choice set. Both the relationship and similarity are hypothesized to have a large impact on the choice process as well as the choice outcome.

Huber, Payne, and Puto (1982) introduced a new paradigm, which they called one of *asymmetrically dominated alternatives.* In this paradigm, two distinct items are held constant throughout the different experimental conditions. One item is better on some dimensions and the other better on the others. An example could be an expensive and tasty beer when compared with a cheaper and less tasty beer. When attributes conflict, as they do in this example, then trade-offs are required, and there is no fixed rule for making them. Therefore this kind of problem is considered to be a difficult one to solve, as noted by Payne, Bettman, and Johnson (1992). However it should be noted that people often make choices involving a large number of trade-offs and do so without much noticeable effort. It is the theorizing about such choices that is difficult, not necessarily the choices themselves.

The paradigm of asymmetrically dominated alternatives is one in which the third alternative is constructed so that it is dominated by one of the options but not by the other one. The third alternative is called the *decoy* and since it is constructed to be inferior to one of the other alternatives, it is (almost) never chosen as the best option. However the decoy can influence the choice of other alternatives in the set; hence its name. The effect of the decoy on choice can be assessed by manipulating its characteristics and observing changes in the choice outcome. The asymmetrically dominated alternatives paradigm can be most easily understood with the aid of a graphical representation, as shown in Fig. 1. In this figure (and as convention throughout the paper), capital letters (such as A) represent items or objects. A capital letter followed by a prime (such as A′) stands for an item that is similar to A but inferior to it. Figure 1 shows a relationship in which item A is better than item C on dimension 2 but

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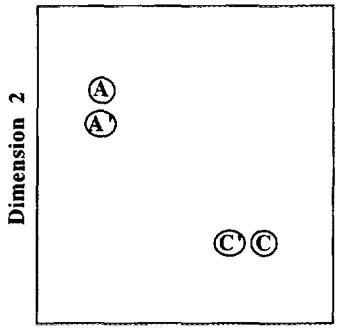

FIG. 1. A graphical illustration of the asymmetrically dominated alternatives paradigm.

is worse on dimension 1. (Hereafter we will use as a convention that the further away a value is from the intersection of the axes the more desirable it is. For example if the attribute is quality than quality increases with distance from the intersection. If the attribute is cost, than cost decreases will distance from the intersection.) Items A′ and C′ are dominated by A and C, respectively, and they are the decoy items. In this paradigm, A′ or C′, but not both, will be added to the choice set on different conditions.

Recently Wedell (1991, 1993) as well as Simonson and Tversky (1992; Tversky & Simonson, 1993) looked more deeply into this phenomenon. Often in these studies, the dominated alternative was not really dominated, but nearly so. One can assume that in such cases, when the relationship is one of near dominance, the representation (perception) might be one of *subjective dominance.* We define subjective dominance as a perceived relationship in which a certain difference on some dimension, although noticeable, is considered unimportant and the values on this dimension are considered to be subjectively equal, while simultaneously all other dimensions are clearly perceived as better for one of the items. Huber and Puto (1983) used decoys that were subjectively dominated and found them to have a similar influence as fully dominated decoys.

Simonson and Tversky studied the asymmetric dominance paradigm under various circumstances and with various experimental designs. Since the results for all the experiments mentioned previously are basically similar, we will describe only one such experiment, conducted by one of us and a colleague (Ariely & Chajut, 1991). In this study subjects were divided into two groups. Group 1 chose between microwave ovens A and B, with microwave A being expensive and of high quality and microwave B being less expensive and of medium quality. The distribution of preferences was 40% to microwave A and 60% to microwave B. Group 2 chose among three microwave ovens A, B and A′, with A′ being very similar in all dimensions to A except for a higher price, which made it obviously inferior to A. The distribution of the preferences this time was 56% to microwave A, 8% to microwave A′ and 36% to microwave B.

Very few people preferred A′. However its addition to the choice list changed the ratio of preference between microwaves A and B. Since this change in preference was caused by the presence of the dominated alternative, it was named the *asymmetric dominance effect* (ADE) by Huber *et al.* (1982). This result is an obvious violation of the normative axiom of independence of irrelevant alternatives: For any item that is an element of set **A** (as a convention from now on we will use bold capital letters to indicate a set of items) when **A** is in turn a subset of **B,** the probability of choosing X from **B** cannot exceed the probability of choosing X from **A.** Formally, for all $X \in \mathbf{A} \subseteq \mathbf{B}$, $P(X;\mathbf{A}) \geq P(X;\mathbf{B})$. This principle is obviously violated in the data just described.

An additional aspect from Tversky and Simonson's experiments (Simonson & Tversky, 1992; Tversky & Simonson, 1993) is that the explanation of this change in choice pattern cannot be in the display itself or in limited knowledge of the alternatives. That is, the phenomenon occurred even when subjects viewed all of the items before the task, and therefore knew all the possibilities.

In their original paper Huber *et al.* (1982) demonstrated the ADE phenomenon but did not test any explanation for it. In the following years two different theories have been developed to account for the ADE. One, which is based on the idea of dimensional weighting, was given by Tversky and Simonson (1993; Simonson & Tversky, 1992). In their "Extremeness Aversion" model, concepts of loss aversion and dimensional range are developed mathematically to account for the aggregated choice data. This theory uses local contrasts instead of overall value and, by adding the assumption of loss aversion, yields a model of rational choice that can account for the ADE.

The other theory, based on the idea of added value, was proposed by Simonson (1989). The idea in an added value approach is that an item's appeal to the decision maker (DM) can increase for reasons other than its dimensional values. Simonson demonstrated that the size of the ADE increased when subjects were told that they would later be asked to explain their choices. From those data he inferred that the dominated alternative gives the DM a simple and justifiable reason for choosing the dominating alternative, and the term "justifiability" was introduced as an explanation for the ADE. One of the main points in this theory is that the structure of the choice problem itself influences the choice process and hence the final choice.

The theory to be presented here draws from both the dimensional weighting and the added value approaches. From the dimensional weighting approach, the theory takes its reliance on the item's values and its relationship to other items. The ideas of limited processing capability and the emphasis on a tight relationship between the structure of the choice problem and the choice process itself, are adopted from the added value approach. It is hoped that the present theory will have the ability to both explain the ADE phenomenon and provide a more general framework for understanding choice behavior.

THE THEORY

The theory is aimed at choice tasks in which no item clearly dominates the other alternatives. Trade-offs are necessary in these cases and the theory specifies how local values and context influence the weighting of the different attributes. In doing so it also explains the ADE.

The decision maker, after observing that no alternative dominates, subjectively reconstructs the choice space. We assume that the DM does not necessarily represent the items according to their original multidimensional value structure (Lichtenstein & Slovic 1971; Shepard, 1964). Rather, with Payne, Bettman and Johnson (1992), we assume that the DM reconstructs the information in a manner that reduces the complexity of the task. There is evidence that the problem-reconstruction is both personality (Beach, 1990) as well as task dependent (Payne, 1982; Payne *et al.*, 1992) We assume that because the items are complex, the decision maker subjectively reduces the number of dimensions and controls the amount of effort in the task (Thomas, 1983). This process is accomplished by collapsing across dimensions to achieve a simpler representation of the different items. The goal of the stimulus reconstruction process is to develop a subjective dominance relationship among the items.

We assume that the choice space is dynamically reconstructed in order to yield subjective dominance (Montgomery, 1987, 1989; Montgomery & Svenson, 1989) and therefore an easy solution to the choice problem. The DM ignores differences on some attributes while enhancing others, so that a clear (subjective) preference relationship emerges. Attributes are combined into a smaller number of dimensions with weights determined according to the local context, such that dimensions that may help the DM solve the problem are weighted more heavily.

How does this process explain the ADE? In order to answer this question consider a concrete example of choosing among microwave ovens, A, A′, and C (cf Fig. 1), as in the Ariely and Chajut (1991) study. We might assume that the DM forms a representation of size, power, durability, etc. and combines them into an imprecise representation of quality. This representation is compared against another important attribute like price. This construction and comparison constitutes the first stage of the process. At this stage of the decision process, if there is no obvious preference between the items, the search for dominance continues and the DM notices that one of the items (A) and the decoy (A′) are similar on this new attribute "quality." Because A is cheaper than A′, there is a subjective dominance relationship between them (at least for some subjects). The other item (C), on the other hand, is distinctly different on the new attribute of quality as well as on price. At this stage the DM observes that price is a dimension that is important for choosing between A and A′ and therefore assigns a greater weight to it, hence changing his or her preference scale.

The experiments described were designed to test the notions introduced by the theory. The central point of the theory is that changes in weights are highly dependent on the similarity relationship among the items. The more similar a set of items is, the easier it is to notice discrepancies among their dimensions, so that observed discrepancies on a given dimension increase its weight.

The theory suggests the following hypotheses,

H1. An obvious preference relationship between two options, A and A′, will make A more appealing in the presence of A′ than in its absence. (This is just a restatement of the basic ADE result.)

H2. The importance of a dimension will increase when the preference relationship is induced by that dimension relative to situations when the preference is due to other dimensions.

H3. Finally, there exists a real and intrinsic value change for the items, associated with their relationship to the decoy.

The following three experiments test each of these three hypotheses, one at a time.

METHOD

Subjects

Eighty subjects were recruited from the introductory psychology pool at the University of North Carolina at Chapel Hill. Twenty of the subjects participated in a pilot study and 60 participated in the main study, each in a single session and in a set order. Each subject first participated in a Value-Setting Experiment, then in a Dimension-Weighting Experiment and finally in an Item-Preference Experiment. Subjects received experimental credit for their time. As a way of motivation in the main study, a reward of $20 was promised to the most accurate subject in the main experiment, determined in a manner to be described below.

THE PILOT STUDY

This study was used to set standards for the payoffs of the main study. Subjects in the pilot study were presented with the same tasks as the subjects in the main experiments, as will be described below, with one major difference. Subjects in the pilot study were asked to answer the questions according to their own values, whereas the subjects in the main experiments were asked to answer according to the majority of the sample in the pilot study. This strategy was used after noticing in previous studies that subjects were fast to dismiss different dimensions with arguments such as "I don't care about dimension X" or "I don't care about cost." In hypothetical scenarios such as these choice experiments, subjects could use such strategies to reduce the complexity of the problem. The hope was that by asking them to predict the behavior of a known sample of people, and by offering them a payoff that depends on their performance, they would not use such a strategy. The average answer (over all experimental conditions) in the pilot study was calculated for each question and a sum of all absolute deviations from the average answers for each subject in the main study as a measure of correctness. The main-study subject with the smallest overall absolute deviation was awarded $20.

THE MAIN STUDY

The main study consisted of three experiments. The experiments are now described in a sequence easiest to understand. They were conducted in the reverse order.

Experiment 1: Item Preference

The choice items. Five different types of products were used: bicycles, microwaves, TVs, running shoes, and computers. For each of these product categories, three items were presented to the subjects on each trial. Three dimensions, price, and two others were used in the experiment. We used three rather then two attributes, which is the more common, to minimize the possibility that DMs will simply compare and trade off a pair of ratios. The values used for Item A were taken from a consumer magazine and other newspapers. Item A was fixed throughout the experiment. Item C was also constant and was created by fixing its values as certain percentages of the values on item A, ranging from 45 to 70%.

The two experimental conditions were created by constructing two versions of item B, one similar but inferior to A (A′) and the other similar but inferior to C (C′). The two conditions were made in the following way: In condition 1A item B was made similar and less preferable to item A by making one of its dimensions (dimension 1), substantially less appealing. This was done by setting the value of dimension 1 of item B to 40% or 50% of the corresponding value in A for positive dimensions, and 140% or 150% for negative dimensions. The two other dimensions (2 and 3) were made more appealing for item B than for item A by setting their values to 110% of the corresponding values in A for positive dimension, and 90% for negative dimensions. The aim was to create a preference relation between items A and B in which dimension 1 is strongly better in item A and dimensions 2 and 3 are weakly better in item B. This condition is called 1A since dimension 1 was the source of the largest discrepancy between items A and B. Condition 1C was made in a similar way to condition 1A, only this time item B was made similar and inferior to item C, again due to the large difference in dimension 1 favoring C, and a smaller difference on dimensions 2 and 3 favoring item B. For the values used in this experiment see Table 1.

Procedure. Subjects were seated in front of a Macintosh computer and the choice task was explained. Up to four subjects ran simultaneously in a large room sitting far apart. Subjects were told that like in the TV game, Family Feud, they were to answer the questions in the same way that the average of a sample did. Subjects were told that they would be rewarded on the basis of accuracy relative to this sample. The instructions appeared again on the computer screen prior to the beginning of the experiment. Subjects were told the following: "You have one hundred points and you are given information about three products. Please assign

TABLE 1
Descriptions of All Items Used for the Item-Preference Experiment and for the Five Different Item Categories

Products	Dimensions	Item A	Item C	Item B: B/1A (A′)	Item B: B/1C (C′)
Microwaves	Price ($)–	380	209	532	292.6
	Capacity (ft^3)+	1.8	1.2	2	1.3
	Wattage (W)+	1000	700	1100	770
Running shoes	Comfort+	8.5	5.5	5.1	3.3
	Durability+	6.8	4.4	7.5	4.9
	Price ($)–	90	58.5	81	52.7
Computers	Speed (Hz)+	33	21.5	16.5	10.8
	Memory (MB)+	8	4.4	8.8	4.8
	Price ($)–	1900	1235	1710	1111.5
TVs	Screen size (in)+	20	14	12	8.4
	Price ($)–	650	357.5	585	321.8
	Wattage (W)+	25	15	27.5	16.5
Bicycles	Price ($)–	400	180	560	252
	Weight (LB)–	15	22.5	13.5	20.3
	Wheel base (in)+	52	36.4	57.2	40

Note. Dimensions without units were used on a scale from 0 to 10, where 10 was the most desirable level. The plus and minus signs next to the dimensions indicate the direction of the dimensions, as it was presented to the subjects in the information booklet.

these point in a way that the number of points reflects their relative preference in the population. Do it in a way that a higher number indicates a higher preference and give two items the same amount of points only if you think they are equally as appealing to the sample. All points must be used." Subjects were also given a small brochure with descriptions of the choice items and a detailed description of the dimensions and their meaning. The information appeared on the computer screen as a 3 × 3 matrix with the items as columns and the dimensions as the rows (see Fig. 2 for a typical screen). Subjects were instructed to use a mouse and the buttons at the bottom of the screen to adjust the values that describe the relative overall appeal of each item such that the weights summed to 100. Subjects were asked to raise their hand if they encountered any difficulty during any stage of the experiment.

Results. The purpose of this experiment was to test whether the relative preference values of items A and C would be affected by their relationship to item B. The hypothesis was that item A would be given a higher preference rating (relative number of points) in condition 1A then in condition 1C and the converse would be true for item C. In separate 2 × 2, conditions (1A versus 1C) by item (A versus C), designs for each of the product types, significant interactions were taken as an indication that the preference relationship had changed between the two conditions. Significant interactions in the expected directions were observed for running shoes, $F(1,116) = 18.36$, microwaves, $F(1,116) = 7.56$, both $p < .01$; and TVs, $F(1,116) = 4.922$, $p = .03$. The interactions were not significant for bicycles, $F(1,116) = 1.02$, $p = .31$, or computers, $F(1,116) = 0.84$, $p = .36$. These results can be seen in Fig. 3.

In this experiment it was not just the presence of an interaction that was important but its specific shape and the simple effects. According to the predictions, Item A was expected to receive a higher rating in condition 1A than in condition 1C, and this prediction was verified for all items except the computers. The opposite statement that item C would receive a higher rating in condition 1C than in condition 1A was verified for all items except the bicycles.

Discussion. In this study the ADE was observed for three of the five product categories. This is by no means a surprising result. It only demonstrates that the effect can be observed with relative weights and not just with choice. Having demonstrated that the stimuli used can produce the ADE, we now move to the next experiment in which the theory presented is first tested.

Experiment 2: Dimension-Weighting

The choice items. Items A and C were identical to those in the Item-Preference Experiment, but Item B was manipulated in a different way. Condition 1A was identical to that in the previous experiment. Two additional conditions, 2A and 3A, were also used. These conditions were similar to condition 1A, but the preference relationship was due to dimensions 2 and 3, respectively. For the values used in this experiment see Table 2.

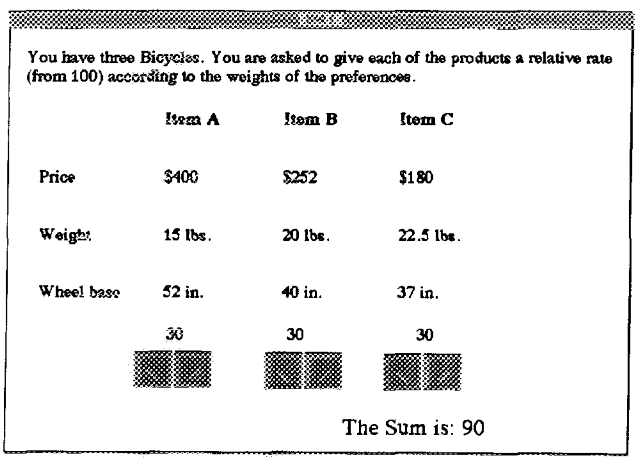

FIG. 2. A sample screen that was presented to the subjects in the Item-Preference Experiment. By clicking on the push-buttons below each of the items, subjects controlled the weight given to each item and the number changed accordingly. Initial weights (30 for each item) did not sum to 100 so that the subject was forced to adjust the weights. The subject could not continue to the next task unless the sum of the weights equaled 100.

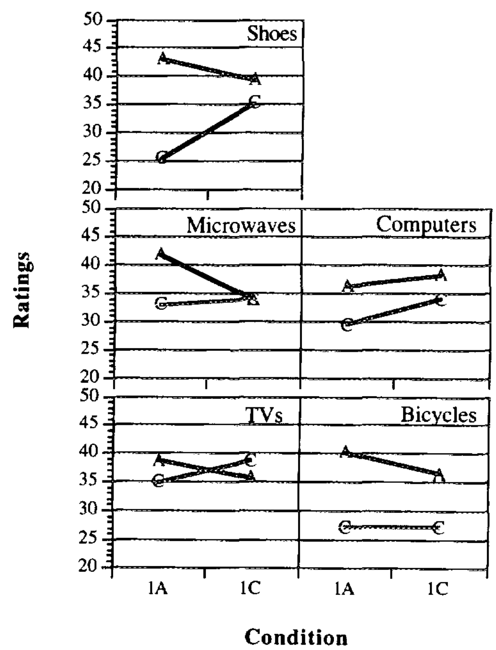

FIG. 3. Ratings of items A and C in condition 1A and 1C separately for each of the products in the Item-Preference Experiment.

TABLE 2

Descriptions of All Items Used for the Dimension-Weighting and Value-Weighting Experiments

Products	Dimensions	Item A	Item C	%	B/1A	B/2A	B/3A
Microwaves	Price ($)–	380	**209**	55	342	342	342
	Capacity (ft^3)+	1.8	1.17	65	2	1.1	1.98
	Wattage (W)+	1000	700	70	1100	1100	600
Running shoes	Comfort+	8.5	**5.5**	65	5.1	9.4	9.4
	Durability+	6.8	4.42	65	7.5	3.4	7.5
	Price ($)–	90	58.5	65	81	81	126
Computers	Speed (Hz)+	33	**21.5**	65	16.5	36.3	36.3
	Memory (MB)+	8	4.4	55	8.8	4	8.8
	Price ($)–	1900	1235	65	1710	1710	2850
TVs	Screen size (in)+	20	**14**	70	12	22	22
	Price ($)–	650	357.5	55	585	910	585
	Wattage (W)+	25	15	60	27.5	27.5	15
Bicycles	Price ($)–	400	**180**	45	560	360	360
	Weight (LB)–	15	22.5	50	13.5	21	13.5
	Wheel base (in)+	52	36.4	70	57.2	57.2	31.2

Note. For the Value-Setting Experiment, the value of c_1. (marked in boldface) was missing and this was the value the subject was asked to set. Dimensions without units were used on a scale from 0 to 10, where 10 was the most desirable level.

Procedure. Subjects were told the following: "You have one hundred points and you are given information about three products. Please assign these points in a way that the number of points reflects the relative importance of these dimensions when choosing one of the products. Again you are asked to indicate the importance of the different dimensions on the choices made by the sample. Do this in a way that a high number indicates a higher preference and give two dimensions the same amount of points only if you think they are equally important. You must use all the points." The setting and the display structure were very similar to the Item-Preference Experiment, the only difference being that subjects entered numbers at the end of each row to describe the importance of the different dimensions.

Results. This experiment tested the hypothesis that the observed change in proportion of choice associated with the ADE is due to a change in the weightings of the different dimensions. More specifically, the hypothesis is that a dimension will get the largest weight when the preference between the similar items (A and B) are due to that dimension. The experimental predictions are that dimension 1 will get a higher weight in condition 1A than in conditions 2A and 3A, dimension 2 will get a higher weight in condition 2A than in conditions 1A and 3A, and dimension 3 will get a higher weight in condition 3A than in conditions 1A and 2A. To test this hypothesis, a Student-t test was conducted for each of the three conditions comparing the hypothesized "heavier" dimension to the two "lighter" dimensions. Generally speaking, as can be seen in Fig. 4, most results were significant, (for the test statistics, see Table 3) but even more important is

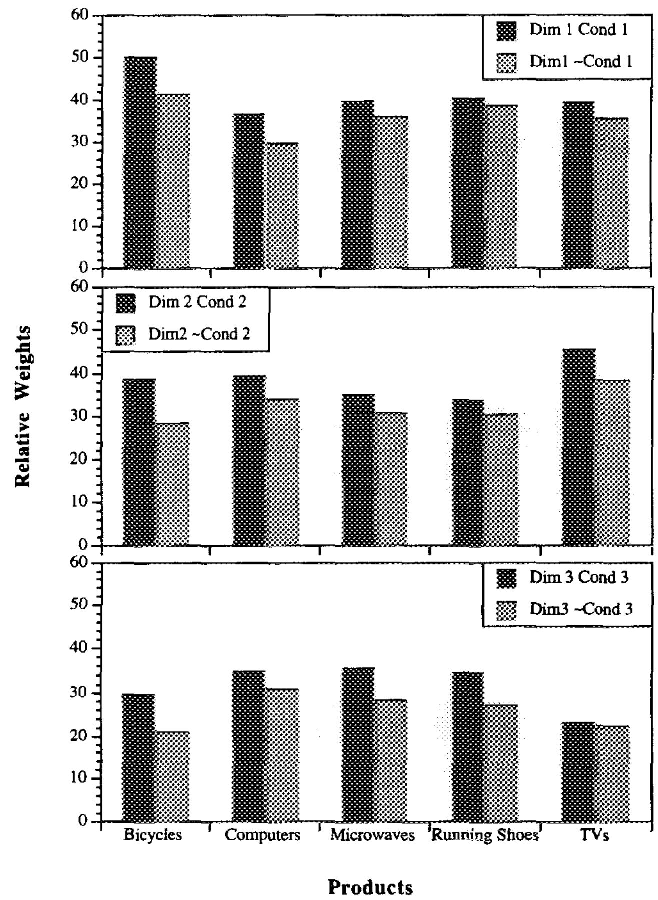

FIG. 4. Weights for each of the dimensions under the condition that a dimension was responsible for the preference relationship between items A and B, compared with the conditions when this dimension was not responsible for the preference relationship.

TABLE 3
One-Tailed *t* Tests for the Dimension-Weighting Experiment

Products	*t* Value	*p* Value (based on $df = 58$)
For dimension 1 in condition 1A vs 2A and 3A		
Bicycles	$t = 9.70$	$p < .01$
Computers	$t = 1.96$	$p = .03$
Microwaves	$t = 4.21$	$p < .01$
Running shoes	$t = 6.78$	$p < .01$
TVs	$t = 3.26$	$p = .01$
For dimension 2 in condition 2A vs 1A and 3A		
Bicycles	$t = 2.28$	$p = .01$
Computers	$t = 4.26$	$p < .01$
Microwaves	$t = 0.99$	$p = .16$
Running shoes	$t = 0.23$	$p = .41$
TVs	$t = 6.78$	$p < .01$
For dimension 3 in condition 3A vs 1A and 2A		
Bicycles	$t = 1.94$	$p = .03$
Computers	$t = 0.97$	$p = .17$
Microwaves	$t = 1.58$	$p = .06$
Running shoes	$t = 0.54$	$p = .30$
TVs	$t = 7.55$	$p < .01$

the fact that all the results were in the predicted direction.

Discussion. Results from this experiment showed that subjects assigned weights to the different dimensions in a way that was sensitive to the source of the preference relationship between A and B (A′). Namely, higher weights were given to the dimension that caused this preference relationship. However, one of the problems with such an experiment is that it is hard to known whether subjects first made a choice and then assigned the weights according to the choice they had already made or whether the weight assignment was carried out with no choice process. The next experiment was designed to look at this problem.

Experiment 3: Value-Setting

The choice item. Choice items were the same as in the Dimension-Weighting Experiment, including conditions 1A, 2A, and 3A, except that one value in the 3 × 3 matrix was missing. The missing value was always the value of the first dimension on item C (top right hand corner of the screen).

Procedure. Subjects were asked to set the value of the missing cell for item C (in a way that matches the values set by the sample) in order to make item C, as a whole, as appealing as item A. In order for the subjects to get a better understanding of the task, the following example was given to them: Imagine that we have two cars, one is an expensive luxury car like a Jaguar and the other is a simple small car like a Ford Escort. For this example, we are going to consider only three attributes of the cars, cost, performance and prestige. It is obvious that the Jaguar costs more and has better performance and a higher prestige associated with it, but which car do you prefer? If the Ford Escort is very cheap, say $10, most people would prefer it rather than spend $60,000 for a Jaguar. On the other hand if the price of the Ford Escort was $50,000 it is likely that most people would prefer to spend the difference and get a much better car. Somewhere between $10 and $50,000 there is a point that makes these two cars, as distinct as they are, have a similar overall appeal. You are asked to indicate what is the value of this point for the sample population.

Theory. This experiment complements the Dimension-Weighting Experiment. According to the theory, the process of reconstructing the items and their values depends to a large extent on the local context of the choice. Not only does the importance of the different dimensions depend on their contribution to solving the problem, but there is a real change in the value of the item as a function of its relationship to other items. This experiment was done under the three conditions 1A, 2A, and 3A. The hypothesis tested in the Dimension-Weighting Experiment was that dimension 1 would be more heavily weighted in condition 1A than in conditions 2A or 3A. The hypotheses in the current experiment was that the missing value of dimension 1 of item C would be set to a higher utility value in condition 1A compared with conditions 2A or 3A, under specified values of the other two dimensions. This prediction follows from an additive representation of the theory and is derived in the Appendix.

Results. The mathematical development of the weighted additive model (WAM) in the appendix showed that the conditions necessary for a specific prediction were met in only three cases. All three were ones in which a positive dimension was set in comparison with a negative one. The predictions of the model were that the utility value of dimension 1 of item C (c_{11} in the Appendix) will be set higher in condition 1A than in 2A or 3A (c_{12} and c_{13}). Looking at Table 4, the only tasks that had the constrained structure needed by the WAM are marked with a minus sign in the third column. The fourth column of Table 4 shows the mean difference of the set values $c_{1.}$ under the different conditions. The differences that were predicted by the WAM were not observed. In fact, the results were in the opposite direction. It is notable that all values were affected in the same way by the manipulation.

Comparing the value that was set by the subjects for $c_{1.}$ under condition 1A to that set in condition 2A or in condition 3A with a Fisher's PLSD (protected least significant difference test) for each of the choice item cat-

TABLE 4

The Relationship between the Predictions of the Weighted Additive Model (WAM) for the Value-Setting Experiment and the Difference between Values Set for $c_{1.}$ in Condition 1A vs 2A and 3A, Respectively

Products	Dimensions compared	a_i-c_i	Difference	Predicted by the WAM?
Bicycles	Price ($) vs Weight (LB)	+	−28.65	?
Bicycles	Price ($) vs Wheel base (in)	+	−76.75	?
TVs	Screen size (in) vs Price ($)	−	−9.75	No
TVs	Screen size (in) vs Wattage (W)	+	−12.7	?
Microwaves	Price ($) vs Capacity (ft^3)	+	−57.05	?
Microwaves	Price ($) vs Wattage (W)	+	−85.95	?
Running shoes	Comfort vs Durability	+	−1.88	?
Running shoes	Comfort vs Price ($)	−	−1.25	No
Computers	Speed (Hz) vs Memory (MB)	+	−5.2	?
Computers	Speed (Hz) vs Price ($)	−	−3.9	No

Note. Only three comparisons were sufficiently constrained to be predicted by the model. None of the observed differences were in the direction predicted by the model.

egories, 9 out of the 10 tests were significant (all but the comparison of price and weight for the bicycles). The results show that values for $c_{1.}$ were always set to a lower level under condition 1A compared with either condition 2A or condition 3A, regardless of the relationship between the utility and the value of the dimension. In other words, looking at the value of the set dimensions under the different conditions, the value was always physically lower under condition 1A, regardless whether the dimension was positive or negative.

Discussion. The current experiment completes the final stage necessary for the theory. From the data of this experiment it is clear that not only is there a shift in the weights given to the different dimensions, but this shift is a predecision process and not a postdecision justification.

GENERAL DISCUSSION

The task used in all three main experiments was to predict the behavior of a specific population. This task was used so that there would be an objective criterion for performance as well as to encourage subjects to think harder about the choice problems. One can ask whether the framing of the question can have caused changes in response strategy. We would like to argue that this is unlikely to have occurred. First, the result of the Item-Preference Experiment is very similar to other (choice based) results. In addition, the data of the pilot experiment are in the same direction. (Because they were based on very few subjects, the pilot data are not presented here.) To conclude this point, we believe that subjects used themselves as reference points when judging how other students would respond.

The goal of the present research was to present a general theory for understanding how DMs solve choice problems. Within this theory certain predictions regarding the ADE were presented and tested. The main point of our approach is that the decision process is an active one in which subjective values are dynamically generated and compared. The notion of seeking subjective dominance was introduced as one way to reduce the difficulty of comparisons. We assumed that choice situations are intrinsically vague because DMs lack knowledge and the ability to compare complex multi-dimensional objects. The idea that stimuli are actively restructured in the search for subjective dominance was applied to the ADE phenomenon, in which choice between two objects is manipulated by their relationship to irrelevant alternatives. The aim of this research was to see whether this approach could provide a possible explanation for the ADE.

The Item-Preference Experiment did not reflect a new phenomenon. Its only purpose was to demonstrate the existence of the ADE with the specific values chosen, and with the use of preference ratings rather than choice. In this experiment three out of the five items showed the expected interaction pattern, and none showed unexpected interactions. It is possible that only a part of the data showed the desired pattern because the advantage relationship was manipulated as preference and not as dominance, which is more subtle and not as pronounced as in previous experiments.

The Dimension-Weighting Experiment showed, as suggested by the theory, that the importance of the different dimensions changes as a function of the source of the preference relationship among the items. The expected result in this experiment was that dimension importance would change over the three conditions as a function of which dimension caused the preference between the two similar items. The main point here is that since DMs lack knowledge about the decision domain, and have no rules about dimension weightings and relationships, they use local context in order to assign the relative importance to the different dimensions. They do so by assigning larger weights to dimensions that can differentiate among similar items. From this experiment it is clear that the local context influenced the weighting of the dimensions and that it did so as predicted. That is, a dimension that carried a large difference, which allowed simple and easy discrimination between the items, was more heavily weighted. This view is well in line with the dominance searching ideas. It seems, then, that the ADE can be associated with changes in the weighting of the different dimensions.

After establishing a change in the importance of the dimensions as a function of their role in solving the choice problem, we concerned ourselves with the cause and basis for this change. There are two classes of such explanations. The first class does not involve a real value change; rather, the changes in the weights of the different dimensions are attributed to either the cognitive miser concept or to accountability (Simonson, 1989). From this perspective, changes in the importance of the different dimensions are only a part of the effort to simplify the choice problem and are not associated with real value changes to the dimensions or the product as a whole. The other class of possible explanations, which is closely related to the theory, says that due to the vagueness of the dimensions the decision makers have no direct access to their values or to the relationship among dimensions. Therefore DMs use the context as a starting point to evaluate the different alternatives and to assign them values. This second approach is more optimistic since it considers the ADE not as another violation of rational thinking, but instead as a valid use of information in an uncertain situation.

The Value-Setting Experiment attempts to distinguish these two classes of explanations. The results indicate that, overall, item values were sensitive to the dimension that determined the preference relationship between the comparison item (A) and the irrelevant item (B). That is, real value changes occurred as a function of the experimental conditions.

We formalized the notions described above as a simple weighted additive model (WAM) with context sensitive weights for the purpose of making predictions in the Value-Setting Experiment. Due to limited constraints of the WAM, specific predictions were made for only three out of ten cases, in which the fixed dimensions were negative. The predictions were that $c_{1.}$ would be set to a higher utility value under condition 1A than under conditions 2A or 3A. In all three cases the data were opposite to the predictions. It is worth noting that in all cases, subjects set lower values under condition 1A than under 2A or 3A, regardless of whether these lower values represented higher or lower utilities. Setting $c_{1.}$ to always have lower values under condition 1A than under conditions 2A and 3A means that when the preference relationship was due to dimension 1 versus 2 or 3, item C was set to an overall higher level of desirability for negative dimensions and to an overall lower level of desirability for positive dimensions. It is unlikely that any WAM could account for such conflicting results between positive and negative dimensions.

To summarize, the results of the three experiments are consistent with the assumption that weights and subjective value and hence preferences are constructed during the choice task in a manner that is sensitive to the specific characteristics of the irrelevant alternatives. Moreover it seems that subjective dominance plays an important role in this process, in a way that dimensions that can help the DM discriminate among items get a higher weight. These changes in weights are not just a postdecision process, but they are essential in the construction of the value of the item itself, as was suggested by the Value-Setting Experiment. When the weighted additive model yielded precise predictions in the Value-Setting Experiment, the results were in the opposite direction. However, the surprising pattern of the data, namely that positive and negative dimensions were consistently set in the same physical direction (opposite utility directions) suggest that the model might fail generally. Wedell (1993) also found the WAM to be an insufficient explanation of the ADE. The model suggested by Tversky and Simonson (1992, 1993) seems to be a more general case of the WAM than the one presented here, and thus might account for some of the data patterns. However, that model is so general that it might better be viewed as a framework within which specific constraints can be proposed and tested.

APPENDIX

We derive the predictions of a weighted additive model here for the comparison between conditions 1A and 2A. (That between conditions 1A and 3A is analogous.)

Conditions 1A and 2A differ in terms of item B's dimension 1 and 2 values; dimension 3 is constant over both conditions. Therefore, we assume that the weight of dimension 3 is constant, but that of dimensions 1 and 2 differ over the two conditions. Let w_{ij} be the weight of dimension i in condition j, $i = 1,2, j =$ 1A, 2A, and w_3 be the weight of dimension 3 in either case. Also let c_{11} and c_{12} be the utility of the dimension 1 value of item C set by the subject on conditions 1A and 2A, respectively, such that he or she is indifferent between A and C. Let a_i and c_i be the utility of the fixed attribute values i, $i = 2,3$. In this way we can write for the two conditions,

$$(1)\ w_{11}a_1 + w_{21}a_2 + w_3a_3 = w_{11}c_{11} + w_{21}c_2 + w_3c_3$$
$$(2)\ w_{12}a_1 + w_{22}a_2 + w_3a_3 = w_{12}c_{12} + w_{22}c_2 + w_3c_3$$

Subtracting equation 2 from 1 and rearranging terms gives,

$$(3)\ w_{11}(a_1 - c_{11}) - w_{12}(a_1 - c_{12}) = (w_{22} - w_{21})(a_2 - c_2)$$

Note that by design (and confirmed by the results of the Dimension-Weighting Experiment) $w_{22} > w_{21}$ and $w_{11} > w_{12}$. Therefore, if $a_2 \leq c_2$, than the right hand side of Eq. (3) is no greater than 0, and $(a_1 - c_{11}) \leq (a_1 - c_{12})$. Therefore c_{11} is predicted to be greater than c_{12}. When $a_2 > c_2$, no clear prediction can be made regarding the relative magnitude of c_{11} and c_{12}. For small positive differences of $a_2 - c_2$, c_{11} would be greater than c_{12}, but for some positive difference values, the prediction would be reversed.

To summarize the derived prediction and extend it to the comparison of conditions 1A and 3A: when dimension 3 is constant over conditions (condition 1A versus 2A), c_{11} will be greater than c_{12} whenever $a_2 \leq c_2$. Similarly, when dimension 2 is constant over conditions (conditions 1A and 3A), c_{11} will be greater than c_{13} whenever $a_3 \leq c_3$. Recalling that we are operating in utility space (so that smaller prices have greater utility), there are only three conditions (TVs, running shoes, and computers) in which comparisons are predicted by the weighted additive model (WAM). Note that predictions were possible only when the compared dimension (i.e., the one that was fixed) was price.

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