

AD-A101 132

DUKE UNIV DURHAM NC GRADUATE SCHOOL OF BUSINESS ADMI--ETC F/6 12/1
ADDING ASYMMETRICALLY DOMINATED ALTERNATIVES: VIOLATIONS OF REG--ETC(U)
JUL 81 J HUBER, J PAYNE, C PUTO N00014-80-C-0114

UNCLASSIFIED

TR-81-2-ONR

NL

1 of 1
AD-A
101 132



END
DATE
FILMED
7-81
DTIC

LEVEL

7.2

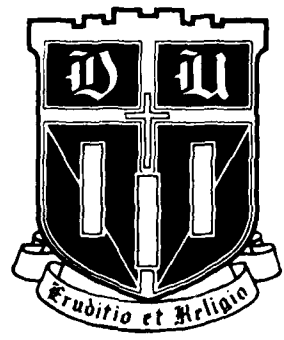
AD A101132

GRADUATE SCHOOL OF
BUSINESS ADMINISTRATION

DTIC FILE COPY

DTIC
JUL 7 1981

A



Duke University
DURHAM, NORTH CAROLINA

This document has been approved
for public release and sale; its
distribution is unlimited.

81 7 07 001

ADDING ASYMMETRICALLY DOMINATED
ALTERNATIVES: VIOLATIONS OF
REGULARITY & THE SIMILARITY HYPOTHESIS

Joel Huber, John W. Payne

Chris Puto

ONR Technical Report 81-2

July 1981

Office of Naval Research Contract N00014-80-C-0114 ✓

John W. Payne, Investigator

Duke University

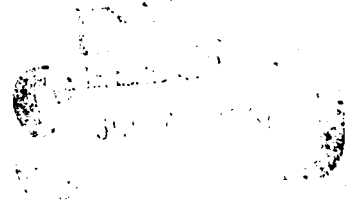
REPRODUCTION IN WHOLE OR IN PART IS PERMITTED FOR ANY PURPOSE

OF THE UNITED STATES GOVERNMENT

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

| | |
|-------------------|---------|
| SEARCHED | INDEXED |
| SERIALIZED | FILED |
| JUL 1981 | |
| FBI - [illegible] | |

A



SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|-------------------------------------|--|
| 1. REPORT NUMBER 81-2 | 2. GOVT ACCESSION NO. AD-A101132 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) Adding Asymmetrically dominated alternatives: Violations of regularity & the similarity hypothesis. | | 5. TYPE OF REPORT & PERIOD COVERED Technical Report |
| 7. AUTHOR(s) Joel Huber, John Payne, and Chris Putc | | 6. PERFORMING ORG. REPORT NUMBER |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Fuqua School of Business Duke University Durham, North Carolina 27706 | | 8. CONTRACT OR GRANT NUMBER(s) N00014-80-C-0114 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Engineering Psychology Programs Office of Naval Research (Code 455) Arlington, VA | | 10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS NR 197-063 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 12. REPORT DATE July 1981 |
| | | 13. NUMBER OF PAGES 31 |
| | | 15. SECURITY CLASS. (of this report) SECRET |
| 16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution is unlimited | | 15a. DECLASSIFICATION DOWNGRADING SCHEDULE |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) | | |
| 18. SUPPLEMENTARY NOTES | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Task Effects Consumer Bahvior Choice Models Dominance Similarity | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) An asymmetrically dominated alternative is one that is dominated by one item in the set but not by another. It is shown that the addition to a choice set of such an alternative can increase the probability of choosing the item that dominates it. This result points to the inadequacy of many current choice models and suggests product line strategies that might not otherwise be intuitively plausible. | | |

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE
S/N 010-104-1001

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ADDING ASYMMETRICALLY DOMINATED ALTERNATIVES:
VIOLATIONS OF REGULARITY AND THE SIMILARITY HYPOTHESIS

One of the most important issues in marketing is understanding how the introduction of a new brand into a market will be reflected in choice probabilities or market shares. A standard model that is used in such situations is to assume that a new offering will take from others in proportion to their original shares. This assumption of proportionality is incorporated in the Luce (1959) model of choice and is central to a number of models of consumer behavior. For example, Pessemier et. al. (1971) and Reibstein (1978) use this assumption as a basis for transforming affect scores into choice probabilities for soft drinks, while Silk and Urban (1978) use a similar method to predict share for packaged goods. The assumption has also been central to models of college choice (Punj and Staelin 1978), in transportation mode choice (McFadden 1974), and in other models of consumer choice.

It is not hard, however, to construct situations in which the assumption of proportionality fails (Debreu 1960; McFadden 1974). Generally there is agreement that a new product takes disproportionately more share from those similar to it than from dissimilar items. This idea, which has come to be called the similarity hypothesis (Tversky 1972), is reflected in the managerial belief that one can minimize cannibalization by designing a new product to be as dissimilar from the firm's current offerings as possible. The similarity hypothesis has served as a basis for a number of alternative theories of choice (Tversky 1972; Hausman and Wise 1978; Batsell 1980; McFadden 1980). These models are increasingly being used to aid marketing managers making marketing entry decisions (e.g., Urban, Johnson and Brudnick 1981).

While substantially different in their underlying assumptions, the Luce choice model and the proposed revisions do share a common assumption that the addition of a new alternative cannot increase the probability of choosing a member of the original set. This condition, called regularity, is a necessary condition for the validity of most probabilistic choice models and has been generally found to hold empirically.

This paper will show that both the similarity hypothesis and the regularity condition can be consistently violated by the addition of an asymmetrically dominated alternative. An alternative is "asymmetric" if it is dominated by at least one alternative in the set but is not dominated by at least one other. We show that the addition of such alternatives increases the share of the item that dominates it, thus violating regularity. Furthermore, since the new alternative is typically closest to the item that dominates it, this result implies that the new alternative set "helps" the items closest--a reversal of the similarity hypothesis which would predict the opposite.

If accepted, the results are important managerially, theoretically and empirically. Managerially, the results imply the counter-intuitive conclusion that there are times when profitability of a product line can be increased by adding a (dominated) alternative that virtually no one ever chooses. The unexpected result is due to the fact that the function of the dominated alternative is to draw attention to a more profitable item rather than to generate direct sales. Theoretically, the results indicate that there is a limit to the range of applicability of most discrete choice models--that the models will either have to be modified to accept the distortion of dominated items or limited in their range to pareto-efficient subsets. Notice this

last restriction rules out most orthogonal designs. Finally, the results have implications for those who empirically estimate the similarity effect (e.g., Batsell 1980). These researchers may wish to include a term that accounts for the dominance structure of the subsets. If such a term is not included the similarity effect may be artificially attenuated, since its effect is reversed when dominance is present.

The paper is organized as follows. First the concepts of regularity, similarity and dominance are reviewed. Then a number of explanations are presented that might account for the hypothesized effects. The experiment is then described and the results presented. Finally, the results are examined with respect to the explanations they support and the future research they suggest.

Regularity and Choice Models

Regularity is a minimum condition of most existing choice models. Formally, for any item which is a part of set A where A is in turn a subset of B, then the probability of choosing X from A must not be less than from B, or

$$\begin{aligned} \text{For all } x \in A \subseteq B, \\ \text{Pr}(x;A) \geq \text{Pr}(x;B). \end{aligned} \tag{1}$$

If this condition is satisfied, one cannot increase the probability of choosing an item by adding other items. Regularity is a reasonable property that is a necessary condition for both Luce's choice model and for Tversky's (1972) elimination by aspects model. Generally, this condition has also been found to be satisfied. Becker, DeGroot and Marshak (1963) in a study of gambles found that while proportionality was violated in choices among gambles, regularity was not. Luce summarized by remarking that the "only property of general choice probabilities that has not been empirically disconfirmed is regularity" (Luce 1977, p. 229).

On the other hand, it is easy to think of examples that violate regularity, particularly if higher order decision rules are imposed on the decision. Corbin and Marley (1974) give two such examples. The first involves a woman in a small town having to decide between two hats. In this case, the probability of choosing a hat would decrease if its duplicate were also available. Presumably, the woman would not want a hat someone else could buy. Thus the probability of purchasing a hat could increase if one of its competitors were duplicated, violating regularity. The second example concerns the probability of choosing an entree where the decision rule is to choose from a set excluding the most expensive. The probability of choosing the most expensive entree could then be increased by simply adding one to the list that is more expensive still. Note that both of these exceptions involve higher order rules where the value of alternatives depend on the choice set. That is, one has to have a rule about the desirability of having a unique hat or the undesirability of the most expensive entree for these exceptions to be plausible.

The exceptions to regularity we shall illustrate below do not depend on the existence of such higher order rules. Indeed the effect occurs in six different product categories and is of sufficient magnitude to have both managerial and theoretical relevance.

Relative Similarity and Choice Models

The similarity hypothesis reflects the intuitively reasonable assertion that a new alternative takes disproportionate share from those with which it

is most similar. Luce and Suppes (1965) have shown that the similarity hypothesis is logically incompatible with either constant utility, or independent random utility models of choice. Others have shown that the similarity effect is operant for individual (Rumelhart and Greeno 1981) or aggregate (Huber and Sewall 1978) choice probabilities.

Accordingly, several authors have attempted to modify choice models to allow for the similarity effect. For example, working with a random utility framework, Hausman and Wise (1978) modified the Thurstone model to accept covariances between alternatives. The similarity effect can then be represented by a positive covariance in the preferences among similar alternatives. Tversky's (1972) elimination by aspects model, arising as a multinomial generalization of Restle's (1961) model, accounts admirably for the similarity effect. Finally, work by Batsell (1980) provides a procedure for directly accounting for the similarity effect given choice probabilities on different choice sets.

In all of these modifications the addition of an alternative lowers the choice probability of similar items proportionately more than dissimilar ones. As will be shown, however, the addition of a dominated alternative appears to have the opposite effect, increasing choice of the similar item that dominates it. Further, this effect is stronger as relative similarity increases, thus limiting the applicability of the similarity hypothesis to choice sets where such dominance does not occur.

Dominance and Choice Models

It has proven difficult to capture the effect of dominance in the context of most choice models. For example, it is easy to show that the existence of an asymmetrically dominated alternative in a choice set implies that

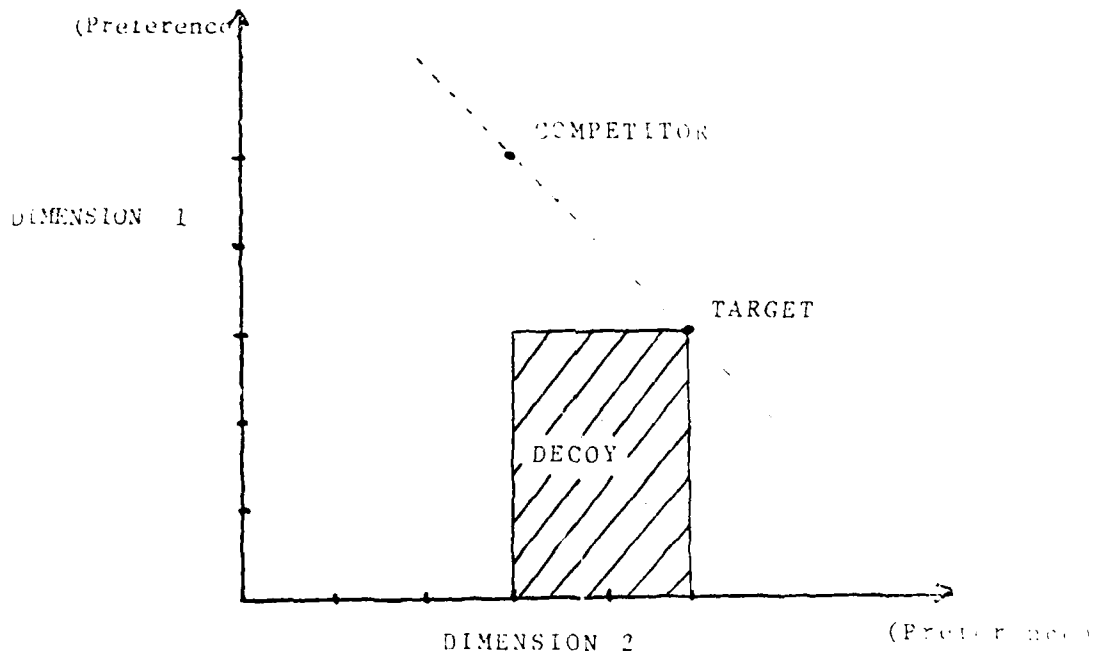
pairwise probabilities cannot be modeled by a one-dimensional scale. Consider three items, A, B, and B' where A and B are pareto efficient (non-dominating) and B' is dominated by B but not by A. In this set, which will form the experimental paradigm for the succeeding experiment, the distance between B and B' must be infinite so that one would never choose B' over B. The problem arises in that both distances to A must be finite, thus indicating that there is no one-dimensional scale that can simultaneously account for all three paired probabilities.

Previous models of choice have handled the issue of dominated alternatives in a number of ways. Both Restle's model (1961) and elimination by aspects (Tversky, 1972) account quite well for extreme probabilities. Since the probability of choosing an item is a function of its unique aspects, a dominated alternative lacking unique aspects has no probability of being chosen. Luce (1959) simply restricted the choice set to items where none is absolutely preferred. Consequently, many of the tests of choice models have not explicitly tested choices with dominated alternatives. It can also be reasonably argued that respondents initially delete dominated alternatives, leaving the choice along the efficient frontier unaffected (Coombs and Avrunin 1977). However, as will be shown, the very presence of the dominated alternative results in quite different choice probabilities among the remaining alternatives than in the pristine state where such items are never considered.

Why Asymmetric Dominance Leads to a Violation of Regularity

The test of the effect of asymmetric dominance uses the three stimuli pictured in Exhibit 1. Two stimuli, the target and the competitor, are positioned in the space such that neither dominates the other--each has a dimension on which it is superior. A decoy is then a stimulus in the shaded region of Exhibit 1 where it is dominated by the target but not by the competitor.

EXHIBIT 1
PLACEMENT OF ASYMMETRICALLY DOMINATED DECOY



The question we now consider is why the addition of such a decoy should draw attention, and thus choices, to the target at the expense of the competitor.

Notice that in a trivial sense, if a dominated alternative is never chosen, any change in the proportion of choices between the target and competitor results in a violation of regularity since the probability of choosing one of these options must increase. Such violations of regularity would be rather uninteresting even if they could be shown to be statistically significant. In the present case, however, the prediction is directional: adding the decoy is hypothesized to increase the percent of choices to the target. Furthermore, these violations are large and in conflict with the normal similarity effect.

Three explanations are given below indicating why the addition of the asymmetrically dominated alternative might have such effects: (1) a tournament explanation, (2) a satisficing explanation and (3) a popularity explanation. We will not here attempt to tease out which of these explanations is correct; that is the work of future research.

A Tournament Explanation

Suppose choice among the target, competitor and the decoy is made by looking at pairs and eliminating those that are not preferred. In such a tournament, the existence of a decoy could increase the probability of choosing the target since the decoy could knock out the competitor so that it would never be able to compete with the target. An analogy with a chess tournament should make this explanation clearer. Imagine two brothers, both grand masters. Suppose further that the older of the two knew the younger's game and could always beat him. Assuming that other players could not similarly dominate

the younger brother then his entrance in the tournament would increase the older brothers chance of winning. This violation of regularity would happen any time the two brothers do not meet in the first round of the tournament since there is a non-zero chance that the younger player could knock out a competitor who otherwise might have beaten his brother.

Thus a choice that is made on the basis of successive paired eliminations could help the target if a decoy is added. A more subtle form of the tournament explanation is based on a round-robin where each stimulus is compared with other stimuli in the set. The stimulus with the greatest number of paired successes is then chosen. Under this rule, the addition of an asymmetrically dominated alternative helps the target in giving it one easy win that is not shared by the competition. In the choice context, the fact that the target easily defeats one other item in the set may, in itself, increase its probability being chosen.

A Satisficing Explanation

Suppose a person has the following choice rule: randomly pick a pair, if one is clearly better, choose that item. Such a strategy, or any strategy whereby processing is curtailed following elimination of an alternative, may be suboptimal but at least avoids the worst decision. It is thus a kind of satisficing as defined by Simon (1957). This satisficing explanation can also be accounted for by considering the costs of thinking (Shugan 1980). Under that model, the thinking time to choose between dominated pairs is low relative to choosing between non-dominated pairs. Thus a

person minimizing thinking costs would first choose the target over the decoy, since that is the easiest decision. Then, under time pressure or given many alternatives, the other, more difficult comparisons might simply not be done. While the lack of time pressure makes this an unlikely explanation in the present experimental context, it might be quite important in others.

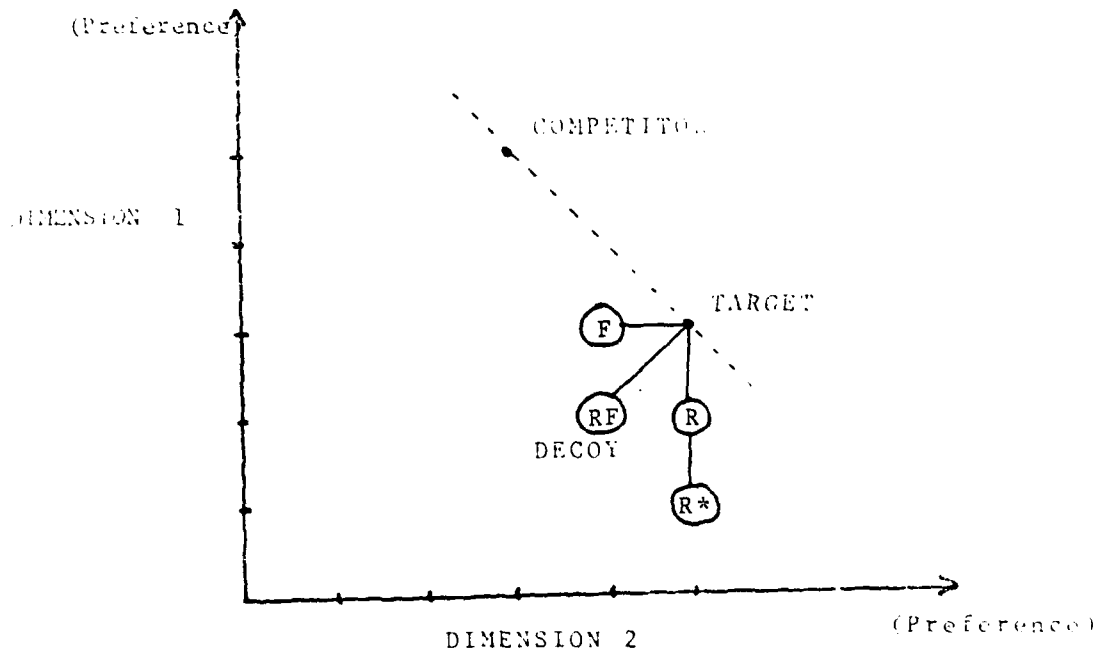
A Popularity Explanation

It may be that the presence of the decoy in the region of the target leads one to assume that these are viable, popular options. This could shift preferences in the direction of these options. Consider going into a store and finding a large range of shirts in one style and but a narrow range in another. If one wished to be in fashion one might justifiably infer that the shirt with few items similar to it is less popular this season and thus be likely to buy it. Notice that this explanation implies that the effect on the target is greater as the decoy's relative similarity to the target increases, since the inference to popularity would be stronger with greater similarity.

Effectiveness of Alternative Decoy Placement Strategies

The preceding section has discussed some of the reasons why the addition of a decoy anywhere in the shaded region of Exhibit 1 might increase the probability of choosing the target. More information can be found by examining the effect of various positions within the region. Consider the four different placements shown in Exhibit 2: one which moderately increases the range of the dimension on which the target is weakest (R), one which strongly increases that range (R*), one which increases the frequency of the dimension

EXHIBIT 2
DIFFERENT DECOY PLACEMENT
STRATEGIES



Where:

R = Moderate range increasing

R* = Extreme range increasing

F = Frequency increasing

RF = Range and frequency increasing

on which the target is superior to its competitor (F), and finally one which includes both a range and a frequency strategy (RF). For the purpose of operationalizing these strategies the units on both dimensions are chosen to form interval scales, making it possible to define such strategies over a broad range of product categories. The justification for each of these strategies is given below.

The Range Increasing Strategies, (R and R*)

In the experimental paradigm both the target and the competitor are superior to the other on exactly one dimension. Increasing the range on the dimension on which the competitor is superior could have the effect of decreasing the importance of a fixed difference on that dimension. This effect is perhaps best illustrated with an example from the beer choice set.

A Range Increasing Strategy

| | <u>Price/Six-Pack</u> | <u>Quality Rating</u> |
|-------------|-----------------------|-----------------------|
| Target | \$1.80 | 50 |
| Competitor | \$2.60 | 70 |
| Added Decoy | \$1.80 | 40 |

To choose the target over the competitor the value of an 80c saving must be greater than a decrement of 20 points in quality. By adding the decoy several things happen. First, the target's quality rating is in the middle rather than the bottom of the set, thus making this disadvantage seem less great. Second, the addition of the decoy increases the range of quality from 20 to 30 points, thus making a fixed quality difference less important. The psychological effect of this change may be similar to the well known result that increasing the range of stimuli tends to narrow category ratings

(Parducci 1974). In an analogous way one may be able to decrease the importance of the 20 quality points by extending the range of the quality levels.

Notice that a range effect would predict that increasing the range (R* versus R) should increase its biasing effect, thus permitting an evaluation of the efficacy of this explanation.

The Frequency Increasing Strategy (F)

By increasing the frequency of items on the dimensions on which the target is superior, this strategy may increase the importance of that dimension. An example is given below:

A Frequency Increasing Strategy

| | <u>Price/Six-pack</u> | <u>Quality Rating</u> |
|-------------|-----------------------|-----------------------|
| Target | \$1.80 | 50 |
| Competitor | \$2.60 | 70 |
| Added Decoy | \$2.20 | 50 |

Such an effect could occur in two ways. First by adding another price level, more attention may be drawn to the dimension (Currin, Weinberg and Wittink, 1981). Second, the addition of a beer with a price of \$2.20 might tend to spread the psychological distance of the 80c price advantage the target has over its competitor. Adding such a decoy would lower the variance along the price dimension, thus making the standardized differences greater. This result is once again analogous to the finding by Parducci (1974) that adding alternatives within the range of others tends to spread out their distances on subjective category ratings.

The Range-Frequency Strategy (RF)

The range-frequency strategy adds a decoy that simultaneously increases the range of the dimension on which the target is inferior while increasing the frequency on the dimension on which it is superior. As such, the strategy should combine the biasing powers of both. In the example, below, however, one difference becomes clear: it may be harder to detect the dominance when one has to consider both dimensions.

A Range-Frequency Strategy

| | <u>Price/Six/Pack</u> | <u>Quality Rating</u> |
|-------------|-----------------------|-----------------------|
| Target | \$1.80 | 50 |
| Competitor | \$2.60 | 70 |
| Added Decoy | \$2.20 | 40 |

Thus, the effect of dominance, per se, may not be as strong with this strategy.

Experimental Procedure

The goal of the experiment was to measure the effect of adding an asymmetrically dominated decoy. Within that classification, it was to gauge the effect of the four decoy placement strategies. In the light of comments by Einhorn and Hogarth (1981), distinguishing within- and between-subject analyses, it was felt that the effects should be established both ways. To accomplish the between-subjects analysis, 153 students in graduate and undergraduate business classes were asked to make a series of choices from among six product categories. Each product class had three choices, a target, a competitor and a decoy. As a parity check verifying its dominated character, the decoy was chosen 2% of the time. The definitions of the items were rotated across four randomly assigned groups in such a way as to balance the effects of (1) the six

different product classes, (2) which of the two competitive items was the target, (3) decision order and, finally (4) order of stimulus presentation within the choice sets. The exact design and rules for developing the stimuli are provided in the Appendix. The design itself was unbalanced in that twice as many observations were used to test the moderate range (R) and the frequency (F) strategies as the other two strategies (R* and RF).

To derive the data on individual choice reversals, a subset of 102 respondents was given the same test two weeks later with all of the decoy stimuli removed. Thus, the test of regularity was measured by the change in the percent choosing the target due to adding the decoy.

Results

A Test of Regularity

Exhibit 3 gives the results of the test of regularity. These results are primarily descriptive as they are defined both within and across respondents (e.g. some of the respondents are in both waves and some only in one).

The first column gives the probability the target was chosen with only the competitor present, while the second gives its probability of being chosen after the decoy was added. The next two columns refer to the same product class except the roles of the competitor and the target have been reversed so that the decoy is hypothesized to shift choices in the opposite direction.

Regularity was then violated when the first of each pair of columns, reflecting the probability of choosing an item in a paired context, is less than the second column, reflecting the effect of adding the decoy. Thus,

EXHIBIT 3

VIOLATIONS OF REGULARITY DUE TO ADDING DECOY

Probability of Choosing Target:

| Product Class | If A is Target | | If B is Target | | Average Point Change Violating Regularity |
|--------------------|----------------|----------------------------|----------------|-------------|--|
| | P(A;A,B)* | P(A;A,B,A')** | P(B;A,B) | P(B;A,B,B') | |
| Beer (n) | .43 (102) | .49 (76) | .57 (102) | .69 (77) | 9.0 |
| Cars (n) | .44 (102) | .55 (76) | .56 (102) | .66 (77) | 10.5 |
| Restaurants (n) | .30 (102) | .32 (76) | .70 (102) | .84 (77) | 8.0 |
| Lotteries (n) | .75 (101) | .70 ^(a) (77) | .25 (101) | .29 (76) | -0.5 |
| Film (n) | .24 (102) | .19 ^(a) (77) | .76 (102) | .86 (76) | 2.5 |
| TV Sets (n) | .75 (102) | .80 (77) | .25 (102) | .46 (76) | 13.0 |
| Average | .48 | .51 | .52 | .63 | 7.0 |

* The probability of choosing A in the non-dominating set [A,B]

** The probability of choosing A in the augmented set [A,B,A'], where A dominates A' but neither dominates B.

(a) Indicates the only 2 instances where regularity is not violated

in 10 out of the 12 cases, regularity was violated in the expected direction, with an overall gain in the targets' choice probability of 7 percentage points due to adding the decoy.

Within-Respondents Reversals

The above analysis is adequate descriptively, but because it mixes within- and between-respondents analyses, it is not strictly appropriate as a statistical test. The appropriate test is taken from the switching matrix defined across 92 respondents x 6 categories shown in Exhibit 4. Notice first that the percentage choosing the target jumps only 3 percentage points (from 53% to 56%) as the decoy is added. This change is less than the 7 points found in the between-subjects analysis, and is reasonably due to a carryover effect where respondents repeated the choice made two weeks prior. Two tests were made on the distorting effect of the decoy. The first was based on the 98% of the choices where the decoy was not chosen. In that sample, 63% of the 109 reversals were to the target and 37% to the competitor. That difference is statistically significant (McNemar Test, Siegel 1956) at a $p < 0.05$ level. Technically, however, the test of regularity should code switching to the decoy as switching from the target, thus merging the decoy and the competitor groups. In that test, 59% switched to the target, while 41% switched away. The difference was marginally significant at a $p < 0.10$ level.

Between-Subjects Analysis of the Different Placement Strategies

A more powerful analysis of the relative effectiveness of the different placement strategies can be done by considering the between-subject differences due to adding decoys in different positions. Exhibit 5 gives the probability

EXHIBIT 4
 INDIVIDUAL CHOICE REVERSALS
 DUE TO ADDITION OF DECOY

3 Item Choice Set

| | | Target | Competitor | Decoy | |
|-------------------------|------------|--------------|--------------|------------|---------------|
| 2-Item Choice Set | Target | 242 (44%) | 40 (7%) | 8 (1%) | 290 (53%) |
| | Competitor | 69 (12%) | 190 (34%) | 3 (1%) | 262 (47%) |
| | | 311 (56%) | 230 (42%) | 11 (2%) | 552 (100%) |

RESULTS:

1. 22% of all choices were reversals
2. 2% switched to the dominated decoy
3. Given the 109 who switched between target and competitor
 63% switched to the target, 37% to the competitor
 McNemar Test: $\chi^2_1 = (28^2)/109 = 7.2$, $p < .05$
4. Grouping those who switched to the decoy with the competitor
 (for a strong test of regularity)
 59% switched to the target while 41% switched away
 McNemar Test: $\chi^2_1 = (20^2)/117 = 3.4$, $p < .10$

EXHIBIT 5

SUMMARY OF CHOICE PROBABILITIES FOR
ALTERNATIVE DECOY PLACEMENT STRATEGIES

| Product Class | Probability of Choosing Target | | | | | | | | | |
|--------------------|--|------------------|-------------|-------------|-------------|--|-------------|-------------|-------------|-------------|
| | A is Target and Decoy Placement Strategy is | | | | | B is Target and Decoy placement Strategy is | | | | |
| | No Decoy | R ^(a) | F | RF | R* | No Decoy | R | F | RF | R* |
| Beer (n) | .43 (102) | .63 (39) | | .35 (37) | | .57 (102) | .75 (38) | .67 (36) | | |
| Cars (n) | .44 (102) | .66 (38) | .52 (33) | | | .56 (102) | | .67 (40) | .67 (36) | |
| Restaurants (n) | .30 (102) | | .21 (39) | .43 (37) | | .70 (102) | .91 (34) | | .87 (39) | |
| Lotteries (n) | .75 (101) | .81 (36) | | | .68 (37) | .25 (101) | .41 (37) | .18 (38) | | |
| Film (n) | .24 (102) | .20 (40) | .19 (37) | | | .76 (102) | | .84 (37) | | .92 (37) |
| TV Sets (n) | .75 (102) | | .87 (38) | | .83 (35) | .25 (102) | .32 (38) | | | .62 (37) |

(a) R = Moderate Range Expanding

F = Frequency Expanding

RF = Range and Frequency Expanding

R* = Extreme Range Expanding

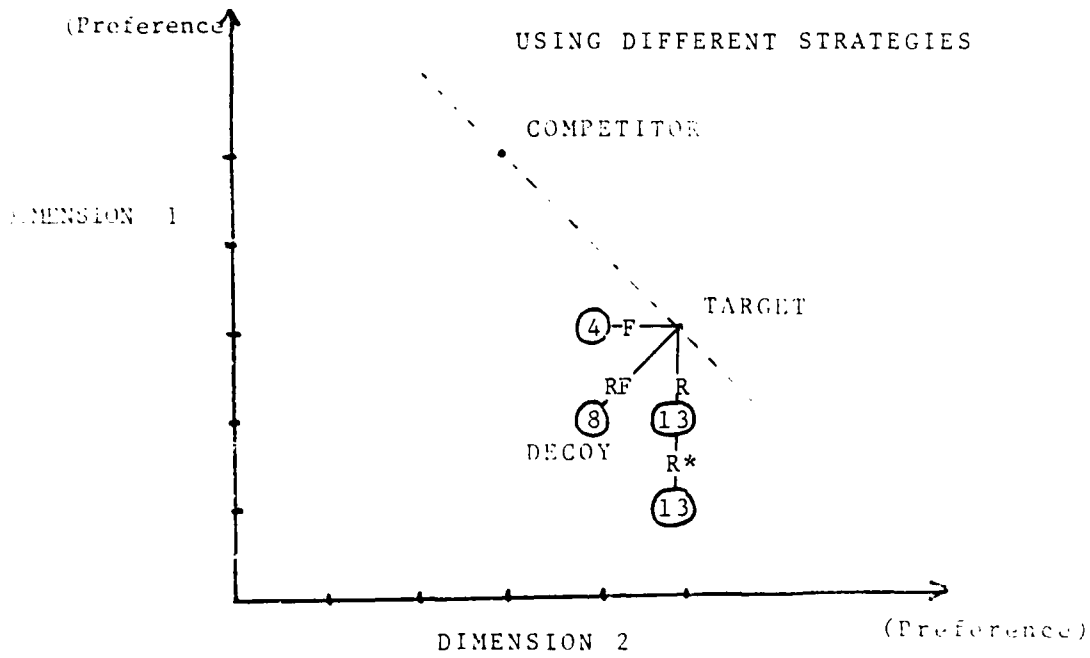
of choosing one item over another given different strategies and positioning of the decoy. Thus one finds that beer brand A (price = \$1.80, quality = 50) is chosen 63% of the time over B (price = \$2.60, quality = 70) when A is the target and the decoy is range increasing (R). By contrast, RF is used, then only 35% choose A.

A simple way to summarize the effectiveness of the various strategies is to compute the average point gain to the target due to adding the decoy. These results are shown in Exhibit 6. The two range increasing strategies increased the average target's penetration by 13 points; next was the range-frequency strategy with a gain of 8 percentage points, followed by the frequency strategy with a net gain of 4 points. A test of the statistical significance of these gains was made by comparing the within-product gain due to a strategy. For example, the R strategy was tested using a Fisher Exact Test, testing if the two R strategies for beer (each with a different target) could have been drawn from the same population. The tests on both the R strategies and the RF strategy were significant at $P < .05$. The frequency increasing strategy was not significant at that level. The same test was used to compare the significance of difference between strategies. Both moderate and extreme range strategies were significantly more effective than the frequency strategy, ($P < .05$) but all other differences were not.

Summary of Results

To summarize, overall asymmetric dominance appeared to have a strong effect in violating regularity. This effect was stronger (7 points) across subjects than it was within subjects (3 points). The fact that the range increasing strategies produced a 12 point change that did not differ with

EXHIBIT 6
 POINT INCREASE IN PROBABILITY OF CHOOSING
 TARGET DUE TO ADDING DECOY
 USING DIFFERENT STRATEGIES



Where:

R = Moderate range expanding

R* = Extreme range expanding

F = Frequency expanding

RF = Range and frequency expanding

the degree of the range extension, suggests that a simple range extension explanation is not sufficient, and that other factors must be found to account for this effect. The weakness of the range-frequency strategy may be due to the aforementioned fact that dominance was not as readily apparent when such double-dominance occurs. Finally, the weakness of the frequency strategy suggests that this strategy is not as successful in revising weights as had been expected; it also says that dominance per se may not be as critical as the particular placement of the decoy.

The concept of relative similarity could account in part for the results found, since the frequency strategy decoy is closest to the competition followed by the decoy for range-frequency and the two range strategies. It may be that the effectiveness of the decoy is related to its degree of relative closeness to the target. Such an explanation could account for the increasing effectiveness of the strategies as one moves away from the competition.

DISCUSSION

The fact that regularity was found to be violated here but not in other studies can be attributed to their choice sets not containing asymmetrically dominated alternatives. Further, in such tests the added alternative typically took, substantial share from the items in the original set so that a substitution effect may have outweighed any distortion effect due to the presence of the new alternative. Thus regularity may have been satisfied because the substitution effect, tending to take share away from the original objects, was stronger than any consistent distortion effect in rearranging share. With the asymmetrically dominated alternatives studied here, by contrast, the substitution effect was virtually negligible (2%) so the distortion effect became clearly evident. It should be emphasized, however, that even though a distortion effect may be masked by a substitution effect, it still occurs, and should be part of our models of choice.

The violations of the similarity hypothesis found here took two forms. First, to the extent that asymmetrically dominating alternatives tend to be similar to the items they dominate, any help from such items results in a reversal of the standard similarity effect. The second violation of the similarity hypothesis occurred in that those decoys whose relative similarity to the target was greatest had the greatest positive effect on the target. While this last violation must be considered to be speculative until a more precise measure of relative similarity can be tested, both results together have rather strong implications for the interpretation of any test of the similarity effect. Specifically, if stimulus sets are mixtures of dominated and non-dominated alternatives then the similarity effect is likely to be attenuated because

of the reversals due to the dominated alternatives. Thus, such tests should account for this interaction with dominance or restrict their applicability to sets of non-dominating objects.

In a managerial sense, such distortions of choice probabilities may be very important. Consider the following hypothetical examples:

*A store owner has two camel hair jackets priced at \$100 and \$150 and finds that the more expensive jacket is not selling. A new camel hair jacket is added and displayed for \$250; the new jacket does not sell, but sales of the \$150 jacket increase.

*A seller of tours to Disney World for \$500 might also offer a tour to a theme park in Europe costing \$2,500. Few tickets for the European tour would be sold but penetration would increase for the domestic tour.

*A manufacturer of cars with relatively poor gas mileage (e.g. 20 MPG) might decrease the effect of this dimension by first showing prospects a high-powered car in the showroom with much worse (8 MPG) mileage.

The preceding examples are interesting in that they are not clear cases of dominance, but rather near-dominance, where the decision from the decoy to the target is easy to make, and the range effects favor the target. In terms of the experimental paradigm such decoys would be positioned just the right of the R or R* strategies in Exhibit 6. Testing such strategies would reflect important managerial extensions of the current study.

In terms of the development of a comprehensive theory of choice, the empirical results given here cannot be accounted for by current theories of choice represented by the Luce model or its extensions. What is missing is a unique explanation for the effects found. Future research to derive the relative importance or validity of various explanations may have either

a weight-shifting or a process orientation. The weight-shifting focus would be most appropriate to test the effectiveness of the popularity and the range/frequency explanations. Weights could be shown to depend systematically on the placement of the decoys, where the weights were elicited either by direct methods or by statistical inferences following profile judgments (e.g., see Currim, Weinberg and Wittink, 1981). A process oriented research stream would provide an appropriate tests for the validity of tournament and the satisficing explanations. Thus, for example, protocols or eye tracking methods would determine if the placement of the decoy changes the probability that the decoy-target pair is evaluated first. Such results might indicate that decoy placement alters the implicit choice agenda.

It is likely that a thorough understanding of the phenomena reported here will come as a result of both statistical estimation methods and process tracing methods. The result of such efforts may be a comprehensive theory that explains the empirical results found here rather than categorizing them as exceptions.

APPENDIX

DETAIL OF EXPERIMENTAL PROCEDURE

I. Sample Choice Problem

Below you will find three brands of beer. You know only the price per six-pack and the average quality ratings made by subjects in a blind taste test. Given that you had to choose one brand to buy on this information along, which one would it be?

| <u>Brand</u> | <u>Price, Six-Pack</u> | <u>Average Quality Rating</u> (100 = Best; 0 = Worst) |
|--------------|------------------------|--|
| I | \$1.80 | 50 |
| II | \$2.60 | 70 |
| III | \$3.00 | 70 |

I would prefer Brand - (Check one only)

I _____ II _____ III _____

II. Attribute Values for
Product Categories

| <u>Product</u> | <u>Dimension 1</u> | | | | | <u>Dimension 2</u> | | | | |
|-------------------|--------------------|------|------|------|------|--------------------|----|----|----|----|
| Beer (Attribute): | (Price/Six-Pack) | | | | | (Quality) | | | | |
| Value: | \$3.40 | 3.00 | 2.60 | 2.20 | 1.80 | 30 | 40 | 50 | 60 | 70 |
| Level: | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | | | | |
|--------|---|----|----|----|-----|---------------|----|----|----|--------|
| Cars: | (Ride Quality) | | | | | (Gas Mileage) | | | | |
| | (100 = Like a Rolls; 60 = Like a Jeep) | | | | | | | | | |
| Value: | 60 | 70 | 80 | 90 | 100 | 21 | 24 | 27 | 30 | 33 Mpg |
| Level: | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | | | | |
|--------------|----------------|----|----|----|--------|----------------|---|---|---|---------|
| Restaurants: | (Driving Time) | | | | | (Food Quality) | | | | |
| Value: | 45 | 35 | 25 | 15 | 5 Min. | 1 | 2 | 3 | 4 | 5 Stars |
| Level: | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | | | | |
|------------|---------------------|-----|-----|-----|-----|-----------------|----|----|----|----|
| Lotteries: | (Chance of Winning) | | | | | (Amount of Win) | | | | |
| Value: | 28% | 42% | 56% | 70% | 84% | \$18 | 27 | 36 | 45 | 54 |
| Level: | 1 | 2 | 5 | 4 | 3 | 1 | 2 | 5 | 4 | 3 |

| | | | | | | | | | | |
|--------|-------------------|----|---|----|--------|------------------|----|----|----|----|
| Film: | (Developing Time) | | | | | (Color Fidelity) | | | | |
| | | | | | | (100 = Best) | | | | |
| Value: | 6 | 4½ | 3 | 1½ | ½ Min. | 89 | 91 | 93 | 95 | 97 |
| Level: | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | | | | |
|----------|-----------------------|-----|-----|-----|-----|--------------------------|---|---|---|---------|
| TV Sets: | (% Distortion 0=Best) | | | | | (Reliability) | | | | |
| | | | | | | (Avg. Time to Breakdown) | | | | |
| Value: | 4.5 | 3.5 | 2.5 | 1.5 | .5% | 2 | 3 | 4 | 5 | 6 Years |
| Level: | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

III. Assignment of Stimulus (Decoy) to Groups

| Product Class | Dimension | Levels of Each Dimension by Group: 5 = BEST | | | | | | | | | | | |
|---------------|-----------|---|---|---|---------|---|---|---------|---|---|---------|---|---|
| | | Group 1* | | | Group 2 | | | Group 3 | | | Group 4 | | |
| | | T | C | D | T | C | D | T | C | D | T | C | D |
| Beer | Strategy | R | | | R | | | F | | | RF | | |
| | D1 | 3 | 5 | 2 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 4 |
| | D2 | 5 | 3 | 5 | 3 | 5 | 2 | 5 | 3 | 4 | 3 | 5 | 2 |
| Cars | Strategy | F | | | F | | | RF | | | R | | |
| | D1 | 3 | 5 | 3 | 5 | 3 | 4 | 3 | 5 | 2 | 5 | 3 | 5 |
| | D2 | 5 | 3 | 4 | 3 | 5 | 3 | 5 | 3 | 4 | 3 | 5 | 2 |
| Restaurants | Strategy | RF | | | RF | | | R | | | F | | |
| | D1 | 3 | 5 | 2 | 5 | 3 | 4 | 3 | 5 | 2 | 5 | 3 | 4 |
| | D2 | 5 | 3 | 4 | 3 | 5 | 2 | 5 | 3 | 5 | 3 | 5 | 3 |
| Lotteries | Strategy | R* | | | F | | | R | | | R | | |
| | D1 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 2 |
| | D2 | 3 | 5 | 1 | 5 | 3 | 4 | 3 | 5 | 2 | 5 | 3 | 5 |
| Film | Strategy | R | | | R* | | | F | | | F | | |
| | D1 | 5 | 3 | 5 | 3 | 5 | 1 | 5 | 3 | 4 | 3 | 5 | 3 |
| | D2 | 3 | 5 | 2 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 4 |
| TV Sets | Strategy | F | | | R | | | R* | | | R* | | |
| | D1 | 5 | 3 | 4 | 3 | 5 | 2 | 5 | 3 | 5 | 3 | 5 | 1 |
| | D2 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 1 | 5 | 3 | 5 |

*Read as follows: For the product class Beer, the attribute values for the Target were determined by selecting level 3 of Dimension 1 (Price) and level 5 of Dimension 2 (Quality) the attribute values for the Competitor were determined by selecting level 5 of Dimension 1 and level 3 of Dimension 2; and the attribute values for the Decoy were determined by selecting level 2 of Dimension 1 and level 5 of Dimension 2. Each level is as defined on the preceding page. The Strategies are:

- R = Moderate Range Increasing
- R* = Extreme Range Increasing
- F = Frequency Increasing
- RF = Range and Frequency Increasing

IV. Choice Problem Situations

Beer:

Below you will find three brands of beer. You know only the price per six-pack and the average quality ratings made by subjects in a blind taste test. Given that you had to choose one brand to buy on this information alone, which one would it be?

Cars:

On this page you will find three car models. They all cost the same at purchase and have similar appearances and quality of construction. Road & Track magazine has tested each car for gas consumption, and the accurate mileage figures are listed below. Additionally, a panel of potential consumers virtually identical to yourself has rated the ride quality of each car. Using only this information, which model would you buy?

Restaurants:

You have a regular routine of eating out at a different restaurant once a week. You are considering three restaurants for your next dinner, and you know only two things about them. One is the food quality, and the other is the driving time to each from your home. The food quality has been rated by the Motil Food Guide, and the driving time has been provided by your neighbor who happens to be a local taxi driver. You must decide between these restaurants for tonight's dinner. Which would you prefer?

Lotteries:

There are several lotteries that cost the same amount to enter. You know the probability of winning each lottery given that you buy a ticket. The payoff if you win is shown next to the chance of winning. If you had to purchase one lottery ticket, which one would you prefer?

Film:

Below you will find three brands of "instant-developing" film. You know only the developing time and the color fidelity, both of which have been tested by Consumer Reports magazine. Given that you had to choose one brand to buy on this information alone, which one would it be?

TV Sets:

On this page you will find three color television sets. You know only the relative percentage of distortion in the picture tube and the reliability rating of each set, both having been provided through a recent issue of Consumer Reports magazine. Given that you had to choose a television set on this information alone, which set would you choose?

References

- Batsell, Richard R. (1980a), "A Market Share Model Which Simultaneously Captures the Effects of Utility and Substitutability," Working Paper #80-007, Wharton School, University of Pennsylvania.
- _____ (1980b), "Consumer Resource Allocation Models at the Individual Level," Journal of Consumer Research, 7, 78-87.
- Becker, Gordon M., N. H. DeGroot and Jacob Marshak (1963), "Probabilities of Choice Among Very Similar Alternatives," Behavioral Science 8, 306-311.
- Coombs, Clyde H. and George S. Avrunin (1977), "Single Peaked Functions and the Theory of Preference," Psychological Review, 84, (March) 216-231.
- Corbin, Ruth and A. Marley (1974), "Random Utility Models with Equality: An Apparent but not Actual Generalization of Random Utility Models," Journal of Mathematical Psychology, 11, (August), 274-397.
- Currim, Imram S., C. B. Weinberg and D. R. Wittink (1981), "Design of Subscription Programs for a Performing Arts Series," Journal of Consumer Research, 8, (June 1981) 76-75.
- Debreu, G. (1960), "Review of R.D. Luce," American Economic Review, 50, 186-188.
- Einhorn, H. J. and Robin M. Hogarth (1981) "Behavioral Decision Theory: Processes of Judgment and Choice," Annual Review of Psychology.
- Hausman, J.A. and D.A. Wise (1978), "A Conditional Probit Model for Qualitative Choice: Discrete Decisions Recognizing Interdependence and Heterogeneous Preferences," Econometrica, 46, 403-26.
- Huber, Joel and Murphy A. Sewall (1978), "Covariance Bias of Thurstone Case V Scaling as Applied to Consumer Preferences and Purchases Intentions," Advances in Consumer Research, 6, Association for Consumer Research, Chicago, Illinois 578-581.
- Luce, R.D. (1959), Individual Choice Behavior, New York: John Wiley.
- _____ (1977), "The Choice Axiom after Twenty Years," Journal of Mathematical Psychology, 15, 215-233.
- _____ and P. Suppes (1965), "Preference, Utility, and Subjective Probability," in R.D. Luce, R.R. Bush and E. Galanter, Handbook of Mathematical Psychology, Vol. III, Ch. 19, 249-410.
- McFadden, Daniel (1974), "Conditional Logit Analysis of Quantitative Choice Behavior," in Paul Zarembka (ed), Frontiers of Econometrics, p. 105-142, New York: Academic Press.

- _____ (1980), "Econometric Models for Probabilistic Choice Among Products," Journal of Business, 53, (March), 513-529.
- Parducci, A. (1974) "Contextual Effects: A Range-Frequency Analysis," in L. Carterette and M.P. Freidman, Handbook of Perception, Volume II. New York: Academic Press.
- Pessemier, E.A., P. Burger, R.D. Teach and D.J. Tigert (1971), "Using Laboratory Brand Preference Scales to Predict Consumer Brand Purchases," Management Science, 17, (February) 371-385.
- Punj, Girish N. and Richard Staelin (1978), "The Choice Process for Graduate Business Schools," Journal of Marketing Research, 15, (November, 1978) 588-598.
- Reibstein, David (1978), "The Prediction of Individual Probabilities of Brand Choice," Journal of Consumer Research, 5, (December) 163-168.
- Restle, F. (1961), Psychology of Judgment and Choice: A Theoretical Essay, New York: John Wiley.
- Rumelhart, D.L. and Greeno, J.G. (1971), "Similarity Between Stimuli: An Experimental Test of the Luce and Restle Choice Models," Journal of Mathematical Psychology, 8, 370-81.
- Shugan, Steven M. (1980), "The Cost of Thinking," The Journal of Consumer Research, 7, (September), 99-111.
- Siegel, Sidney (1956), Nonparametric Statistics, New York: McGraw Hill.
- Silk, A.J. and G.L. Urban (1978), "Pre-Test Market Evaluation of New Packaged Goods: A Model and Measurement Methodology," Journal of Marketing Research, 15, (May), 171-191.
- Simon, H. A. (1957), Models of Man, New York: John Wiley
- Sjoberg, L. and D. Capozza, (1975), "Preference and Cognitive Structure of Italian Political Parties," Italian Journal Psychology, 2, 391-402.
- Tversky, Amos (1972), "Elimination by Aspects: A Theory of Choice," Psychological Review, 79, (July) 281-299.
- _____ and Daniel Kahneman (1981), "The Framing of Decisions and the Rationality of Choice," Science, 211, (January), 453-458.
- Urban, Glen, Philip L. Johnson and Richard H. Brudnick (1981), "Market Entry Strategy Formulation: A Hierarchical Modeling and Consumer Measurement Approach", Working Paper No. 1103-80, Massachusetts Institute of Technology.

A.

DISTRIBUTION LIST

OSD

CDR Paul R. Chatelier
Office of the Deputy Under Secretary
of Defense
OUSDRE (E&LS)
Pentagon, Room 3D129
Washington, D.C. 20301

Department of the Navy

Director
Engineering Psychology Programs
Code 455
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217 (5 cys)

Director
Operations Research Programs
Code 434
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Director
Statistics and Probability Program
Code 436
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Director
Information Systems Program
Code 437
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Code 430B
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

LCDR W. Moroney
Code 35MP
Naval Postgraduate School
Monterey, CA 93940

Department of the Navy

Commanding Officer
ONR Eastern/Central Regional Office
ATTN: Dr. J. Lester
Building 114, Section D
666 Summer Street
Boston, MA 02210

Commanding Officer
ONR Branch Office
ATTN: Dr. C. Davis
536 South Clark Street
Chicago, IL 60605

Commanding Officer
ONR Western Regional Office
ATTN: Dr. E. Gloye
1030 East Green Street
Pasadena, CA 91106

Office of Naval Research
Scientific Liaison Group
American Embassy, Room A-407
APO San Francisco, CA 96503

Director
Naval Research Laboratory
Technical Information Division
Code 2627
Washington, D.C. 20375 (6 cys)

Dr. Bruce Wald
Communications Sciences Division
Code 7500
Naval Research Laboratory
Washington, D.C. 20375

Dr. Robert G. Smith
Office of the Chief of Naval
Operations, OP987H
Personnel Logistics Plans
Washington, D.C. 20350

Naval Training Equipment Center
ATTN: Technical Library
Orlando, FL 32813

Department of the Navy

Human Factors Department
Code N215
Naval Training Equipment Center
Orlando, FL 32813

Dr. Alfred F. Smode
Training Analysis and Evaluation
Group
Naval Training Equipment Center
Code N-00T
Orlando, FL 32813

Dr. George Moeller
Human Factors Engineering Branch
Submarine Medical Research Lab
Naval Submarine Base
Groton, CT 06340

Dr. James McGrath, Code 302
Navy Personnel Research and
Development Center
San Diego, CA 92152

Navy Personnel Research and
Development Center
Planning and Appraisal
Code 04
San Diego, CA 92152

Navy Personnel Research and
Development Center
Management Systems, Code 303
San Diego, CA 92152

Navy Personnel Research and
Development Center
Performance Measurement and
Enhancement
Code 309
San Diego, CA 92152

CDR P. M. Curran
Code 604
Human Factors Engineering Division
Naval Air Development Center
Warminster, PA 18974

Dean of the Academic Departments
U.S. Naval Academy
Annapolis, MD 21402

Department of the Navy

Dr. Gary Poock
Operations Research Department
Naval Postgraduate School
Monterey, CA 93940

Dean of Research Administration
Naval Postgraduate School
Monterey, CA 93940

Mr. Warren Lewis
Human Engineering Branch
Code 8231
Naval Ocean Systems Center
San Diego, CA 92152

Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
Code RD-1
Washington, D.C. 20380

Department of the Army

Mr. J. Barber
HQS, Department of the Army
DAPE-MBR
Washington, D.C. 20310

Dr. Joseph Zeidner
Technical Director
U.S. Army research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Director, Organizations and
Systems Research Laboratory
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Department of the Air Force

U.S. Air Force Office of Scientific
Research
Life Sciences Directorate, NL
Bolling Air Force Base
Washington, D.C. 20332

Department of the Air Force

Dr. Donald A. Topmiller
Chief, Systems Engineering Branch
Human Engineering Division
USAF AMRL/HES
Wright-Patterson AFB, OH 45433

Air University Library
Maxwell Air Force Base, AL 36112

Dr. Erl Alluuisi
Chief Scientist
AFHRL/CCN
Brooks AFB, TX 78235

Foreign Addresses

North East London Polytechnic
The Charles Myers Library
Livingstone Road
Stratford
London E15 2LJ
ENGLAND

Professor Dr. Carl Graf Hoyos
Institute for Psychology
Technical University
8000 Munich
Arcisstr 21
FEDERAL REPUBLIC OF GERMANY

Dr. Kenneth Gardner
Applied Psychology Unit
Admiralty Marine Technology
Establishment
Teddington, Middlesex TW11 OLN
ENGLAND

Director, Human Factors Wing
Defence & Civil Institute of
Environmental Medicine
Post Office Box 2000
Downsview, Ontario M3M 3B9
CANADA

Dr. A. D. Baddeley
Director, Applied Psychology Unit
Medical Research Council
15 Chaucer Road
Cambridge, CB2 2EF, ENGLAND

Other Government Agencies

Defense Technical Information Center
Cameron Station, Bldg. 5
Alexandria, VA 22314 (12 cys)

Dr. Craig Fields
Director, Cybernetics Technology
Office
Defense Advanced Research Projects
Agency
1400 Wilson Blvd
Arlington, VA 22209

Dr. Judith Daly
Cybernetics Technology Office
Defense Advanced Research Projects
Agency
1400 Wilson Blvd
Arlington, VA 22209

Other Organizations

Dr. Gary McClelland
Institute of Behavioral Sciences
University of Colorado
Boulder, CO 80309

Dr. Miley Merkhofer
Stanford Research Institute
Decision Analysis Group
Menlo Park, CA 94025

Dr. Jesse Orlansky
Institute for Defense Analyses
400 Army-Navy Drive
Arlington, VA 22202

Professor Judea Pearl
Engineering Systems Department
University of California-Los Angeles
405 Hilgard Avenue
Los Angeles, CA 90024

Professor Howard Raiffa
Graduate School of Business
Administration
Harvard University
Soldiers Field Road
Boston, MA 02163

Other Organizations

Dr. Arthur I. Siegel
Applied Psychological Services, Inc.
404 East Lancaster Street
Wayne, PA 19087

Dr. Paul Slovic
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Amos Tversky
Department of Psychology
Stanford University
Stanford, CA 94305

Dr. Robert T. Hennessy
NAS - National Research Council
JH #819
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Dr. M. G. Samet
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Meredith P. Crawford
American Psychological Association
Office of Educational Affairs
1200 17th Street, N.W.
Washington, D.C. 20036

Dr. Ward Edwards
Director, Social Science Research
Institute
University of Southern California
Los Angeles, CA 90007

Dr. Charles Gettys
Department of Psychology
University of Oklahoma
455 West Lindsey
Norman, OK 73069

Dr. Kenneth Hammond
Institute of Behavioral Science
University of Colorado
Room 201
Boulder, CO 80309

Other Organizations

Dr. William Howell
Department of Psychology
Rice University
Houston, TX 77001

Journal Supplement Abstract Service
American Psychological Association
1200 17th Street, N.W.
Washington, D.C. 20036 (3 cys)

Dr. John Payne
Duke University
Graduate School of Business
Administration
Durham, NC 27706

Dr. Baruch Fischhoff
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Leonard Adelman
Decisions and Designs, Inc.
8400 Westpark Drive, Suite 600
P. O. Box 907
McLean, VA 22101

Dr. Lola Lopes
Department of Psychology
University of Wisconsin
Madison, WI 53706