Representing Psychological Dimensions of Decisions: Implications for Behavioral Decision Models

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Abstract

This study investigated the dimensions of the psychological similarity space associated with decisions people commonly encounter in their life. Four distinct clusters were found within a three-dimensional space, which suggested that people classifiy decisions based on content per se (professional-personal), as well as general characteristics of the decisions, namely, importance and complexity. These findings have implications for decision strategy selection.

Introduction

Many theories of decision making assume that every decision can be represented as a choice in the gambling paradigm (i.e., it can be reduced to outcomes and their associated probabilities). Most prominent normative theories based on this assumption, e.g., expected utility (EU) and subjective expected utility (SEU) theory, take into account only those elements of a decision problem that remain after reduction to such a representation. According to SEU theory, because "all information that could determine the decision is contained in this reduced representation" (Wagenaar, Keren & Lichtenstein, 1988), this forms the *deep structure* of the decision problem. In the past four decades after the development of EU theory by von Neumann and Morgenstern (1947) and that of SEU theory by Savage (1954), a great deal of evidence has accumulated that people's choices deviate systematically from models that only take into account the deep structure. The predominant interpretation of these findings has been that people fail to conform to the normative model as a result of various cognitive deficiencies (Frisch & Clemen, 1994). With this premise, Tversky and Kahneman (1974) developed the "Heuristics and Biases" program to describe how these deviations occur as the result of cognitive limitations. However, after over two decades of effort, the program has failed to systematically consider when these anomalies occur, since they are considered to be "anomalies." A different perspective of humans as adaptive decision makers that we endorse, focuses on determining the factors that influence how people select -- consciously or unconsciously -- different decision strategies. With such perspective in mind, we review some of the "anomalies" found in decision making.

Variance due to Content Per Se

Wagenaar et al. (1988) presented a variety of cover stories, all of which had the same deep structure, namely, versions of Tversky and Kahneman's (1981) well-known Asian disease problem. Although the mode of presentation (with or without pictorial illustration) did not influence the results in their study, the change in the role assumed by the participants (public health officer vs. islander) as well as the change in the identity of the potential victims (islanders subject to a disease vs. children held hostage by terrorists) had a profound effect on the choices of participants who were all considering the same deep structure problem. Wagenaar et al. (1988) suggest that this effect can be perceived to be the result of differences in framing (i.e., the phonomenon that some simple wording changes -- e.g., from describing outcomes in terms of lives saved to describing them in terms of lives lost -- can lead to different preferences). However, varying responses to different cover stories can also be attributed to the content of the stories if certain characteristics of content elicit different modes of processing, hence altering the choices (Goldstein & Weber, 1995).

In a review of framing effects in personal health decisions, Rothman and Salovey (1997) determined that depending on the categories of health behavior (whether it was preventative, diagnostic, or recuperative), the effectiveness of gain vs. loss framing changed. This suggests that not only the perception of the outcomes affects

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the behavior but also the decision content mediates the effect.

Cognitive Perspective on Decision Making

The fact that choices are not predictable from their deep structure seems to indicate that people's preferences do not result solely from the calculation of outcome and probability information. Preferences for and beliefs about objects or events of any complexity appear to be constructed, and this construction seems to be affected by variables not represented in models such as EU or SEU. It appears that decision makers have a variety of strategies for identifying their preferences and developing their beliefs, and they seem to use different strategies contingent on decision content and context, such as those discussed above (Payne, Bettman & Johnson, 1992).

Variance due to Complexity and Importance

Some decisions are more complex than others by nature. For example, choosing a marriage partner is much more complex than deciding to buy one type of candy bar versus another. A number of studies have been conducted to assess the influence of complexity on the choice of decision strategies with the hypothesis that the more complex the decision problem, the more people use simplifying decision heuristics (Payne et al., 1990).

Some studies examined the impact of the number of alternatives available. They found that people tend to use compensatory decision strategies when faced with two alternatives; however, when faced with decision tasks with more alternatives, they prefer using noncompensatory choice strategies (e.g., Johnson, Meyer & Ghose, 1989; Sundstrom, 1987). Others studied the effect of the number of attributes of decision alternatives, finding that decision quality decreases with increases in the number of attributes beyond a certain level of complexity (e.g., Keller & Staelin, 1987). Also, time constraints influence both the speed of processing and the shift in processing strategies (e.g., Payne et al., 1988).

In the accuracy-effort framework presented by Payne et al. (1990), it is also believed that the importance of a decision increases the amount of effort one will put in to arriving at a decision. This implies (though not always) people tend to use more compensatory choice strategies for important decisions. The result of a study by Lindberg, Garling, and Montgomery (1989) supports that factors such as perceived importance affect which decision rule is used.

Towards Predictability in the Choice of Decision Strategies

There are many other task and context related factors, as well as some individual-difference factors, which have been found to lead to choices deviating systematically from predictions of the EU/SEU models (for a review, see Payne, Bettman & Johnson, 1992). From such findings, the question arises whether people systematically choose to use different strategies. In other words, are people coherent, adaptive decision makers? Results obtained from Payne et al. (1990) seem to suggest that people tend to choose strategies that optimize accuracy/effort tradeoffs. If this is true, what are the factors that determine required decision accuracy and effort?

To answer these questions, it would be useful to know how people categorize the decisions they commonly encounter in their life. If people indeed are adaptive decision makers who select decision strategies in a systematic fashion, there must be in their mind some representation of the similarity between decisions. However straightforward and logical this may sound, there has not been any attempt to arrive at a representation of decision similarity. Thus, exploratory methods of hierarchical clustering analysis and multidimensional scaling (MDS) were used to discover the dimensions of such a representation.

Method

Stimuli

In a pilot study, 64 introductory psychology students wrote down 20 decisions they had made within the last two years. The majority of decisions used as stimuli in our study came from this list. Some decisions, which may have been too non-deliberative to appear on the list (e.g., deciding to stop at a red light) or which they may not yet have encountered (e.g., whether to leave a spouse of many years) were added to extend the range of decisions. Fifty decisions were selected to represent a variety of contents (e.g., decisions related to money, school, relationship, one's future, moral conduct, societal well-being) and decision characteristics (e.g., nature and number of alternatives, consciously/unconsciously made decisions) known to influence decision processes. The decision situation questionnaire (DSQ) was constructed to assess how participants perceived each of the 50 decision situations in terms of importance, length of time taken to make each decision, emotional involvement, pleasantness, amount of information required, difficulty, and the consequences associated with each decision (for a list of specific decision characteristic assessed for each item, see Table 2). A question about the frequency with which similar decision situations had been encountered was also included. A small amount of context (generally one sentence of description) was added to provide respondents with similar interpretations of the decision situation. Each decision was also printed on an index card which was subsequently used in a sorting task.

Participants and Procedure

Seventy-eight introductory psychology students at the Ohio State University participated in this study in fulfillment of a course requirement. Participants were each given a set of 50 index cards. They were asked to sort the decisions into categories on the basis of similarity, which we intentionally left undefined. The instructions explained that there were no right or wrong way to sort the decisions, and that they could sort them into as many or as few categories as they wished. As an example, they were told that typically people in similar sorting tasks use two to fifteen categories, to suggest a lower and an upper limit for the number of categories. The instructions also stated that if a decision situation did not seem similar to any other, respondents were allowed to put it in a category labeled miscellaneous. Upon completing the task, participants were asked to write down the decisions that appeared in each category on a category recording form and to label each category. This was done to discourage respondents to arrive at meaningless categories. Then the sorting task was repeated to enable us to assess reliability. Subsequently, respondents were asked to complete the DSQ and a personal information sheet inquiring about some demographic information. The order of tasks was counterbalanced. Thus, a group of 38 students completed the sorting task twice first, and then filled out the DSQ and the personal information (group 1) while the other 40 students completed the DSQ and the personal information sheet first, and then performed the sorting task twice (group 2).

Results

Aggregate Data

Because of the nature of the free sort technique, the sorting information was aggregated across individuals to produce a dissimilarity matrix for each group. Each entry in the matrix denoted the number of times (across participants and replications) that the two corresponding decisions were not sorted together in the same category. High numbers indicated that the sorters perceived high dissimilarity between two decisions, whereas low entries indicated low dissimilarity. Our interest in this study was to arrive at a representation of decision similarity common to relatively homogeneous individuals who had similar prior exposures to the decision items. We initially aggregated the data into two different groups because it is quite possible that those who completed the DSQ first might have utilized a different scheme to sort the decisions, having been influenced by the questions in the DSQ. Conversely, the sorting task might have introduced a certain bias in responding to the DSQ.

Participants appeared to sort the cards reliably. A measure of reliability, lambda, had a mean of .73 and .79 in the two groups, respectively. This means that knowing the result of an individual's first sort, there is 73% or 79% reduction in error (in comparison to random responses) in predicting the result of the second sort on average (Siegel & Castellan, 1988).

Hierarchical clustering The hierarchical clustering using between groups average linkage was conducted on the two matrices. Aldenderfer and Blashfield (1984) describes the average linkage clustering as "an antidote to the extremes of both single and complete linkage." It computes an average of the similarity of the decision item under consideration with all items in the existing cluster, and joins the item to that cluster if this value exceeds a specified level of similarity (Aldenderfer and Blashfield, 1984). Between-groups average linkage has been found on the average to recover the underlying clusters more accurately than other methods (Sneath & Sokal, 1973).

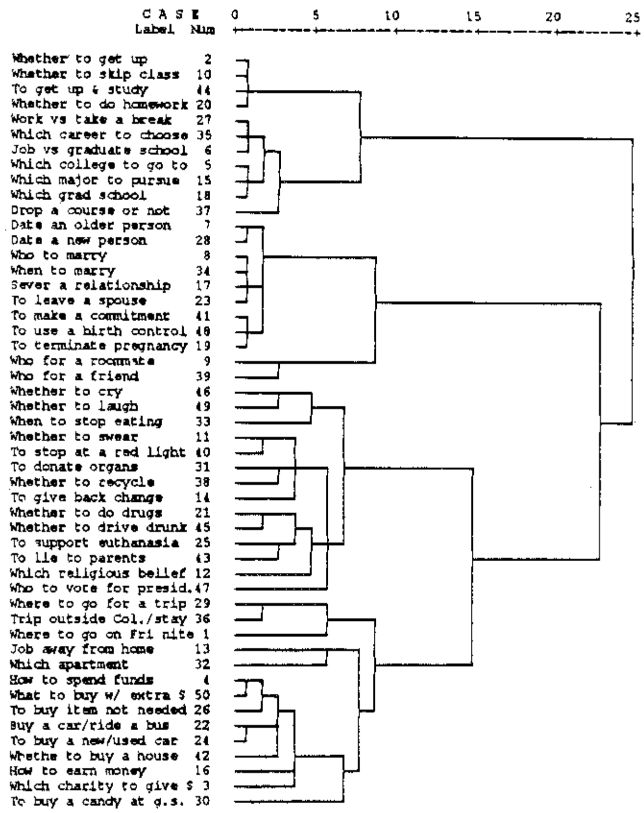

Figure 1: Dendrogram of hierarchical clustering solution

Four distinct clusters can be identified for both groups. The same items belonged in the same clusters for both groups, with only a minor difference in the order of clusters. Thus, the two groups were combined to create a 50 x 50 dissimilarity matrix for the whole sample. The dendrogram of the hierarchical clustering solution is shown in Figure 1.

The first cluster can be identified as school/professional decisions, which includes decisions such as which college to attend and whether to start working immediately after

Table 1: INDSCAL stress, R^2, and dimension weights for two-, three-, and four-dimensional solutions

Dimensionality	Group	Stress	R^2	Dimension weights			
				1	2	3	4
2	1	.184	.815	.61	.74		
	2	.204	.773	.62	.73		
3	1	.123	.890	.51	.55	.64	
	2	.131	.877	.52	.56	.62	
4	1	.107	.896	.43	.46	.52	.57
	2	.114	.882	.44	.46	.50	.57

graduation. Beneath this is a cluster concerned with relationships. It included some friendship-related items such as deciding who to have as friends, as well as some relationship items such as whether to leave a spouse of many years. The third cluster is a group involving non-deliberative decisions. A small sub-cluster included simple non-deliberative items such as whether to cry (after hearing your good friend died in an accident), and a larger sub-cluster included more value-laden items involving religious preference, drug use, and support of euthanasia. Finally, the last cluster can be identified as concerning monetary or consumer decisions. This cluster also included a range of items from whether to buy a candy bar to whether to buy a house.

Multidimensional scaling Given our interest in determining whether the sorting results can provide a basis for understanding the structure by which decisions are categorized in a psychological space, a multidimensional scaling (MDS) analysis was the next logical step. In MDS, it is assumed that judgments about stimulus similarity depend in some fashion on attributes of the stimuli; thus, its purpose is to identify those attributes (MacCallum, 1988). A three-way multidimensional scaling using INDSCAL was performed on the dissimilarity matrices for the two groups to determine whether the two groups indeed share a similar stimulus space, and if so, whether each dimension was weighted similarly (for a description of INDSCAL, see Arabie, Carroll & DeSarbo, 1987).

Two-, three-, and four-dimensional solutions were obtained to compare the fit of these solutions. Table 1 displays the Stress values, the proportions of variance accounted for (i.e., R^2) in the two groups, and the dimension weights for the two groups for all solutions. Because the Stress value and R^2 improved significantly from the two-dimensional solution to the three-dimensional solution but did not improve appreciably from three to four, the three-dimensional solution appeared to be most appropriate. Also, the dimensions in this solution seemed very interpretable, and the clusters found in the previous analysis appeared distinctively in the solution. This can be seen in Figure 2. Thus, the three-dimensional solution was retained for further analysis. The two almost overlapping needlepoints (labeled 1 and 2) in the middle of the stimulus

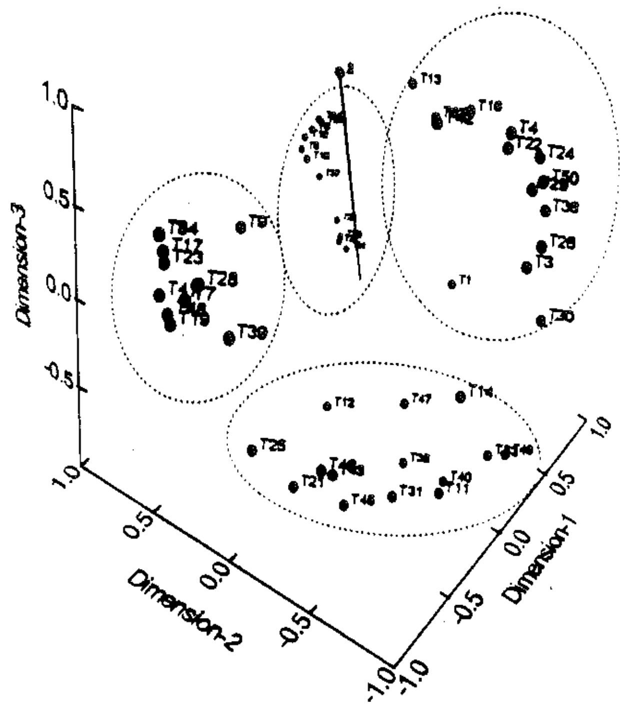

Figure 2: INDSCAL 3-dimension configuration

space indicate the centroids for the two groups. This, with the similarities in dimension weights for all solutions indicated that two groups had nearly identical representations of the decisions.

Linear regression for dimensional interpretations In order to determine whether the INDSCAL configuration extracted previously had some systematic associations with characteristics of the decision items, a sequence of linear regressions was performed. Kruskal and Wish (1978) describe this common method of performing a linear multiple regression, using a scale that measures a potentially relevant characteristic of the decisions (each of nine Likert-scale questions from the DSQ) as the dependent variable and the decision coordinates of the three-dimensional decision space as the independent variables because we "seek some weighted combination of the coordinates of the configuration which agrees with or

Table 2: Linear regressions of rated decision characteristics on dimensions of decision similarity

Rated Decision Characteristics (from DSQ)	Regression Weights (Direction Cosines) DIM 1	DIM 2	DIM 3	Mult. Corr.
1. Importance of making the decision	-.120	.927	.357	.767**
2. Length of time taken to make the decision	.041	.763	.645	.791**
3. Emotional involvement in making the decision	-.468	.804	.366	.813**
4. Pleasantness in making the decision	.500	-.424	.755	.499**
5. Information required to make the decision	.061	.758	.649	.772**
6. Difficulty in making the decision	-.020	.832	.554	.787**
7. Length to live w/ the consequences of the decision	-.246	.910	.335	.795**
8. Frequency w/ which to think of the effects	-.260	.871	.417	.800**
9. Frequency of previous similar encounter	.361	-.366	.451	.421*

** $p<.001$, * $p<.01$

'explains' the variable as well as possible." The first three columns of Table 2 show the optimum weights corresponding to each multiple correlation; these are the direction cosines, which are regression coefficients normalized for their sum of squares to equal 1.00 for every scale. Kruskal and Wish (1978) mention two necessary conditions for a scale to provide a satisfactory interpretation of a dimension: 1) the multiple correlation for the scale must be high, and 2) the scale must have a high regression weight on that dimension. As can be seen in Table 2, most rated decision characteristics, except for 4 and 9, had a multiple correlation greater than .75. Among those, three characteristics loaded high on the second dimension and relatively low on the other dimensions. These were the importance of making the decision, the length with which to live with the consequences of the decision, and the frequency with which to think of the effects of making this decision, all of which are related to the concept of (perceived) decision importance. None of the decision characteristics loaded high on the first dimension although emotional involvement loaded moderately on all three dimensions. Some items, which also loaded on the second dimension, loaded moderately on the third dimension. Thus, it appears that dimensions 1 and 3 did not correspond closely to the decision characteristics assessed by the DSQ. The patterns of loadings nevertheless provide some indications of what these two dimensions represent. Cluster 2 (dealing with relationships) was found on the lower end of dimension 1 while clusters 1 (school/career) and 4 (monetary) were found on the higher end. Along with a moderate loading of emotion, the first dimension may have to do with the professional-personal distinction Frisch, Jones and O'Brien (1993) found in their study (cited in Frisch & Clemen, 1994). On the other hand, length of time taken, information required, and difficulty in making the decision are loaded moderately on the third dimension, suggesting that it may be concerned with decision complexity; seeing the decision of whether to buy a candy bar (#30) on the lower end and that of who to marry (#8) on the higher end adds support to this interpretation.

Discussion and Conclusion

Our analysis identified three rather stable dimensions of decision similarity. One dimension appeared to correspond to the perceived importance of decisions. Another distinguished between professional and personal decisions. The last dimension seemed related to the complexity of decisions.

Our results succeeded in tying together two sets of results in decision making described in the introduction. One set of studies has shown that factors such as type of decisions (personal vs. professional), perceived decision importance, and decision complexity influence the choices people make above and beyond the effects of outcome and probability value. Presumably these factors affect decision outcomes because they trigger different decision strategies.

Another set of studies has shown that decision strategy selection is mediated by accuracy/effort maximization. Our results show that the factors that affect decision outcomes (i.e., type of decisions, perceived importance, complexity) are, in fact, dimensions of the space used by people to categorize decisions. This makes it very plausible that they would also be used as factors in the selection of decision strategies, in the sense that people would apply the same decision strategy to "similar" decisions and a different decision strategy to "different" decisions. It is important to note that the two groups who performed the sorting and the rating tasks in the different orders arrived at virtually the same similarity space, suggesting that the underlying dimensions are relatively stable.

Our results also have implications for other areas of cognitive science. For example, what if the factors that distinguish experts from novices showed up as a different dimension in the decision similarity space or as different weight of the same dimensions in the decision similarity space? Knowing the decision similarity space for experts should then facilitate the development of more faithful expert systems in AI. Also, the comparison of decision spaces of children vs. older people, as well as that of experts vs. novices may provide us with evidence about the evolving nature of decision processes.

The decision items included were limited to those that are commonly made (though not necessarily encountered everyday) in this particular population. Further exploration that targets different populations and different situations is needed to determine the generalizability of our results and to identify other factors that may affect decision strategy selection.

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