

IDENTIFICATION OF DETERMINANT ATTRIBUTES OF AUTOMOBILES: OBJECTIVE ANALOGUES OF PERCEPTUAL CONSTRUCTS

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It is well established that consumers use a set of determinant attributes in making choices among available alternatives. While the knowledge of determinant perceptual attributes (e.g., comfort rather than length and width of a car) may be sufficient to promote cars, it is equally important for the engineering managers to know the corresponding objective (design) attributes. Information about determinant objective attributes is useful to managers in redesigning products to enhance consumer satisfaction. Such clear definition of objective determinant attributes is also valuable to the consumer researchers for estimating quality, utility, and attitude towards new cars. This study identifies nine determinant objective attributes on new cars which effectively tap the determinant perceptual constructs elicited from new car buyers.

INTRODUCTION

Consumers may not use all attributes for making decisions to buy a particular product. There is a considerable amount of agreement for using determinant attributes of products to measure overall consumer attitudes (Alpert, 1971; Wilkie and Pessemier, 1973) and to estimate utility functions. Alpert (1971) reported that "those attributes projected by the product's image which lead to the choice of that product may be called determinant, since they determine preference and purchase behavior." The utilization of determinant attributes not only results in parsimony, but also is a desirable feature for cross-sectional analysis of data. Determinant attributes of a product may be either perceptual (e.g., comfort of a car) or objective (e.g., width and length of a car). Perceptual attributes can be represented by corresponding objective attributes (Nelson, 1981; Hauser and Clausing, 1988). For example, copy quality in photo copiers can be represented by objective attributes such as darkness, streaks, width of line etc., (Narasimhan and Sen, 1989).

Although knowledge of determinant perceptual attributes is important in promoting cars, it is equally important for the engineering managers to know the corresponding objective (design) attributes to enable

them to modify a product. This study identifies determinant perceptual attributes of new cars in the language of consumers and then translates them into corresponding objective (design) attributes.

BACKGROUND

Traditional approaches to the identification of determinant attributes of a product include direct and indirect questioning, observation and experimentation (see Alpert, 1971 for a comparison of these methods). Perhaps the most common and easily applied approach is direct questioning where the researcher gives the respondents a list of objective attributes and asks them which determined their choice. A problem with this approach is that the respondents may not be able to respond accurately because of the difficulty in translating objective attributes into corresponding perceived benefits. For example, it may not be easy for a respondent to imagine how the number of cylinders and engine displacement in an automobile translate into engine performance.

Armstrong and Hosseini (1994) suggest the Analytic Hierarchy Process to identify determinant attributes. Their approach overcomes potential problems of traditional direct questioning methods. Another approach is to identify determinant objective attributes of a product by using multidimensional scaling. In this article, we are not concerned about comparing various methods of identifying determinant attributes. Such comparisons may in any event be problematic in view of Alpert's (1971) observation that no consistent, validated

standard exists for assessing the relative efficacy of different methods. Instead, we attempt to identify determinant objective attributes of new cars which can provide a basis for the engineering managers to modify cars and deliver attributes that consumers demand.

Using Kelly's Repertory Grid Technique, this study identifies determinant objective attributes of new cars. In brief, this is achieved in two stages. The first involves generating salient perceptual constructs of a chosen product using Kelly's Repertory Grid technique. The second step involves applying an analytical procedure to translate the salient perceptual constructs into their corresponding determinant objective attributes.

KELLY'S REPERTORY GRID

Kelly's Repertory grid test (Kelly, 1955) has extensively been used by British market researchers to generate attribute lists. This technique has also been applied by the U.S. researchers (e.g., Sampson, 1972; Horsky and Nelson, 1992). The repertory grid test, henceforth labeled as KRGT, is a valuable tool because it allows a researcher to generate perceptual constructs of the products being evaluated in the language of consumers. It is based on Kelly's (1955) fundamental postulate: "A person's processes are psychologically channelized by the ways in which he anticipates events" (p. 46). Kelly defines a construct as "a way in which some things are construed as being alike and yet different from others" (p. 105). Several marketing studies suggest that the attributes included in the measurement of attitudes must reflect consumers' perceptual dimensions rather than objective product characteristics which are directly measurable (c.f., Wilkie and Pessemier, 1973). The basis for such an argument is that perceptual dimensions are closer than objective external indicators of product attributes or performance to actual consumer preference or choice.

Once a product's salient perceptual constructs are obtained through the KRGT, the next step involves the statistical translation of these constructs into their corresponding objective attributes. To the authors' knowledge, there is not a single published study that uses such a technique to develop determinant objective attributes that reflect perceptual dimensions derived from the KRGT. This following section applies these principles and methods in the context of consumers' automobile purchase decisions; it describes a repertory grid procedure to obtain salient perceptual constructs and develops a method to identify determinant objective analogues of those perceptual constructs.

IDENTIFYING AUTOMOTIVE DETERMINANT ATTRIBUTES

Method

A convenience sample of twenty-nine new car buyers was selected from the Metropolitan Statistical Area of Buffalo, New York. This is considered an adequate sample size for the KRGT in view of Frost and Braine's (1967) suggestion that 20 to 40 interviews are generally sufficient to exhaust the repertory of constructs. The interviews were conducted at the respondents' homes. Interviews lasted an average of 90 minutes with a range of 45 to 120 minutes.

Each respondent was shown a set of 37 pictures of cars sold during the model year in which the respondents purchased their cars. Cars of all sizes (subcompact, compact, midsize, etc.) were included to represent the automobile market. The number of cars picked from each size class was based on the market share of the size classes. The car pictures were obtained from *Ward's Automotive Year Book*. To avoid any misrepresentation, all the car pictures were reduced to the same size. To prevent damage to the car pictures, they were inserted in plastic covers and stacked together like a deck of cards for presentation to respondents. Model name and make of the manufacturer were indicated on the car pictures. For the convenience of recording the responses, each car was given an identification number. The respondent was asked to pick about twenty models with which s/he was most familiar. The less familiar models were not considered throughout the rest of the interview.

The next step involved showing a set of three cars drawn randomly from the set of familiar vehicles the respondent had previously picked. The respondent was asked to look at these three car pictures and think of a way in which any two cars could be similar to each other and yet different from the third car. Then the respondent was asked how the third car could be different from the other two cars which were similar. To illustrate this, assume that the respondent reported that cars X and Y (out of three cars X, Y and Z) were similar because both appeared very sporty. Then the respondent would have been asked to tell how the third car (Z) is different from X and Y. S/he might then have described Z as less sporty than X and Y. In this case, the construct elicited would be "sportiness," with the two opposite poles of "least sporty" and "most sporty." The elicited construct might then be represented on a five-point scale as follows:

Least Sporty 5 : 4 : 3 : 2 : 1 Most Sporty

Kelly assumes that such constructs are bipolar in nature. For example, the construct "size of car" can be treated as bipolar, with the two poles being "small" and "large." Despite this assumption, unipolar items such as "less luxurious - more luxurious" can also be accommodated, since the practical implications of the difference between bipolar and unipolar scales are not substantial in this context (Sampson, 1972).

Once a construct was obtained, the next step involved rating all the familiar cars on a five-point scale. For example, if the construct elicited was "sportiness," the respondent might be asked to sort out and place the most sporty cars on one side, the least sporty cars on the other side, and the rest of the cars in between those two groups based on his/her judgment. This information was then recorded on a separate sheet.

To elicit more constructs, a second set of three vehicles was randomly drawn from the "familiar car" deck and the respondent was again asked to compare them. If the new set of three cars was already drawn, then the interviewer would randomly pick another set of three cars. The process of eliciting another construct and the rating of the cars on the new construct was repeated in the manner described earlier. The respondent, however, was told not to compare the new set of three cars on the previously elicited constructs. In such cases, the respondent was asked to think of another way in which two of the three cars are similar but different from the third car. Similarly, more constructs were obtained by randomly drawing another set of three cars and repeating the above procedure. The process was repeated until the presentation of different sets of vehicles no longer elicited new constructs. The average number of constructs elicited was 11 with a range of 7 to 14.

Analysis

From the repertory grid data, the salient perceptual constructs elicited by the respondents were identified. Because these perceptual constructs might be correlated, factor analysis (using principal components analysis) was performed on all the salient perceptual constructs. For the factors selected (based on the scree test), factor scores were computed. Each of the factors represents a set of perceptual constructs. Objective information on each of the 37 vehicles with respect to 51 attributes was gleaned from *Consumer Reports* and *Ward's Automotive Year Books*. To identify those objective attributes which correspond to the salient perceptual constructs derived from the KRGT, each of the 51 objective attributes was regressed on the factor scores of the perceptual constructs obtained from the

principal components analysis. The objective attributes which were significantly related to one or more of the factors representing the perceptual constructs were chosen as the determinant attributes. Since several objective characteristics were correlated (e.g., length and gas mileage), only uncorrelated objective characteristics were finally selected as the determinant attributes. To validate the procedure for transforming the KRGT perceptual constructs obtained through the KRGT into their objective analogues, canonical correlation analysis was done between the final set of perceptual constructs and the determinant objective attributes.

Results

The nature of the perceptual constructs elicited from the KRGT and their frequencies, obtained from the respondents, are shown in Table 1. Similar constructs (e.g., trunk space, luggage space) were combined into one category to avoid duplication. Some constructs were more often elicited by the respondents than the others. However, for cross-sectional analyses it is not meaningful to use all 44 constructs, especially those with a very low frequency (since they are not perceived by most of the respondents). In order to make the model more parsimonious, only those constructs with a frequency of more than eight were considered as salient perceptual constructs. The procedure thus eliminated most of the idiosyncratic constructs noted by very few persons. Based on this procedure, the first sixteen constructs shown in Table 1 were considered as salient and were used in the subsequent analysis.

Having developed a list of salient perceptual constructs using the KRGT, the final step involved identifying the determinant objective attributes. The list of the objective characteristics of the 37 cars culled from *Consumer Reports* and *Ward's Automotive Year Books* appears in Table 2. Strictly speaking, not all the attributes listed in Table 2 are truly objective in nature. For example, physical characteristics such as length, engine displacement and fuel tank capacity are more objective in nature (as they are measurable on a physical scale) than attributes such as front-seat comfort and ride (which cannot be measured directly on a physical scale). Myers and Shocker (1981) define the former type (e.g., length of car) as physical characteristics and the latter type (e.g., seat comfort) as pseudo-physical characteristics. They consider physical characteristics to be objective in nature because they reflect physical properties that are generally understood by both manufacturers and consumers. We also treat pseudo-physical characteristics as objective in nature, since we are able

TABLE 1
FREQUENCIES OF CONSTRUCTS ELICITED FROM KELLY'S GRID

Constructs	Frequency of Elicitation	Constructs	Frequency of Elicitation
1. Size	25	23. Aerodynamics	4
2. Price	25	24. Number of doors	2
3. Sportiness	23	25. Resale value	2
4. Gas mileage-expressway	22	26. Number of options	2
5. Foreign or domestic	18	27. Durability	2
6. Acceleration/pickup	17	28. Number of cylinders	2
7. Handling	14	29. Technology	2
8. Comfort	13	30. Interior design	2
9. Luxury	13	31. Front or rear wheel	2
10. Reliability	11	32. Mfr. reputation	1
11. Safety	11	33. Braking	1
12. Style	10	34. Insurance costs	1
13. Quality	10	35. Functional (for pleasure or business)	1
14. Internal roominess	10	36. Center of gravity	1
15. Trunk space	9	37. Level of advertising	1
16. Engine power	8	38. Warranty	1
17. Image/status	7	39. Convenience	1
18. Single person-family car	6	40. Carrying capacity	1
19. Design	5	41. Sound system	1
20. Popularity	5	42. Weight	1
21. Younger or older people	5	43. Conservative/Tradition	1
22. Ride	4	44. Back space	1

to use *Consumer Reports'* scientifically generated evaluation scores as input data for purposes of analysis.

The emerging data set, then, was comprised of the ratings of the 37 cars on the 51 objective attributes and the respondents' ratings of the familiar vehicles on the salient perceptual constructs (based on the five-point scales emanating from the KRGT). For tractability, the missing responses on the ratings of the salient perceptual constructs were replaced by the mean values of each of the 37 models of cars.

To overcome the problem of collinearity between the perceptual constructs, factor analysis was done to develop a set of orthogonal factor scores. Principal components analysis of the sixteen salient constructs (with VARIMAX rotation) yielded five factors based on the scree test. These five factors explained eighty percent of the variance in the data matrix. The eigenvalues of the factors are presented in Table 3. The factor loading matrix of the sixteen constructs is shown in

Table 4. Based on the factor loadings, the factors were labeled as comfort and luxury, performance, sportiness, reliability and gas mileage. Factor scores were computed for each of these five factors.

The final step involved selecting noncorrelated objective analogues that best represented the perceptual constructs which were obtained from the KRGT. This was done first by regressing each of the 51 objective attributes with the five orthogonal factor scores representing the salient perceptual constructs. An objective attribute, the dependent variable in the regression equations, was identified as determinant if it had at least one significant regression coefficient representing a perceptual-construct factor. Based on this decision, nine of the objective attributes emerged as determinant. However, since most of the objective characteristics were correlated, only those which were uncorrelated were selected. The results of the regressions of the chosen determinant objective attributes are presented in Table 5. The regression results suggest good

TABLE 2
EXHAUSTIVE LIST OF OBJECTIVE CHARACTERISTICS

1. Wheel base	27. Emergency handling*
2. Overall length	28. Braking
3. Overall width	29. Ride*
4. Front shoulder-room	30. Noise*
5. Maximum front leg-room	31. Driving Position*
6. Front head-room	32. Front seating*
7. Rear shoulder-room	33. Rear seating
8. Rear Fore-and-aft seating room	34. Heating*
9. Rear head-room	35. Ventilation*
10. Door top to ground	36. Air conditioning*
11. Turning circle in feet	37. Controls*
12. Steering factor	38. Displays*
13. Curb weight in pounds	39. Trunk
14. Tire size	40. Safety
15. Engine displacement	41. Bumpers
16. Number of cylinders	42. Reliability*
17. Net horse power	43. List price
18. Transmission auto or manual	44. Luggage volume in cubic feet
19. Acceleration from 0 to 60 mph-in seconds	45. Gas mileage-city driving
20. Acceleration at the end of 1/4 mile in mph	46. Gas mileage-expressway driving
21. Passing time 45-65 mph in second	47. Cruise range in miles
22. Starting and running*	48. Braking-from 60 mph with no wheels locked
23. Acceleration	49. Braking-initial half G stop-pedal effort
24. Transmission*	50. 10 th successive stop pedal effort
25. Economy	51. Fuel tank capacity in gallons
26. Routine handling*	

Note: * The Consumer Reports rates these attributes on a five point scale with 1 as 'Poor' and 5 as 'Excellent'.

correspondence between the objective analogues and the perceptual constructs. For example, it seems that "performance" (a perceptual construct) can be represented by two objective attributes -- acceleration and routine handling. Similarly, the "luxury and comfort" factor may be represented by rear leg room, front seating and ride. The final list of the determinant objective attributes is presented in Table 6.

To see if there are any strong relationships among the determinant objective attributes, a test for multicollinearity was conducted. Each of the determinant objective attributes was regressed with the rest of the seven attributes. The results obtained from the regressions are shown in Table 7. The R^2 values seem to be low enough to rule out any multicollinearity among the chosen determinant objective attributes.

Finally, to validate the above procedure of transforming the salient perceptual constructs into the corresponding objective attributes, canonical correlation analysis was performed with the sixteen perceptual constructs as the criterion set and the determinant attributes as the predictor set. It may be noted that, though the sixteen perceptual constructs are correlated, it is permissible to use correlated variables as the criterion set in canonical analysis. The results of the canonical correlation analysis are shown in Table 8.

Based on the canonical correlation of the first canonical function, we can say that the two sets of linear composites account for (0.6451) or 41.6 percent of the shared variation between the two sets of variables. Furthermore, the second canonical function explains (0.2541) or 6.3 percent of the shared variance between the two sets of variables. To test the null hypothesis that the set of criterion variables (perceptual constructs) is

TABLE 3
EIGENVALUES OF THE FACTOR ANALYSIS OF 16 CONSTRUCTS

Factor	Eigenvalue	Cumulative percent of Variance
1	6.10	40.0
2	3.23	62.3
3	1.44	71.9
4	0.66	76.3
5	0.53	79.9
6	0.48	83.2
7	0.42	86.0
8	0.37	88.5
9	0.33	90.7
10	0.28	92.7
11	0.26	94.4
12	0.24	96.1
13	0.21	97.5
14	0.21	98.0
15	0.16	100.0

TABLE 4
FACTOR ANALYSIS OF THE PERCEPTUAL CONSTRUCTS
(VARIMAX ROTATED FACTOR LOADING MATRIX)

Construct	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Comfort	.88890	.09504	.15250	.06859	.08200
Luxury	.82727	.27733	-.03478	.03625	.22550
Safety	.77658	.03223	.34311	.08914	.22910
Size	.76625	-.05280	.26992	-.09689	.32060
Internal Roominess	.73153	-.01672	.42631	.08332	.29130
Quality	.67646	.48855	-.11971	.23218	-.07370
Style	.58990	.49467	-.42738	.04464	.07830
Engine Power	.58225	.33143	-.12923	.17478	.52620
Handling	.13870	.90983	-.08776	.07000	-.00650
Acceleration	.07559	.79970	-.31203	.03950	.14970
Sportiness	-.08165	.41571	-.76560	.11820	.03800
Trunk Space	.40133	.15145	.74804	.09410	.17920
Foreign or Domestic	.08178	.03636	.10692	-.89960	.06650
Reliability	.35006	.26313	.14670	.73440	.00370
Gas Mileage	-.34838	-.04734	-.12989	.13838	-.84260

Labels for Factors

Factor 1: Comfort and Luxury

Factor 2: Performance

Factor 3: Sportiness/lesser Trunk capacity

Factor 4: Reliability

Factor 5: Gas Mileage

TABLE 5
REGRESSIONS OF THE SELECTED OBJECTIVE ATTRIBUTES WITH
THE FIVE FACTOR CONSTRUCTS

Objective Analogue (Dependent Variable)	R ² (Adjusted)	Significant Factor Construct (Significant Regression Coefficient)
1. Rear leg room	0.28226	Luxury and Comfort (9.321)*
2. Acceleration	0.25053	Performance (8.163)
3. Routine Handling	0.28719	Performance (1.800)
4. Ride	0.44451	Luxury and Comfort (19.586)
5. Front Seating	0.23472	Luxury and Comfort (10.283)
6. Luggage Capacity	0.20979	Sportiness and Trunk (5.340)
7. Reliability	0.63710	Reliability (27.397)
8. Gas Mileage	0.57879	Gas Mileage (12.454)

* t values are given within parentheses.

TABLE 6
LIST OF THE DETERMINANT OBJECTIVE ATTRIBUTES

1. Price	6. Routine Handling
2. Reliability	7. Ride
3. Gas Mileage	8. Front Seating
4. Rear leg room	9. Luggage Capacity
5. Acceleration	

TABLE 7
CHECK FOR MULTICOLLINEARITY AMONG THE
FINAL DETERMINANT OBJECTIVE ATTRIBUTES
(Results from Multiple Regressions)

Dependent variable	Independent variables	R ² (adjusted)
1. Gas mileage	All the remaining attributes	0.30700
2. Reliability	All the remaining attributes	0.38304
3. Ride	All the remaining attributes	0.11888
4. Routine handling	All the remaining attributes	0.24239
5. Luggage volume	All the remaining attributes	0.41962
6. Rear leg room	All the remaining attributes	0.27094
7. Acceleration	All the remaining attributes	0.20447
8. Front seating	All the remaining attributes	0.25315

TABLE 8
RESULTS OF THE CANONICAL CORRELATION ANALYSIS
BETWEEN THE SALIENT PERCEPTUAL
CONSTRUCTS AND THE DETERMINANT OBJECTIVE CHARACTERISTICS

	Canonical correlation	Bartlett's test for remaining eigenvalues		
		Chi square	D.F	Tail prob
Function 1	0.64518	210.17	6	0.000
Function 2	0.25210	22.85	2	0.000

unrelated to the set of predictor variables (objective characteristics), Bartlett's Chi-square test was used. Since Bartlett's Chi-square value is highly significant (see Table 8), we can conclude that the salient perceptual constructs are significantly related to the determinant objective attributes. Thus, the procedure employed for translating the perceptual constructs into their objective analogues is justified.

In summary, our study developed a list of nine determinant objective attributes for automobiles using Kelly's repertory grid technique. The following is the list of determinant objective attributes for automobiles (with the perceptual constructs for which they serve as analogues appearing in parentheses): price (perceived price); reliability (perceived reliability); gas mileage (perceived gas mileage); rear leg room, ride and front seating (perceived luxury and comfort); acceleration and routine handling (perceived performance); and luggage capacity (perceived sportiness and trunk). *Consumer Reports* publishes objective measures for each of these attributes.

CONCLUSIONS

The objective of this study was to identify determinant objective attributes of new cars based on perceptual attributes elicited in the language of consumers. This paper presents not only a complete repertory grid analysis but also a procedure for translating perceptual constructs into objective attributes. This study identifies the following nine objective attributes of new cars as determinant in consumers' decision making process: price, reliability, gas mileage, rear leg room, ride, front seating, acceleration, routine handling, and luggage capacity. Automobile manufacturers can use the knowledge of objective determinant attributes as a basis for

redesigning their cars to improve customer satisfaction. Identification of determinant objective attributes is also useful for the operationalization of choice models and for the estimation of utility functions and objective quality.

The procedure suggested in this paper is most appropriate where perceptual constructs can be represented in terms of their objective physical dimensions. For example, this procedure is less useful for food products, as it is difficult to translate constructs such as "tasty" and "spicy" into consistent physical ingredients of the products. It may be seen from Table 2 that, except for "sportiness" and "style," the first sixteen perceptual constructs seem to have their objective analogues that could be represented by the physical dimensions of automobiles. As observed by Pessemier and Wilkie (1977) and Myers and Shocker (1981), it is difficult to represent perceptual constructs such as styling of a car into meaningful physical dimensions. Given this limitation, ideally, the attributes "sportiness" and "style" should be added to the list of determinant attributes shown in Table 6.

Limitations and Suggestions for Future Research

While the use of KRGT to identify determinant objective attributes of products represents an apparent advance over common attribute-selection practices, it is not without limitations. The process is constrained by the respondent's ability to verbalize salient perceptual constructs. Future investigations should focus on the statistical properties and interpretive insights associated with the use of KRGT-generated determinant attributes in attitude, choice and utility models. Using different samples, this study may also be replicated to check for the convergency of results.

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