Volume 58 Number 1 Spring 1982

Situational Psychophysics and the Vending-Machine Problem

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Vending machines provide a mechanism well suited to adjusting the sensory aspects of the consumption experience according to preferences in contrasting shopping situations. This paper proposes a method useful in the investigation of situational psychophysics and illustrates its application in a study of the situational determinants of responses to systematic variations in the formulation of a beverage. Such situational moderators of psychophysical response suggest applications to the use of vending machines in retail shopping environments.

Vending machines provide the retailer with an effective, automated mechanism uniquely suited for tailoring product formulations to match differing customer needs and wants. When dispensed via a vending machine, the same ingredients may be mixed in varying proportions to satisfy a wide spectrum of consumer preferences. One classic example is the vending of hot coffee, which can automatically be mixed with different levels of cream and sugar to be selected by the push of a button. A second is the pumping of gasoline, where devices have been designed to provide different octane levels from the same pump. A third is the "extra ice" button that often appears (but seldom works) on soft-drink machines.

The flexible use of vending machines to cater to differing customer wants offers a broad array of possible applications limited only by the retailer's imagination. One use might be to adjust product formulations to differences in preference caused by the influence of situational factors. This paper focuses on the methodological underpinnings of such an application by presenting an approach to the study of situational differences in psychophysical response.

NEGLECTED FACTORS IN THE SHOPPING ENVIRONMENT

Situational influences on consumer behavior have recently fallen under the intense scrutiny of marketing researchers (Belk 1974, 1975a, 1975b, 1976). Sandell (1968) presented a pioneering demonstration of situational effects; more recent research has attempted to provide explicit models integrating situational factors into formal representations of attitude structure (Berkowitz, Ginter, and Talarzyk 1977; Holbrook 1981b; Miller 1975; Miller and Ginter 1979; Warshaw 1980). Clear evidence has accrued to support the proposition that consumer preferences often depend heavily on the nature of the consumption situation. Moreover, as discussed elsewhere in this issue (Donovan and Rossiter 1982; Holman and Wilson 1982), situational effects also apply in a retail setting. The definitions of purchase situations are likely to hinge on the nature of consumption-related life styles and to involve considerations of the ways consumers spend their discretionary time (Hawes 1977), the kinds of leisure activities they engage in (Holbrook 1980; Holbrook and Lehmann 1981), and the kinds of entertainment they prefer (Andreasen and Belk 1980; Batsell 1980). A jogger, for example, may prefer a beverage different from that sought by a swimmer. A downhill skier might develop a craving for cocoa while someone going cross-country might work up a desire for cold chocolate milk. Strategically located vending machines could do a lot toward satisfying these differing needs, and those proffering flexible product formulations could adjust mixtures of ingredients or design features to take account of situational influences.

This conceptualization of the *vending-machine problem* raises some important methodological questions. Foremost among these is how perceptions of (and preferences toward) differing product formulations vary across different situations. Most fundamentally, this concerns how sensory impressions (and their evaluative interpretations) depend on situational influences and raises a set of problems that we shall refer to as *situational psychophysics*.

Though well developed as an area of psychological inquiry (Amerine, Pangborn, and Roessler 1965; Baird and Noma 1978), sensory research has inspired remarkably little interest among investigators of consumer behavior. Since the early work of Day (1968; Kuehn and Day 1962) and Benson (1966), only a smattering of major articles in the marketing literature has dealt with modeling the sensory aspects of products (Srinivasan 1975; Huber 1974, 1975; Moskowitz, Jacobs, and Firtle 1980; Holbrook 1981a). Instead, interest has focused primarily on developing models of attitude or evaluative judgment, assumed to result directly in choice commitments. The outcome has been a gap in our understanding of the ways in which objective brand characteristics are tied to ultimate preferences through the intervening effects of sensory impression.

The purpose of this paper is to further explore such sensory issues—in particular, to examine the question of how sensory impressions reflect differences in product formulations (the vending-machine problem) and how such relationships depend on situational factors (situational psychophysics). We shall draw on an illustration that applies a method for conducting situational psychophysics to the case of a beverage evaluated under different circumstances. First, the method, as illustrated by this application, will be described. Next, the results of this example will be reported. Finally, their implications for the use of situational psychophysics to address the vending-machine problem will be discussed.

METHOD

Product Variations

The product investigated was a citrus beverage that varied in its levels of the following three ingredients:

Ingredient	*Levels*	*Description*
Sweetener	Low	X
	Medium	1.25X
	High	1.50X
Flavor	Low	Y
	High	1.67Y
Acidity	Low	Z
	High	1.88Z

These levels of each ingredient were combined in all 3 X 2 X 2 possible ways to create 12 product variations, comparable to the array of choices that might be available from a well-programmed vending machine. Unlike the ingenious study by Shimp and Yokum (1982), our budget did not permit the use of actual vending equipment. Instead, the beverage was prepared in 12 batches, kept at 45 to 50°F (to control for temperature-taste interactions), and served to subjects in paper cups (similar to those normally dispensed from vending equipment).

Subjects

In accord with the illustrative purposes of the present example, 54 subjects were drawn from a university population. These subjects ranged in age from 19 to 25 years and were relatively homogeneous with respect to cultural eating patterns, socioeconomic status, and intelligence—so that factors were held constant that might otherwise have influenced results. They were asked to eat nothing for at least two hours prior to performing the experimental task.

Experimental Task

The experimental task collected graded paired comparisons on similarity of refreshment for all 66 possible pairs of the 12 stimuli. To minimize order-effect biases, the pairs were randomly divided into nine groups. Each group was judged in a separate experimental session. The sessions occurred twice a week, began at 1 P.M., and involved no more than eight pairwise comparisons on any one occasion.

In performing a paired comparison, the subject first tasted the beverage in the cup on the right, swirling it in the mouth for about 4 seconds before ejecting it and rinsing with distilled water. After 25 seconds, the same routine was followed with the beverage on the left. The pair was then judged for similarity by placing a check mark on a 5-inch line anchored at "exactly the same" and "most different" in ability to provide refreshment. These check marks were scored by ruler measurements from 1 to 99 and assigned a positive (negative) sign if the beverage on the right (left) was judged as more refreshing.

Four minutes elapsed before the next paired comparison was made. This time interval between judgments helps to avoid the adaptation effects that may result from recent experience with similar (McBurney and Lucas 1966) or dissimilar (McBurney and Bartoshuk 1973) stimuli. An interval of 4 minutes has been suggested by Schiffman, Reynolds, and Young (1981) to guard against such biases. The procedure was also designed to avoid satiation effects by preventing subjects from swallowing the beverage. This prevents the bodily absorption of ingredients from contaminating judgments of subsequent beverage samples.

Situational Conditions and Assignment to Treatments

In order to explore the influence of an important situational factor, the subjects were assigned randomly to one of two treatment conditions. The active group (n = 28) performed 15 minutes of vigorous exercise just prior to engaging in the tasting task. By contrast, the inactive group (n = 26) simply provided the taste comparisons without first participating in any prescribed physical activity.

Analysis

Sensory responses and the effects of situational moderators were investigated by the use of a regression-based analytic scheme analogous to the componential segmentation developed by Green and DeSarbo (1977). In this analysis, dummy variables are coded to represent levels of the various ingredients and interactions both among levels of ingredients and between ingredient levels and the situational manipulation. The difference in our approach is that, here, the analysis involves the use of graded paired comparisons rather than the more straightforward single-product ratings or rankings typically employed in conjoint analysis. To handle the graded comparisons data, the procedure first proposed by Scheffé (1952) and subsequently used in various forms by Pessemier and Teach (1968), Huber and James (1976), and Bechtel and O'Connor (1979) is modified to fit the regression-analytic framework in the manner developed by Huber and Holbrook (1980, 1981).

Specifically, a covert measure of sensation (s_i) toward stimulus i is assumed to be related to ingredient levels (x_{ik}) by the following expression:

$$s_i = \sum_k x_{ik} \cdot v_k + \sum_{k'} x_{ik'} \cdot v_{k'} + \sum_{k''} x_{ik''} \cdot v_{k''} + \sum_k c \cdot x_{ik} \cdot w_k + \sum_{k'} c \cdot x_{ik'} \cdot w_{k'} + \sum_{k''} c \cdot x_{ik''} \cdot w_{k''} \quad (1)$$

where x_{ik} ($k = 1, \ldots, 4$) is a set of four indicator (-1, 0, +1) variables specifying the values of stimulus i on the one three-level and two two-level ingredients; $x_{ik'}$ ($k' = 1, \ldots, 5$) is a set of five indicator variables representing the two-way interactions between ingredient levels; $x_{ik''}$ (k'' = 1, 2) similarly indicates the three-way ingredient interactions; c is a dummy variable representing the physically inactive (-1) and active (+1) situational conditions; v_k, $v_{k'}$, and $v_{k''}$ indicate the main effects, two-way interaction effects, and three-way interaction effects respectively; and w_k, $w_{k'}$, and $w_{k''}$ represent changes in these main, two-way, and three-way effects due to the situational manipulation (i.e., moderator effects associated with level of physical activity).

The indicator variables were defined using the following rules: (1) for the variables defined at two levels (acidity, flavor, and activity), the indicator variables has a value 1 when the aspect is present and -1 otherwise; (2) for the three-level variable (sweetener), the transformation follows the specification shown below.

	Indicator variables	
	High sweetener (X_{i1})	*Moderate sweetener* (X_{i2})
Sweetener level		
High	1	0
Moderate	0	1
Low	-1	-1

The justification for using indicator variables rather than dummy (0-1) variables is that the results of a standard regression with indicator variables correspond more closely to a fixed-effects analysis of variance (Neter and Wasserman 1974, page 633).

Given the implicit model, an observed graded paired comparison (GP_{ij}) is assumed to depend on the difference in sensory response between stimuli i and j:

$$GP_{ij} = s_i - s_j + e_{ij} \tag{2}$$

where e_{ij} is an error term assumed to be independently, identically distributed.

Combining equations 1 and 2 results in the following explicit model based upon observable variables:

$$GP_{ij} = \sum_{k} (x_{ik} - x_{jk}) \cdot v_k + \sum_{k'} (x_{ik'} - x_{jk'}) \cdot v_{k'} + \sum_{k''} (x_{ik''} - x_{jk''}) \cdot v_{k''} + \sum_{k} c \cdot (x_{ik} - x_{jk}) \cdot w_k + \sum_{k'} c \cdot (x_{ik'} - x_{jk'}) \cdot w_{k'} + \sum_{k''} c \cdot (x_{ik''} - x_{jk''}) \cdot w_{k''} + e_{ij} \tag{3}$$

where the v_k and w_k terms indicate the effects on sensory impressions of ingredients, ingredient interactions, and situational moderators and are estimated by ordinary least-squares regression analysis.

One should note what this kind of analysis can and cannot reveal. Since the data are derived from differences in "refreshingness" of each pair, they cannot indicate whether the stimuli in general are perceived to be more or less refreshing by the subjects who did and those who did not exercise. What can be revealed, as shown above, are patterns of *relative* preference differences across groups. In a retail context, for example, a store owner might use the graded pairs technique on a group of shirts. While the analysis would indicate those most preferred, it would not reveal whether any would be purchased. However, this lack of an anchor on the scale can be remedied rather easily. In the example, the scale could be anchored by asking direct purchase likelihoods on the shirts most and least liked in the set. Though straightforward, this refinement was not included in the present study.

RESULTS

Table 1 gives the results of applying the situational psychophysics model given by equation 3 to the beverage data. The fit of this equation pooled across subjects was $R^2 = .19$, reflecting substantial heterogeneity across tasters. By contrast, if GP_{ij} is first averaged across subjects, the R^2 for the same equation is .95. The coefficients have meaning in terms of differences between pairs of stimuli. For example, the average difference in perceived refreshment between a stimulus that had high sweetener (value = 8.8) and one with medium sweetener (value = -2.1) is 10.9.

TABLE 1

Results of Regression Model of Taste Data

	Main effects		*Interactions with activity*	
	B	Standard error	B	Standard error
High sweetener (HS)	8.8[a]	.83	1.4[b]	.83
Medium sweetener (MS)	-2.1[a]	.83	0.1	.83
Flavoring (FL)	1.0[b]	.59	-0.8	.59
Acidity (AC)	-14.5[a]	.59	-0.9	.59
HS x FL	5.7[a]	.83	-1.8[a]	.83
HS x AC	4.1[a]	.83	0.8	.83
MS x FL	-1.0	.83	-0.1	.83
MS x AC	-2.1[a]	.83	0.4	.83
FC x AC	-0.8	.59	0.3	.59
HS x FC x AC	2.6[a]	.83	0.6	.83
MS x FL x AC	-4.7[a]	.83	0.0	.83

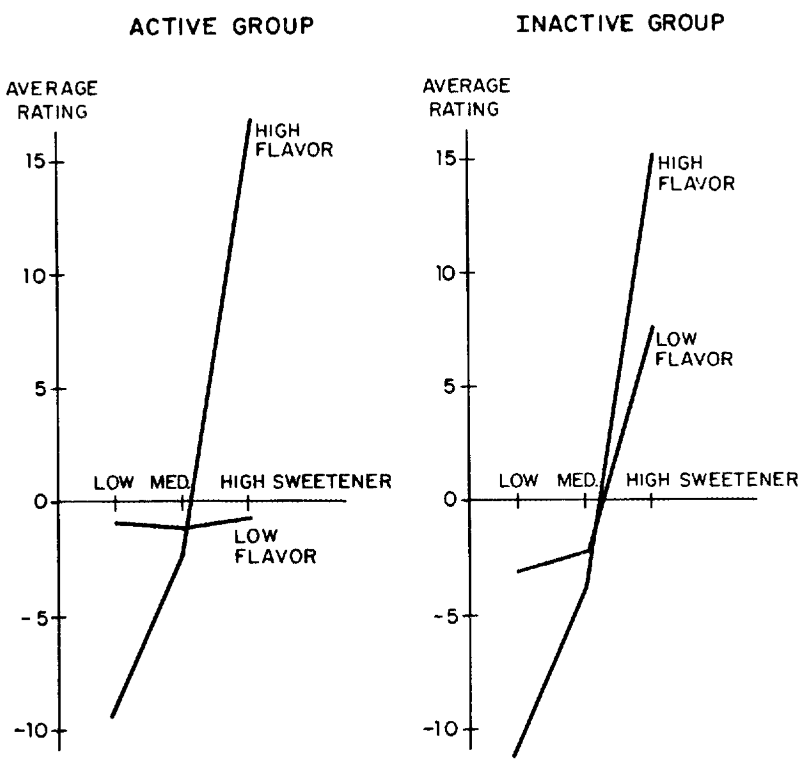
[a] $p \leq .05$ ($F_{1,3552} = 3.84$).
[b] $p \leq .10$ ($F_{1,3552} = 2.71$).

Since the third-order interactions ($v_{k''}$) are significant, all the ingredient interactions are included. Notice, however, that only two of the situational moderating effects (w_1 and $w_{1'}$) are significant. Here, all the variables are included for completeness and ease of interpretation. Deleting the nonsignificant variables and rerunning the estimation resulted in only slightly higher F-values and substantially equivalent coefficients.

Figure 1 gives the average values for the two significant activity-related moderator effects. In both groups, an increase in flavor brought

FIGURE 1

Interaction of Activity with Sweetener and Flavor



about an increase in the marginal value of sweetener. This result is the familiar mutual enhancement effect (Pangborn 1961) where the presence of one ingredient enhances the effect of another. Activity on the part of the respondent appears to modify this effect in that the change in slope (the degree of mutual enhancement) is much greater for the inactive than for the active group.

DISCUSSION

Managerially, the results shown in Figure 1 imply that physical activity enhances the value of additional sweetener added to low-flavor beverages. Thus, for a vending machine that is placed close to some area of intense activity (such as a tennis court), high sweetness in this particular beverage is appropriate regardless of the level of flavoring. By contrast, for inactive subjects tasting low-flavored drinks, the highest rating occurred at the lowest sweetener level, thus allowing a possible cost saving while providing a consumer benefit from the placement of a vending machine in a low-exercise environment.

We have shown by empirical illustration that psychophysical reactions to product offerings can differ according to the situation. In the present case, the refreshing effect of sweetener and flavoring depended on whether subjects had exercised prior to tasting. Because the experimental study was conducted on students, one should maintain caution in generalizing these results to the overall population. However, the findings do illustrate the potential moderating effect of situational factors on psychophysical relationships.

Regardless of the type of response investigated, it is becoming increasingly clear that important aspects of the shopping experience may depend on underlying situational factors. In both automatic vending and other forms of retailing, the situational context is likely to affect the shape of customer responses. The methods for dealing with situational psychophysics proposed and illustrated in this paper should prove useful in measuring such effects.

EXECUTIVE SUMMARY

The vending-machine problem is similar to that faced by many retailers who must supply various offerings to satisfy the tastes of exercise. The results indicated that generally there was relatively little of products that can be changed (e.g., extra milk or sugar) to reflect different needs. The techniques of situational psychophysics provide a way to measure liking for different physical products with changes in the context in which they are consumed.

The process is illustrated in a study of consumer preferences for citrus beverages where the levels of sweetener, flavoring, and acid were systematically changed. The task involved tasting pairs of the beverage and indicating the degree to which one was preferred over the other in each pair.

In an experiment, two groups of consumers made such judgments. The groups differed in that one participated in 15 minutes of active exercise before the tasting while the other did not. It was expected that the need for sweetener, acidity, and flavoring would change with exercise. The results indicated that generally there was relatively little difference in preference due to exercise. However, the test was sensitive enough to show that for *specific combinations* of ingredients, strong differences did occur. In particular, for low-flavored beverages, the addition of sweetener was desired by those who exercised but not by the others. This result suggests a possible cost saving to those offering low-flavored beverages in a sedentary setting such as an office.

Thus the purpose of the article is to detail a method whereby changes in preference due to situational differences can be measured. While illustrated in terms of beverages in a vending-machine context, the method can also apply to other product designs, to store layouts, or even to the atmosphere of retail establishments.

While framed in terms of the vending-machine problem—where the composition of a beverage is indeed a real issue—the general idea of situational psychophysics is central to the overall merchandising function of the retailer. Indeed, issues of product design (what features to include in an offering), merchandise display (what constitutes the most esthetically appealing array of attributes), or packaging (what components make a container more attractive and eye-catching) can all be investigated using the method proposed here. For example, the same kinds of analysis can be used in broader contexts involving consumer responses to products such as clothing (Holbrook and Moore 1981), and cameras (Huber and Sheluga 1979).

Moreover, as discussed elsewhere in this issue, the effects of store atmosphere may well depend on situational moderators. For example, those in a hurry are unlikely to appreciate the soothing potential of dim lights or soft background music in the retail environment. Rather, such sensory and sensuous aspects of the shopping experience might actually prove annoying to consumers caught in a time-constrained shopping situation.

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