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The Role of Inference in Context Effects: Inferring What You Want from What Is Available

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It has recently been suggested that a number of experimental findings of context effects in choice settings can be explained by the ability of subjects to draw choice-relevant inferences from the stimuli. We aim to measure the importance of this explanation. To do so, inferences are assessed in an experiment using the basic context-effect design, supplemented by direct measures of inferred locations of available products on the price-quality Hotelling line. We use these measures to estimate a predicted context effect due to inference alone. For our stimuli, we find that the inference effect accounts for two-thirds of the average magnitude of the context effect and for about one-half of the cross-category context-effect variance.

The term “context effect” refers to the finding that the proportion of subjects choosing a particular product from a set is influenced by set composition in a manner apparently inconsistent with stable preferences. In a typical demonstration, the share of one item—the target—increases absolutely when a second item—the decoy—is added to the choice set. If the decoy is constructed to be strictly inferior to the target, we have the so-called attraction effect (Huber, Payne, and Puto 1982; Huber and Puto 1983); if it is constructed to extend the choice set along one attribute, we have the “compromise effect” (Simonson 1989). Context effects may have striking implications for competition in price-quality space. The compromise effect, for instance, implies that a new super-premium product should draw market share away from the lower end of the product line, instead of—as might be expected—from the old high-end models.

A possible explanation for this phenomenon has re-

cently been offered by one of us (Wernerfelt 1995). The idea is that consumers will frequently be uncertain about the specific values of attributes they most prefer but will be more certain about how their preferences tend to compare with other consumers in the population. For example, a consumer may not know the specific mix of features desired when purchasing a camera but may have a good idea whether this requirement is likely to be below, equal to, or above those typically required by other consumers. Hence, if a choice set is thought to carry information about the absolute location of other consumers’ ideal points, then a consumer can use this to infer the absolute location of his or her own ideal point.

To illustrate this effect we asked 110 visitors to the Boston Museum of Science to tell us their height and to choose a rain poncho from a set of three models distinguished only by length. This was a task for which subjects were likely to have a good sense for their relative size in the population (e.g., small, medium, large), but few would have a good sense for how this relative preference should translate into an absolute required length. Subjects saw one of four choice sets: (32, 34, 36 inches), (34, 36, 38 inches), (36, 38, 40 inches), or (38, 40, 42 inches). Actual ponchos average 50–52 inches, so with perfect information, almost all subjects should have chosen the longest poncho in their choice set. In contrast, few subjects actually did this; actual choices seemed more driven by relative length, with, for example, short subjects choosing the shortest poncho. Specifically, we found that 70 percent of the actual choices could be explained with a two-parameter “short-medium-long” model, such that subjects

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shorter than cutoff height H_1 select the shortest poncho, those taller than cutoff height H_2 select the longest poncho, and the rest select the middle poncho. In contrast, only 35 percent of choices could be explained with a five-parameter “absolute ideal length” model, with five heights (h_1, h_2, h_3, h_4, h_5) such that subjects below h_1 select 32 inches or the shortest available, subjects between h_2 and h_1 select 34 inches over 32 inches, and the shortest available poncho if 34 inches is not available, and so forth. Evidently, subjects were relying on poncho rank and not absolute length as a clue in choosing the best-fitting size.

A theoretical argument for this kind of rank-based inference has been given previously (Wernerfelt 1995). The purpose of this article is to test systematically its importance in explaining context effects in typical experimental settings.

THEORY

Our hypothesis about context effects rests on two premises. First, subjects are unsure of their valuations of products but would be able to refine their valuations through information about the valuations of others. Second, subjects believe that there is some chance that the choice set provides this information about the valuation of others. Both premises are illustrated by the poncho example. Suppose that we define a subject’s relative ideal point as “the percentage of people who are less tall,” and a poncho’s location, or product address, as “the percentage of people whose ideal length is less than this.” We can then describe a subject’s prior (or precontext) conjectures about the product address of a 36-inch poncho by a distribution. If the subject is shown a 34-inch poncho as well, one could surmise that the distribution for the 36-inch poncho is shifted to the right. Thus a person of average height might, a priori, feel that 36 inches is on the short side but if presented with a choice between 34 inches and 36 inches would actually choose the shorter 34-inch poncho.

More generally, the elements of the choice set will carry information whenever subjects believe that these are realistic—for example, in this case, when subjects believe that the poncho lengths are drawn from the distribution of ponchos sold in the market. Of course, subjects do not know the exact rule that the experimenter uses to create these choice sets, but virtually any conjecture they might make about such a rule will support context-based inferences. One specific conjecture might be that the poncho lengths are sampled randomly from the distribution of reasonable lengths; a second, perhaps more sensible conjecture might be that only the central length represents a random drawing, while the other two are ± 2 -inch offsets; a third possibility might be that the lengths are representative of the market poncho distribution (e.g., derived from the twenty-fifth, fiftieth, and seventy-fifth quantiles), and so forth. Each such conjecture would cause a slightly different revision of prior distributions into posterior distributions, and in this article we will not attempt to iden-

tify or test any single one of them. Our hypothesis is only that product attribute values, as presented in a choice set, are a source of information about the fit between individual tastes and these same attributes.

To demonstrate experimentally that context-sensitive inferences about products contribute to context effects we are obliged to show two things. First, we need to document that product addresses are indeed context sensitive for a substantial fraction of product categories. Second, we need to show that the size of the context effect as measured through choice percentages is related to the context sensitivity of product addresses, so that product categories where we observe little or no shift in product addresses will also be the product categories with small or nonexistent context effects.

EXPERIMENT

Our main hypothesis is that context-sensitive product addresses will explain a significant part of the context effects observed in experimental studies. To test the hypothesis, we need to induce context effects with usual paper-and-pencil choices and then extract information about product and taste addresses.

In keeping with much of the literature, we focus on categories where products and subjects are differentiated in terms of price and quality trade-offs. Relative ideal points are therefore defined in terms of willingness to pay for quality rather than height. Specifically, r_i is consumer i ’s relative willingness to pay for quality, defined by the percentage of consumers who are willing to pay less for quality than i is. Products are ordered on a similar scale such that product j ’s “address,” s_j , indicates the percentage of all products sold that are of lower quality. The consumer should buy the product located at $s = r_i$, if such is available. If not, we assume that the consumer should buy the product that is closest to r_i in terms of percentage. This is clearly a very rough model and our estimates of the importance of inference effects will be biased downward by this approximation.

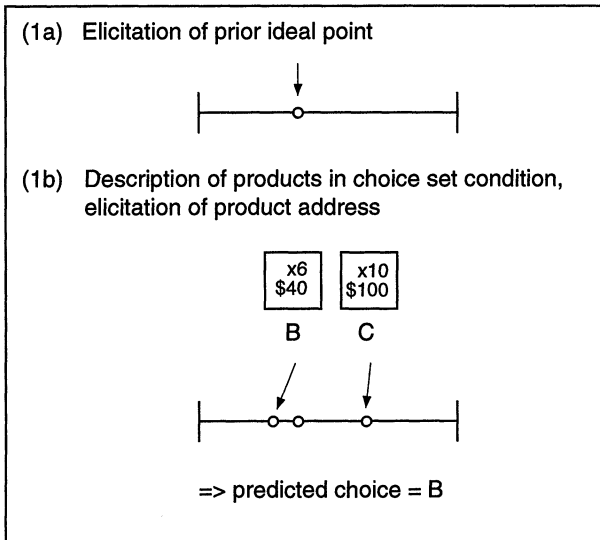
Figure 1 gives the sequence in which specific items of information were elicited. We used a panel design where questionnaire 1 asked subjects to provide information about their ideal points and about the addresses of specific product models, while questionnaire 2 asked subjects to choose between the same products they had rated in questionnaire 1. The two questionnaires were distributed about a week apart to 102 M.B.A. students in an introductory marketing class. The questionnaires were tagged by an identification number of the subject’s choosing, typically his or her social security number. Seventy-four answers contained matching identification numbers across the two questionnaires and were used for analysis.

Part *a* of questionnaire 1 consisted of a single sheet of paper, identical for all subjects, which began with the following instructions: “Each question refers to the market offerings for a particular product category in terms of a trade-off between price and one quality attribute. Imag-

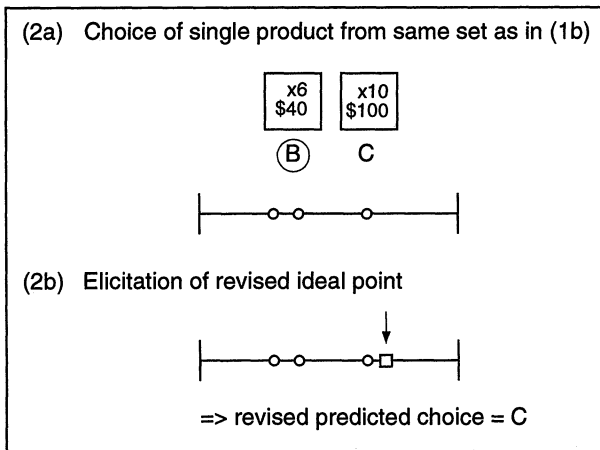
FIGURE 1

SEQUENCE IN WHICH SUBJECTS ANSWERED QUESTIONS (ILLUSTRATION FOR A TWO-ALTERNATIVE CHOICE SET)

Questionnaire 1:



Questionnaire 2:



ine that you are about to buy a product in that category. Please check which quality segment is most likely to contain your choice (segmenting the market into 10 percent bins).” The remainder of the page contained eight categories of durable consumer goods like those shown

in Figure 2. We interpret the box that the subject checked (Fig. 2) as his or her relative ideal point for that attribute (Fig. 1, 1a). This would be the analogue of physical height in the poncho study. The second part of questionnaire 1 then showed eight choice sets, one per page, such as in Figure 3. We interpret these numbers as the product addresses for the two models (Fig. 1, 1b).

In questionnaire 2, subjects were shown the exact same eight choice sets that they faced one week earlier. The eight sets were again presented in booklet form, with one choice problem per page. On each page, they were first asked to indicate which of the two or three products they would choose (Fig. 1, 2a); after making the choice they were asked to indicate again their ideal price-quality segment (Fig. 1, 2b).

In ordering the items in the questionnaires, our main concern was to prevent rationalization of ratings by choices, for example, where a person might rate a product more highly because it is the product that he or she remembers choosing. This is why we elicited choices *after* eliciting the ratings. A secondary concern was to avoid having the subject feel that by providing the ideal point for a category, s/he was implicitly choosing a specific product from a choice set. This is why, in questionnaire 1, we elicited ideal points before showing any product descriptions and choice sets. Finally, the second elicitation of the ideal point was intended to control for any shifts in ideal point that might result from information contained in the choice sets. This might happen if context subtly redefines the product category. For instance, a subject who finds that the category of “coffeemakers” also includes a \$1,500 espresso maker (not the case in our study!) will probably lower his or her ideal because the boundaries of the category have been shifted to include commercial-quality products. The second measure of the ideal point let us control for this possibility. In point of fact, we found no influence of context set on revised ideal points. In subsequent analyses we will only make use of the initial ideal-point measures.

Figure 4 summarizes how we induced and measured context effects. We used eight consumer durable product categories, with products differentiated by price and a single quality attribute, such as binoculars of different price and magnifying power. The stimuli were culled from our own work and resemble closely the stimuli used in published studies (Simonson 1989).

For each product category, there were three possible choice sets. A choice set was a two- or three-element

FIGURE 2

EXAMPLE OF IDEAL POINT ELICITATION

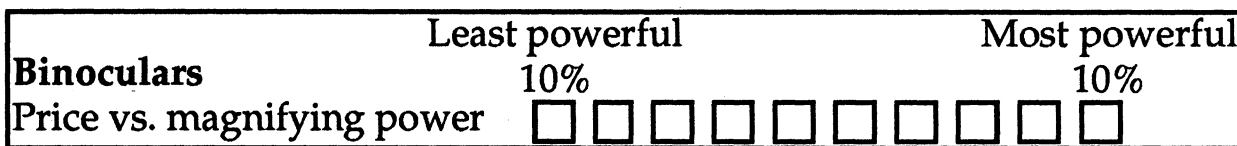


FIGURE 3
EXAMPLE OF CHOICE SET FROM PART 2 OF QUESTIONNAIRE 1

BINOCULARS: These two binoculars differ only in price and magnifying power.

	Model 1	Model 2
Magnifying power	6	10
Price	\$40	\$100

Of the binoculars sold in the US last year, what fraction do you think are more powerful than the described models? (please estimate a % below)

Fraction of binoculars more powerful than model 1: _____ %

Fraction of binoculars more powerful than model 2: _____ %

subset of the full stimulus set, containing products A, B, C, and D, given in Table 1. Each person saw exactly one of three choice sets per category, either a core set (B and C), a low-quality extension (A, B, and C), or a high-quality extension (B, C, and D). One-half of the extensions created a linear price-quality frontier, supporting a compromise effect design, and one-half created a concave frontier, supporting an attraction effect design with a relatively inferior alternative (Huber and Puto 1983).

Because each person chooses only once from a product category, context effects are measured as between-subject differences in choice proportions or “market shares.” Our basic pairwise measure of the effect is the difference between the market share of an alternative in the binary core set and its share in the three-alternative set where it is an extreme option (i.e., highest price or lowest quality; see Fig. 4). Thus each of the two alternatives in the core set is associated with exactly one basic context-effect data point. The eight product categories contributed 16 separate context-effect measurements, eight with high-quality extensions and eight with low-quality ones. In addition, we will also test whether there is a measurable context effect when all three choice sets are considered simultaneously. This may be done by pooling the choices in categories A and B and categories C and D, as indicated by the dashed line in Figure 4. If context does not influence choice, the combined shares of A and B (C and D) should be identical across the three choice sets.

RESULTS

Context Effects Computed from Actual Choices

We verify first that context effects appear in the experiment. Table 2 reports the choice shares for each context. The null hypothesis of no context effect is decisively rejected in six categories (the only exceptions being rain boots and running shoes). In addition, there are eight instances where the percentages in the three-alternative condition violate regularity—that is, the share of product B or C increases absolutely when product A or D is added to the choice set. The size of the context effect averages 19.6 percent across the 16 comparisons of a three-alternative extension and the core set and is significantly larger for high extensions (31.6 percent) than for low extensions (7.5 percent). This is consistent with the finding of “polarization” in favor of the high-quality alternatives (Simonson and Tversky 1992; Tversky and Simonson 1993). There are no significant differences between the attraction and compromise contexts.

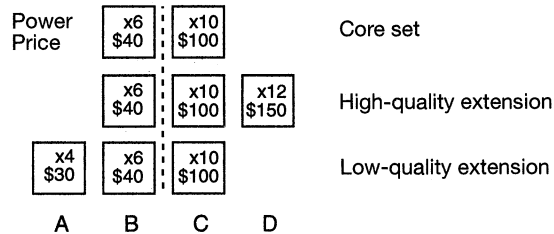
We now move on and check for the impact of context on product addresses. Recalling that the question was phrased to give an address as a percentage (the percentage of products sold that were of lower quality), we can check if the midpoint between product addresses B and C is influenced by context. We find that the midpoint is significantly affected by context in six out of eight product categories, the exceptions again being rain boots and running shoes.

FIGURE 4

SUMMARY OF INDUCEMENT AND MEASUREMENT OF CONTEXT EFFECTS

Stimulus design

Example: Binoculars



Measure of context effect:

Change in market share of the product that should not be affected
(product B in the high-quality extension and product C in the low-quality extension)

$$\text{Context Effect} = \begin{cases} B(\text{core set}) - B(\text{high-quality extension}) \\ \text{or} \\ C(\text{core set}) - C(\text{low-quality extension}) \end{cases}$$

Context Effects Predicted from Ideal Points and Product Addresses

We next combine the ideal points and product addresses to compute predicted market shares from which we can calculate predicted context effects. The predicted choice for each subject is the product with address closest (on our percentage scale) to that subject's relative ideal point.

Table 3 shows that predicted market shares were significantly influenced by the choice set condition, yielding large predicted context effects in five categories. These also happen to be categories with significant actual context effects in Table 2. The categories with no predicted context effect, rain boots and running shoes, also did not show an actual context effect in Table 2. The category of coffeemakers had a weak actual context effect and no predicted context effect. The size of the context effect averages 13 percent across the 16 comparisons of a three-alternative extension and the core set, and although again we see a greater context effect for high-quality extensions, that difference is not significant.

Figure 5 presents a scatter plot of predicted context-effect magnitude and actual context-effect magnitude, for all 16 extensions. It is evident that the predicted context effects are qualitatively consistent with the effects observed with choice, even though the predicted effects come from an entirely different set of judgments, collected one week earlier.

How much of the context effect is due to context-induced changes in product addresses? One can formulate two types of numerical estimates. First, one can compare

the mean magnitude of the predicted and actual context effects. The average actual context effect across all cases is 19.6 percent, while the corresponding average predicted effect is 13.0 percent, which is about two-thirds of the actual one. Looking separately at high and low extensions, we see that for lower-quality extensions the predicted and actual context effects are about the same, while for higher-quality extensions the actual context effect is about twice as large as the predicted one. Because this latter effect is driven by two product categories (rain boots and vacuum cleaners) only, one would need more data to see if it is robust. Second, matching individual cases, the Pearson correlation between the actual and predicted effects is +.66 and is highly significant ($p < .005$). Equivalently, a linear regression of predicted context effect magnitude against actual context-effect magnitude would explain 44 percent of the cross-category variance in actual context-effect magnitude.¹ The slope and intercept of the regression equation are .99 and .07, respectively, and are not significantly different from one and zero (respectively). If the slope and intercept are constrained to exactly 1.0 and 0.0, respectively, then the resulting 45-degree line reduces the cross-category variance in context-effect magnitude by 34 percent. This "zero-parameter" model

¹This would seem to rule out a simple response-scale interpretation of our results, e.g., along the lines of Parducci (1965). A response-scale explanation ought to apply equally to all product categories in the experiment and would therefore not predict the cross-category correlation between simulated and actual context-effect magnitude. For other evidence against pure response-scale explanations of context effects, see Lynch, Chakravarti, and Mitra (1991).

TABLE 1
STIMULI

Product category and quality dimension	Model A	Model B	Model C	Model D
Air conditioners:				
Operating noise rating	7	8	9	10
Price (\$)	200	300	400	500
Binoculars:				
Magnifying power	4	6	10	12
Price (\$)	30	40	100	150
Auto-focus cameras:				
Number of features	3	5	8	9
Price (\$)	60	80	120	160
Coffeemakers:				
Quality rating	5	6	8	10
Price (\$)	20	30	50	70
Rain boots:				
Durability rating	5	7	9	10
Price (\$)	20	30	40	60
Running shoes:				
Cushioning ability rating	6	7	8	8
Price (\$)	50	50	70	80
Vacuum cleaners:				
Suction power rating	50	60	70	80
Price (\$)	50	100	150	200
VCRs:				
Durability rating	5	6	7	8
Price (\$)	150	200	300	400

TABLE 2

ACTUAL MARKET SHARES

	Product A (%)	Product B (%)	Product C (%)	Product D (%)
Air conditioners	27.3	40.9	31.8	...
$p < .001^a$	...	77.8	22.2	...
$p = .005^b$	...	28.0	52.0	20.0
Binoculars	13.6	54.6	31.8	...
$p < .001^a$	...	51.9	48.2	...
$p < .001^b$	...	16.0	64.0	20.0
Cameras	4.6	63.6	31.8	...
$p < .001^a$	...	40.7	59.3	...
$p < .001^b$	...	12.0	48.0	40.0
Coffeemakers	32.0	28.0	40.0	...
$p = .084^a$	...	40.9	59.1	...
$p = .014^b$	...	29.6	48.2	22.2
Rain boots	12.0	20.0	68.0	...
$p = .338^a$	...	22.7	77.3	...
$p = .112^b$	...	14.8	44.4	40.7
Running shoes	.0	40.7	59.3	...
$p = .068^a$	...	56.0	44.0	...
$p = .147^b$	...	22.7	59.1	18.2
Vacuum cleaners	14.8	63.0	22.2	...
$p < .001^a$	...	68.0	32.0	...
$p = .013^b$	...	9.1	59.1	31.8
VCRs	18.2	40.9	40.9	...
$p = .034^a$	...	51.9	48.2	...
$p = .002^b$	...	24.0	40.0	36.0

NOTE.—*N* equals 73 or 74 per condition.
^a $\chi^2(2)$ test of equal A+B shares across all three conditions.
^b $\chi^2(1)$ test of equal A+B shares across both three-alternative conditions.

TABLE 3

MARKET SHARES SIMULATED FROM PRODUCT ADDRESSES AND IDEAL POINTS

	Product A (%)	Product B (%)	Product C (%)	Product D (%)
Air conditioners	52.4	28.6	19.1	...
$p = .016^a$	...	84.0	16.0	...
$p = .020^b$	...	44.0	40.0	16.0
Binoculars	54.6	22.7	22.7	...
$p = .017^a$	...	73.1	26.9	...
$p = .010^b$	...	41.7	33.3	25.0
Cameras	31.8	40.9	27.3	...
$p = .062^a$	...	63.0	37.0	...
$p = .024^b$	...	40.0	32.0	28.0
Coffeemakers	37.5	41.7	20.8	...
$p = .214^a$	...	60.0	40.0	...
$p = .122^b$	...	57.7	30.8	11.5
Rain boots	28.0	40.0	32.0	...
$p = .563^a$	...	54.6	45.5	...
$p = .357^b$	...	55.6	25.9	18.5
Running shoes	18.5	25.9	55.6	...
$p = .966^a$	...	48.0	52.0	...
$p = .944^b$	...	50.0	10.0	40.0
Vacuum cleaners	33.3	40.7	25.9	...
$p = .063^a$	...	60.0	40.0	...
$p = .019^b$	...	42.9	33.3	23.8
VCRs	54.6	22.7	22.7	...
$p = .016^a$	...	61.5	38.5	...
$p = .005^b$	...	37.5	41.7	20.8

NOTE.—*N* equals 73 or 74 per condition.
^a $\chi^2(2)$ test of equal A+B shares across all three conditions.
^b $\chi^2(1)$ test of equal A+B shares across both three-alternative conditions.

provides the most conservative estimate of explained cross-category variance.

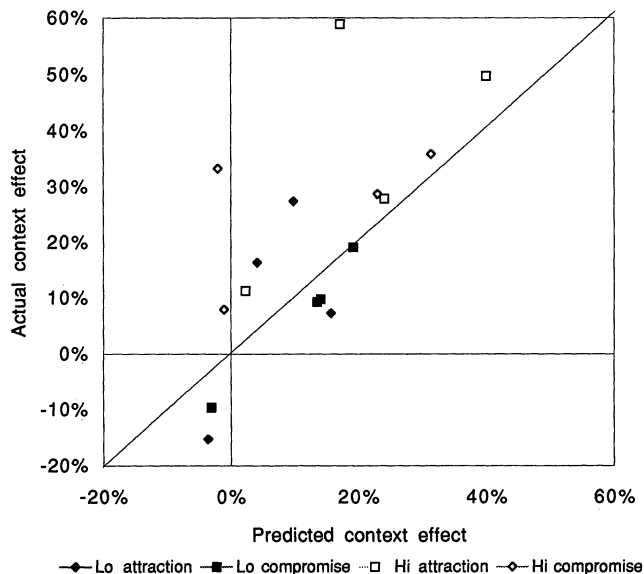
It is true, of course, that our elicitation of relative ideal points and product addresses is fraught with measurement error and that our minimum distance model is ad hoc. However, this should not bias the mean estimates, and, if anything, it should bias the variance reduction figures toward zero. We conclude that for these stimuli, context sensitivity in product addresses explains about two-thirds of average context-effect magnitude and about one-half of cross-category context-effect variance.

The Discrepancy between Predicted and Actual Choices

What remains of the context-effect phenomenon after the component due to product address inferences is partitioned out? We can get an answer to this question by tabulating within-subject discrepancies between predicted and actual choices. Table 4 presents the conditional frequencies of actual choice (columns), given predicted choice (rows). The conditional frequencies are computed separately for the three types of contexts. Looking at the core set panel, we see that our simple "choose-nearest-product" model is well calibrated for the two-alternative choice set. Three out of four subjects choose the appro-

FIGURE 5

COMPARING PREDICTED AND ACTUAL CONTEXT EFFECTS



appropriate product, with address closest to their ideal point. In the three-alternative conditions, however, predicted choices underpredict market share for the middle alternative and overpredict share for the low alternative. Our subjects are systematically choosing a higher-quality product than would be inferred from their stated ideal points and product addresses. The deviation from predicted choice is most pronounced for those who should choose the lowest out of three quality levels, with more than half of such subjects moving up to the middle-quality product. This is consistent with the finding by Simonson, Nowlis, and Lemon (1993) that subjects are more likely to choose the cheapest of three alternatives if the choice is elicited via pairwise preferences rather than directly from the set of three.

Apparently, a substantial fraction of people avoid choosing the lowest-quality product from a set of three even when their prior judgments of product quality and their own tastes indicate that this is the right product for them to choose. This effect does not occur for the most expensive product from a set of three, nor does it occur for either the higher- or lower-quality product from a set of two. In other words, being the cheaper of two creates no gap between judgment and choice; being the cheapest of three or more does create such a gap. The very simple inferences studied here cannot explain this.

DISCUSSION

Our main result is that consumers rely partly on context to make inferences about the fit between specific brands and their own preferences, and this inference explains a substantial proportion of context effects found in experiments.

TABLE 4

CONDITIONAL PROPORTIONS OF ACTUAL CHOICE GIVEN PREDICTED CHOICE

Predicted choice	Core set		Low extension			High extension		
	B (%)	C (%)	A (%)	B (%)	C (%)	B (%)	C (%)	D (%)
A	...	...	41	50	9	...	...	...
B	75	25	9	62	29	42	52	6
C	27	73	0	21	79	7	64	29
D	...	...	...	...	...	2	30	68

We do not claim that inferences are a complete explanation of the context effects observed in this article, let alone in other published studies. Our more modest theoretical claim is that context is a legitimate source of information, especially in studies that use realistic product descriptions. Whenever we show subjects calculators costing \$15 and air conditioners costing \$500—not the other way around!—we are implicitly telling them something about typical prices for each category. The argument survives even if subjects do not use information efficiently (i.e., if they do not behave like perfect Bayesians). Consequently, any theory of context effects that claims to be comprehensive will need to account for context-generated information. At the same time, the fact that context effects have been observed in studies with apparently unambiguous stimuli (e.g., lotteries [Wedell 1991]) or with products that could be observed and handled (e.g., paper towels or pens [Simonson and Tversky 1992]) indicates that some part of the effect may not yield as easily to inference-based explanations.

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