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Motivating Mammography Adherence in Elderly Latinas:

A Test of Three Mathematical Models of Decision Making

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Many elderly Latinas do not have mammography every one to two years as recommended by cancer organizations. To elucidate the causal factors underlying this behavior, 52 Latinas, aged 65 and over, were asked to judge the likelihood of having yearly mammography in 79 different scenarios constructed from factor levels of cost, perceived risk, and the source of a recommendation (none, a recognized cancer organization, a doctor), assuming a convenient mammography facility. A configural-weight-averaging model, with different parameter values for the 30 adherers (women who reported having had mammography at least twice in the preceding four years) and the 22 non-adherers, gave a good fit to the data and did well in predicting reported mammography adherence ($r = 0.85$). According to this model, offering free mammography would not induce non-adherers to adhere; they would require a recommendation, and value a doctor's as highly as that of a recognized cancer organization, but reported never having received one from either source. All 52 women reported never receiving risk information from any source. These results have direct educational and dissemination implications for cancer organizations. *Key words:* breast cancer screening; screening barriers; testing decision models; elderly Latinas. (*Med Decis Making* 1999; 19:448–465)

Researchers estimate that early detection of breast cancer by mammography reduces deaths from this disease by 30% in women over 50 years of age.^{1–5} Despite this capability, many women over 50 fail to be tested every year or every other year, the frequency recommended by cancer organizations.* This underuse of mammography is especially high in certain populations of women, such as those at lower income and educational levels, minorities, and the elderly.^{6–10}

Researchers propose that these and other factors act as barriers to regular mammography screening.⁶

Some of the proposed factors have special implications for policymakers because they can be changed. Examples of these are high screening costs; inaccessibility of mammography services; lack of a doctor's recommendation; lack of knowledge about the dangers of breast cancer and the life-saving advantages of screening, including clinical breast examinations (CBEs) and self breast examinations (SBEs), for detecting and treating breast cancer early; low perceived risk of contracting breast cancer; and the apprehensions and fears related to the screening process.

To date, the best evidence of barrier factors comes from correlations with screening frequencies, usually determined by self-reports. Factors that may act as barriers to or motivators for breast-cancer screening have received very little attention in causal research frameworks, and thus, little to nothing is known about the *causal* roles, if any, they may play in women's decisions to be screened for breast cancer.

It is reasonable to assume that, if we had a credible theory of mammography decisions, we would better understand the major factors that influence these decisions, as well as decisions relating to CBEs and SBEs. Such a theory would specify how women value and trade off specific factors in making their

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*Cancer organizations such as the National Cancer Institute and the American Cancer Society also make recommendations for frequency of clinical breast examinations (CBEs) and self breast examinations (SBEs); recommended CBE frequencies are the same as those for mammography; SBEs once a month are recommended.

mammography decisions and explain how differences in these values influence those who adhere to recommended mammography frequencies and those who do not. The resulting information could guide interventions and policies to motivate adherence in women who do not follow mammography recommendations (non-adherers) while maintaining adherence in those who do (adherers).

It makes economic sense to begin the quest for a theory of mammography decisions in a judgment framework, in which it is possible to test hypotheses about the causal roles of many more mammography scenarios than it would be feasible to create in a behavioral study. Results from judgment research could then guide behavioral studies or interventions.

The psychological-measurement framework employed in this research makes it possible to use judgment data to test among competing mathematical decision-making theories. The theory (in the form of a mathematical model) that accounts for women's judgments of what their screening decisions would be in different scenarios provides measures of women's values and value tradeoffs among the factors that define the mammography scenarios. The judgment research reported here investigated mammography decisions of Latinas 65 years of age and older living in Southern California.

Elderly Latinas

Elderly minority women make up a large proportion of underserved women. The elderly Latina poor may be among the most underserved of all. They typically speak little to no English and fall into the major sociodemographic groups predictive of underuse of screening services—elderly minorities with less than a sixth-grade education who are living near the poverty level.

One in every 12 Latinas will develop breast cancer during her lifetime.¹¹ Breast cancer is the leading cause of cancer deaths in Latinas, perhaps because of the large number of diagnoses made only at late stages, when prognoses are worse.^{12–15} Some studies indicate that Latinas have the lowest breast-cancer-screening rates of any racial/ethnic group in the United States^{16,17} and that large percentages of Hispanic women over 65 have never had mammography.^{10,17}

A mammography model for elderly Latinas should aid our understanding of the conditions under which these women would adhere to mammography recommendations and the conditions under which they would not, thus providing insights into interventions to increase screening rates in this underserved population and perhaps other populations of underserved women.

Hypothesized Mammography-decision—Making Models

Investigating the causal roles of factors in decisions requires reducing the large number of factors proposed in the literature to a manageable few to manipulate in a judgment experiment. In this study, we manipulated selected screening factors by factorially combining their levels to form different mammography scenarios. Women judged the chances they would have yearly mammography in the different scenarios; their judgment data were then used to test among three mathematical measurement models as theories of adherence to mammography recommendations.

THE FACTORS

Although many barrier and motivating factors have been proposed, it is likely that only a few play crucial roles in women's mammography decisions. To get an idea of what these factors might be for elderly Latinas, we conducted three discussion sessions with 13 Latinas aged 65 years and over. Details of the procedures for these sessions are in the Method section.

On the basis of the data from these sessions, we selected three factors to manipulate in the experiment: 1) *cost* of mammography (cost), which could be \$0, \$50, \$100, or \$200; 2) *source of a recommendation* to have mammography yearly (source), which could be none, a recognized cancer organization such as the National Cancer Institute (NCI) or the American Cancer Society (ACS), or a doctor; and 3) their *perceived risk* (risk) of breast cancer, which could be low, medium, or high.[†] A fourth factor, the *convenience* of the mammogram facility (convenience), was held constant at "convenient." Table 1 shows our experimental factors and their factor levels. As can be seen, we selected some factor levels that appear to be barriers to yearly mammography screening (e.g., a cost of \$200, no recommendation, a low perceived risk) and other factor levels that appear to be motivators (e.g., a cost of \$0, a doctor's recommendation, a high perceived risk).

THREE HYPOTHESIZED DECISION-MAKING MODELS

We hypothesized three mathematical models as explanations of elderly Latinas' judged mammogra-

[†]Women came to the study with preconceptions of their risk levels. The perceived risk-factor levels—high, medium, and low—were manipulated by basing the risk-level information on the results of a hypothetical blood test (that does not presently exist). Thus, the factor-level description was, "the results of a blood test indicate your risk for contracting breast cancer is high" (or "medium," or "low").

Table 1 • Experimental Factors and Factor Levels

Factor Name	Factor Description	Factor Levels
Risk	Perceived risk of contracting breast cancer based on results from a blood test	High, medium, low
Source	The source of a recommendation to have mammography yearly	None, organization,* doctor
Cost	The cost of mammography	\$200, \$100, \$50, \$0
Convenience	The convenience of accessing the mammography facility	Convenient (the facility is located at your church or senior-citizen center)

*The two cancer organizations used as examples in the study were the National Cancer Institute and the American Cancer Society.

phy decisions: a weighted-additive model, a constant-weight-averaging model, and a configural-weight-range model. The three models make *different* predictions about how women value and trade off the causal factors that affect their decisions to have mammography yearly.

Weighted-additive model. A weighted-additive model—for example, the multiple regression model—is one a statistician might use to predict mammography rates from such variables as cost, source of a recommendation, and perceived risk. The mathematical formulation of this model is shown as equation A1 in the appendix. This model predicts that women associate a separate scale value for each level of the factors—cost, source, and risk—and attach a separate weight to each of these factors. When a woman makes a judgment about having yearly mammography in the absence of symptoms, she multiplies each factor's weight and its associated scale value and sums these products. When this model is used as a statistical model, a priori values are computed in the model for scale values (e.g., actual dollar amount). In contrast, when this model is used as a judgment model, scale values are regarded as psychological values; they depend on actual values of the factor levels but are estimated from the response data.

Constant-weight-averaging model. Data from a variety of judgment tasks have shown systematic deviations from the predictions of an additive model.^{20–32} Constant-weight-averaging models have done consistently better than additive models in accounting for judgment data.²³ It seems reasonable to consider that this might be the case for elderly Latinas' mammography decisions.

The mathematical formulation of the constant-weight-averaging model is shown as equation A2 in the appendix. Both the additive model and the constant-weight-averaging model predict independence among factors' scale values in their effects on women's mammography decisions; the effect of one factor on judged decisions is predicted to be the same regardless of the level of another factor. For example, the effects of mammography costs on decisions should be the same regardless of whether a

woman has received a recommendation from a doctor or has not received a recommendation from any source. Thus, the two models are indistinguishable with respect to this independence prediction. However, when the *number* of factors describing a mammography scenario is varied in the experimental design, additive and constant-weight-averaging models make *different* predictions under the assumption that, when a factor is not present in the scenario, its weight is zero. The additive model predicts that the effect of a factor is independent of the number and weight of other factors describing a mammography scenario. In contrast, the averaging model predicts that the effect of each factor will be inversely related to the number and weight of the other factors. The mathematical basis for this prediction is illustrated in the appendix.

Configural-weight-range model. Constant-weight-averaging models and additive models predict no interactions among the scale values associated with the factors. However, it is possible that factors interact in women's decisions to have annual mammography. For example, having a recommendation or not having a recommendation may not make much of a difference in a woman's mammography decision if mammography costs \$100, but it may make a big difference if it costs \$50 or \$0. If such interactions are found in the judged mammography decisions, both the additive model and the constant-weight-averaging model will be rejected as descriptive decision-making models.

Configural-weight-averaging models can account for such interactions. They have received support for interactions found in a wide variety of judgment tasks.^{21,22, 24–32} These models, like constant-weight averaging models, predict that the effect of each factor will be inversely related to the number and weight of the other factors in the judgment scenario. In addition, these models hypothesize that people place a special weight (referred to as a configural weight) on a specified configuration of scale values associated with the factor levels describing a scenario. The mathematical form of the configural-weight-range model that was tested in this study is shown as equation A4 in the appendix.

We tested among the psychological models shown

in equations A1, A2, and A4 as explanations of judged mammography decisions, using both the linear and the logistic transformations described in the appendix.

Research Questions

The present research addressed the following questions:

1. Do the factors selected for manipulation in the judgment experiment—cost, source, and risk—play causal roles in elderly Latinas' judged decisions to have yearly mammography?
2. What decision-making model accounts for how elderly Latinas value and trade off among these factors in their decisions?
3. Do differences in decision-making models exist between adherers and non-adherers to mammography recommendations?
4. If differences exist between these two groups of elderly Latinas, do they require different mathematical models to account for their differences, or does the same model account for both sets of data with different parameter values?
5. Does the mammography decision-making model for adherers and non-adherers predict their reported mammography usage?

We addressed questions 1 through 4 using factorial experimental designs that made it possible to test among the hypothesized mathematical decision-making models; we investigated question 5 using correlational analyses.

Method

In this section, we first describe the eligible respondents and their participation. We then describe the focused-interaction sessions for selecting factors and factor definitions to use in the mammography decision-making experiment, the format for the decision-making questionnaire, and the variables to include in the background and opinion survey questionnaire. Next, we describe the design of the mammography decision-making experiment and data-collection procedures for the experimental and survey questionnaires. Finally, we describe our data-analytic procedures.

RESPONDENTS

The 13 respondents in the focused-interaction sessions and the 52 respondents in the questionnaire-administration sessions were Latina volunteers who were 65 years of age or older, who had

never been diagnosed as having breast cancer, and who were in good enough health to participate in the study. The women were recruited from senior-citizen centers and churches in Southern California. A research staff member conducted the sessions in a room at the participating organization or in the respondent's home. The interviews lasted from one and a half to two hours, with two scheduled breaks. Women were paid \$20 for their participation.

FOCUSED INTERACTION SESSIONS

A major goal in constructing a questionnaire for a judgment experiment is to pose enough questions (e.g., mammography scenarios) to the respondents that the resulting data can be used to test among hypothesized models while keeping the questionnaire at an acceptable length.[‡] Although many factors have been proposed in the literature as either motivators for or barriers to mammography screening, it is likely that only a few actually play crucial roles. The purpose of the focused-interaction sessions was to select those factors. The sessions focused on candidate factors. Through a series of structured interactions with eligible respondents, we eliminated factors that did not appear to play major roles in their decisions when paired with other factors.

The procedure. We conducted four focused-interaction sessions, with six, three, two, and two respondents. We began each session by discussing a list of motivator and barrier factors suggested in the literature.[§] After discussing all of the factors, the staff member produced a list of the factors and asked the women to order them by the importance they would have in their decisions to have yearly mammography in the absence of symptoms (ties in ranking were permitted). When the women had completed the rank-ordering task, the research staff member constructed different mammography scenarios from the levels of two or three factors that occupied the first seven or so ranks of their lists; the staff member orally described different combina-

[‡]Our goal in this study was to keep the time needed for administration of the judgment experiment to between 40 minutes and 1 hour.

[§]Besides the four factors specified in the decision-making experiment, the factors discussed covered the following topics: importance of Spanish language of the provider, fear of a painful examination (mammography or CBE), fear of radiation from mammography, religious considerations, and opinions about the efficacies of breast-cancer treatments, diet, and exercise. We specifically did not discuss factors proposed in the literature as breast-cancer-screening barriers that are inherent characteristics of women, such as age, income level, and educational level, since they are impractical to manipulate in research studies. However, we did gather information about these variables in a background and opinion survey questionnaire.

tions of factor levels, and the women estimated the chances that they would have yearly mammography if they were in those situations.**

Factors. Based on these data, we selected three factors—risk, source, and cost—to manipulate in the judgment experiment and one factor, convenience, to hold constant. These four factors, previously described, were ranked as the most important by all 13 women, and each one continued to be so considered when paired with other factors in the hypothetical scenarios we posed to respondents. Factors not selected for the decision-making experiment were incorporated in a background and opinion survey instrument.

Factor levels. We selected factor levels for each of the three manipulated factors (shown in the third column of table 1) to be perceptually different from each other and to cover a wide range of the factor dimension. Each woman had her own preconception of her risk for getting breast cancer. However, we were able to manipulate the risk factor by basing the risk level described in the mammography scenario on a hypothetical blood test (not yet developed).

In the focused-interaction sessions, all 13 women considered that a doctor's recommendation and a recommendation from a recognized cancer organization would influence their decision to have yearly mammography. Influential cancer organizations were the National Cancer Institute and the American Cancer Society. Thus, we used these names in the experiment as the sources of the recommendation from a recognized cancer organization. The women reported that they would be influenced if they received this information from one or more news-media sources—radio, television, magazines, newspapers—or from posters in their churches or senior citizen's organizations. These media sources were presented in the decision-making experiment. The factor level "none" was defined to mean they had never heard of the recommendation to have annual mammography from any source.

To determine the dollar range of the cost factor, mammography charges were obtained from several breast-cancer-screening facilities in Los Angeles County. Prices ranged from \$0 (free) to over \$200. These prices were discussed and manipulated in the focused-interaction sessions; \$200 appeared to be an upper limit for these women, in the most motivating scenario (e.g., high perceived risk and a doctor's recommendation).

Dependent variable. We selected the definition of the dependent variable as "The chance of having a

yearly mammogram," because mammography screening is a more sensitive detector of breast cancer than are CBEs, and yearly is the frequency presently recommended by most cancer organizations. We posed two category rating scales to the women in the focused-interaction sessions: a nine-point scale and a 19-point scale. The nine-point scale provided a more than sufficient number of categories for the range and variety of mammography scenarios constructed from two- and three-factor examples. Thus, we selected a nine-point response scale. After discussing the matter with the Latina women and having them use different wording choices to respond to different mammography scenarios, we selected the wording presented in the Factor section above.

Questionnaire format. We also used the focused-interaction sessions to explore three different questionnaire formats for ease of administration. Using trial mammography scenarios, the women answered about ten questions in which scenarios were 1) randomly ordered, 2) constructed in sets of three sentences (one factor level per sentence as exemplified in the Factor section above), where successive sets varied only one factor level at a time, and 3) organized in a matrix format, constructed so that columns from left to right were successively more attractive levels of one factor and rows from top to bottom were successively more attractive levels of a second factor; separate matrices represented different levels of a third factor. The women were able to compare the different mammography scenarios and respond more quickly using the matrix format, which became the format adopted for the study.††

SCENARIO CONSTRUCTION

Seventy-nine mammography scenarios were generated from the following designs:

- One three-way factorial design—3 (risk) $\times$ 3 (source) $\times$ 4 (cost). This produced 36 mammography scenarios; each scenario was described by the woman's perceived risk for contracting breast cancer, the source (or not) recommending yearly mammography, and the cost of mammography.
- Three two-way factorial designs—1) 3 (source) $\times$ 4 (cost); 2) 3 (risk) $\times$ 4 (cost); and 3) 3 (risk) $\times$ 3 (source). These produced 33 scenarios, each described by two factor levels.

††In our military decision-making research at RAND, we have also found a matrix format to be preferred by military personnel.^{20,22} Statistical tests have produced no effect of order, perhaps because people tend to compare the matrix cells in different orders.

**The women made informal responses to these situations, such as, "Yes, I think I would," or "No, I wouldn't."

- Three single-factor designs—4 (cost); 3 (source); 3 (risk). These produced ten scenarios, each described by one factor level.

The mammography facility was assumed to be convenient (e.g., located at the woman's church or senior-citizen center) for all 79 scenarios.

An example of a question we posed to respondents from the three-way factorial design was:

What is the chance you would have yearly mammograms in the absence of symptoms, if

- you believe your risk for breast cancer is high, based on results from a recent blood test,
- your doctor recommended that you have yearly mammograms, and
- the cost of a mammogram is \$50?

Other questions that included all three factors changed the level of one or more of these factors.

To respond to these scenarios, the women used a nine-point category scale: 1 = "for certain I would not"; 3 = "small chance I would"; 5 = "moderate chance I would" ("maybe yes, maybe no"); 7 = "high chance I would"; 9 = "for certain I would." The women used the numbers 2, 4, 6, and 8 to represent probabilities that fell in between their respective adjacent-category descriptions.

A sample scenario from a two-way factorial design is:

What is the chance you would have yearly mammograms in the absence of symptoms, if

- you believe your risk for breast cancer is low (based on results from a recent blood test), and
- the cost of a mammogram is \$0,

A sample scenario from a one-way factorial design is:

What is the chance you would have yearly mammograms in the absence of symptoms, if

- you believe your risk for breast cancer is high.

For each scenario, the respondent selected a number from the nine-point category rating, to estimate the chance she would have yearly mammography in the absence of symptoms.

BACKGROUND AND OPINION SURVEY QUESTIONNAIRE

The survey questionnaire contained items about the respondent's socioeconomic status, educational level, medical and mammography insurance, family history of breast cancer, history of breast-cancer

screening, doctor recommendations, and opinions about breast-cancer screening and treatments. The questionnaire contained a maximum of 100 items; the actual number of items for a given respondent depended on her answers to some items—for example, whether she had a doctor.

QUESTIONNAIRE-ADMINISTRATION PROCEDURES

Most of the 52 women who participated in the questionnaire-administration sessions worked one on one with a research staff member; a few filled out the survey questionnaire by themselves. In both situations, however, a staff member reviewed all of the questions with them. The women could elect to fill out the questionnaires in either Spanish or English. Half of the respondents took the decision-making questionnaire first, followed by the background/opinion survey questionnaire, and half took the survey questionnaire first.

DATA ANALYSES

We use correlational analysis to assess how well the mammography decision-making model predicted reported mammography adherence. For model analyses, we split the 52 respondents into two groups: 30 adherers—women who had had mammography at least twice in the past four years—and 22 non-adherers, who had had mammography less often.‡‡ Data averages were taken within each group. We conducted the following analyses separately for each set of data.

1. Tests for significant main and interaction effects of selected factors on judged mammography decisions using analysis of variance (ANOVA). Significant interaction effects are a basis for rejecting equations A1 and A2 as mammography-decision-making models.

2. Separate graphic plots for each data set to examine the structures of main and interaction effects. In these graphs, responses were plotted on the y-axis, the levels of one factor on the x-axis (e.g., cost);

‡‡There were various reported lifetime mammography adherence patterns among the adherers and non-adherers. For some adherers, the two mammographic examinations they had had in the preceding four years were the only two they had ever had in their lives; other adherers had been having mammography at least twice every four years for as long as 20 years. Ten of the non-adherers had never had mammography; other non-adherers had been adherers for short periods five to ten years previously but had fallen out of adherence; still others had had their first (and only) experiences with mammography in the preceding four years. This variation in mammography adherence between these two groups can be assessed from the information presented in table 3.

a separate curve for each level of a second factor (e.g., source), and separate panels for each level of a third factor (e.g., risk).

3. Separate graphic plots for each data set to test between adding and averaging models. A separate graph was constructed for each of the three factors, cost, source, and risk. In these graphs, responses were plotted on the y-axis, the levels of the factor under investigation on the x-axis, and a separate curve for the data from each experimental design in which that factor appeared. Taking cost as an example of the variable on the x-axis, a separate curve is plotted for cost when it is: 1) *presented alone* (data from its single-factor design); 2) *presented with one other factor*, which results in two curves—one for cost averaged over source (data from the cost $\times$ source design) and one for cost averaged over risk (data from the cost $\times$ risk design); and 3) when it is *presented with both of the other factors* (cost averaged over source and risk from the three-way factorial design).

If women average factor information (predicted by a constant-weight-averaging model [equation A2] and a configural-weight-range model [equation A4]),

the slope of the line from data from designs with fewer factors should be steeper than that for data from designs with more factors. This prediction is described using the algebra for additive and averaging models in the appendix. Interactions in the data and steeper slopes for data from designs with fewer factors support a configural-weight-range model.

4. Predicted and obtained graphs make it possible to examine location, magnitude, and direction of data from a model's predictions. In these analyses, the fit of a model to data is assessed using a computer program that utilizes Chandler's³⁵ STEPIT subroutine to find a least-squares solution. The program yields the best-fit parameter values and predictions for the model being tested, given the data. Graphs of predicted and obtained data proceed as described in 2 above, except that both predicted responses and obtained responses are on the y-axis and two points rather than one point identify a "response." We reject a model when its predictions do not follow the systematic data structure of the responses. It is possible to reject all hypothesized models.

FIGURE 1. Effects on judged mammography decisions of varying number of factors describing a mammography scenario. Each curve is a plot of the marginal means from a different design involving the x-axis factor. The data support a configural-weight-range model that predicts steeper slopes for designs having fewer factors.

FIGURE 2. Predicted and obtained data from the three-way factorial design for non-adherers and adherers to mammography screening. Interactions in the data that ruled out additive and parallel-averaging models to account for these data were in accord with the predictions of a configural-weight-range model. Filled symbols connected by solid curves are the theoretical predictions of this model; open symbols are the data. Predictions for non-adherers and adherers are based on separate model-parameter estimates.

Modeling-judged Mammography Decisions

Effects of varying number of factors. An averaging model, unlike the additive model, predicts that the effect of a factor increases as the number of factors with which it is paired in a scenario decreases (see the algebraic reasoning for this in the appendix). The configural-weight-range model, because it is an averaging model, also makes this prediction, which is tested in figure 1.

Each panel in figure 1 is a plot of mean certainty of having yearly mammography, on the y-axis. Marginal means from the three-way design are on the x-axis (represented by arrows) for the factor being tested.

Points on the curves in each panel of the figure are the marginal means for the factor on the x-axis when this factor is presented 1) alone as the screening scenario (top curves), 2) with one other factor in the screening scenario (middle two curves, except for panel D), and 3) with two other factors in the screening scenario (bottom curves, except for panel D). Clearly, the slopes of curves are steeper when less information is judged. This difference in steep-

ness of the slopes is most apparent when comparing curves that represent marginal means for a single factor (filled squares) with marginal means averaged over three factors (filled circles). Thus, these data rule out an additive model for both non-adherers and adherers but agree with the predictions of both a constant-weight-averaging model and a configural-weight-range model.

Interaction effects. The configural-weight-range model can account for interactions in data, whereas the constant-weight-averaging model predicts that the effect of one factor should be independent of the effects of other factors simultaneously presented for judgment. Tests of interaction effects in the data are presented in figure 2.

The top three panels in figure 2 display results from the three-way design for the 22 non-adherers; the bottom three panels display results from the three-way design for the 30 adherers. In each panel, the mean certainty of having yearly mammography is plotted on the y-axis as a function of cost on the x-axis; a separate curve is for each level of source; and a separate panel is provided for each level of risk. Filled symbols and solid curves represent predictions of the configural-weight-range model; open symbols are the data.

Table 2 • Psychological Values Derived from the Configural-weight-range Model*

	Logistic Parameters		Configural Weight (ω)	Initial Impression (S_0)	Factor Weight		
	b	c			Risk	Source	Cost
Non-adherers	0.05	0.07	-0.05	-0.16	0.23	0.48	0.38
Adherers	0.09	0.12	-0.04	3.80	0.09	0.43	0.28

*The weight for the initial impression (w_0) was set to 1 within each group to fix the location of the scale.

The slopes of the curves indicate the effects of cost on judged decisions; vertical separations between curves indicate the effects of source. The change in values associated with each point on the curves from the left- to the right-hand panels indicates the effect of perceived risk. If the cost $\times$ source interaction were nonsignificant, the curves in each panel would be parallel; vertical separations between any two curves would be the same, independent of the dollar amount on the x-axis. Instead, the curves deviate from this parallel prediction. When risk is low to medium (left and middle panels), the curves diverge; when cost is high (\$200), the source of the recommendation makes very little difference for both non-adherers and adherers; however, when mammography costs \$50 or is free, having a recommendation makes a big difference.

When adherers' risk is high (figure 2F), the curves actually converge toward the upper end; when mammography is free, the source of a recommendation makes *less* of a difference than when it costs \$100. This cost-by-source interaction was statistically significant ($p < 0.05$), as were the cost-by-risk interaction, the three-way cost-by-source-by-risk interaction, and the main effects of all three factors.

The significant and systematic interactions in the data shown in figure 2 rule out an additive model (equation A1) and a constant-weight-averaging model (equation A2) to explain these elderly Latinas' mammography decisions. Both of these models predict that the curves in each panel of figure 2 should have been parallel, that is, there should have been no interaction among the factors. However, the observed interactions are in agreement with the pre-

FIGURE 3. Scale values derived from the configural-weight-range model. The numerical scale that represents the psychological ruler is shown at the top and bottom of the figure. The line graphs permit comparisons between non-adherers (top line in each panel) and adherers with respect to the psychological ranges associated with the factors and spacings among the factor levels.

dictions of the configural-weight-range model (equation A4).

The configural-weight-range model. The fit of the configural-weight-range model with a linear transformation (equation A4) left systematic data-prediction deviations that were accounted for with the replacement of the linear transformation with a logistic transformation (equation A5). We fit the configural-weight-range model with a logistic transformation to the mean judged mammography decisions simultaneously for all seven designs (79 scenarios), separately for non-adherers and adherers, using a computer program that utilized Chandler's³⁵ STEPIT subroutine to find a least-squares solution.

For each set of data (79 mean data values), the model requires the estimation of 17 parameters—10 scale values, 3 weights, 1 configural-weight term, 1 initial-impression scale value (s_0 in Equation 1), and 2 parameter values for the logistic function (b and c in equation A5); the weight of the initial impression, w_0 , was set to 1 for each group to fix the location of the scale without loss of generality. Thus, for the two sets of data (158 mean data values), the model required the estimation of 34 parameter values. The least-squares solution yielded an average sum-of-squares data-prediction discrepancy of 0.11 for both adherers and non-adherers. The very good fit of this model to the data for both groups can be visually assessed by comparing the open symbols, which represent data points, with the solid points and curves in figure 2, which represent predicted values.

The psychological values of the women's initial impression, weighting, and transformation parameter values, derived from the configural-weight-range model with a logistic transformation, are presented in table 2. This model yielded negative configural weights for both adherers and non-adherers, indicating the tendency for women to shift weight from factor information they valued most to information they valued least when presented with a set of factors defining a mammography scenario. It is this shift in psychological weight from the high- to the low-valued item in the set that produced the divergent interaction tradeoffs among the factors shown in figure 2: the source of a recommendation made a big difference only when mammography cost \$50 or \$0. We can also see from table 2 that the non-adherers, unlike the adherers, began with a negative initial impression associated with having yearly mammography. This negative impression, which was found for non-adherers in the absence of specific information describing a mammography scenario, changed when features of the mammography situation were favorable.

The locations of the factor-level scale values for the adherers and the non-adherers along the "psychological continuum" can be seen in figure 3. At

the top and bottom of figure 3 is a "psychological ruler," used to depict the location of the models' scale values along this psychological continuum; the vertical dotted line represents the psychological zero point. Each panel in figure 3 is for a different factor. As can be seen, the non-adherers and the adherers differed in the ranges of their psychological scale values for the different factors and the psychological spacing among the factor levels. The features of these scale values are discussed further in the next section.

Synopsis. In sum, the significant interactions in the data, shown in figure 2, made it possible to reject both the additive model and the constant-weight-averaging model as appropriate mammography-decision-making models for these women. Interactions in this figure are predicted by a configural-weight-range model with a logistic transformation, as can be seen by comparing the open symbols (data) with the filled symbols and solid curves (model predictions). Further evidence for the configural-weight-range model was provided by comparing data from designs that varied different numbers of factors to generate the mammography scenario (figure 1). As predicted by this model, the effect of a factor on judged decisions increased as the number of other factors with which it was paired decreased. §§

DIFFERENCES IN VALUE TRADEOFFS BETWEEN NON-ADHERERS AND ADHERERS

The configural-weight-range model predicts conditions that might motivate non-adherers to adhere, as well as conditions that might drive present adherers into non-adherence. These mammography situations can be examined with respect to the model predictions shown in figure 2 and the scale values and weights shown in figure 3 and table 2, respectively.***

Cost. High mammography costs provide a barrier to mammography screening for both adherers and non-adherers, as can be seen by examining how decisions change with changes in cost in figure 2. For example, a 7 on the y-axis represents a "high chance" of having yearly mammography in the absence of symptoms. This could represent an achievement goal for a breast-cancer-screening program. Cost barriers to achieving this goal can be

§§The crossovers among many of the curves shown in figure 1 are evidence against a multiplicative model [$J = a(S_c S_s S_n)$] to account for the interactions seen in figure 2.

***The experimental design used in this study provides unique parameter estimates from a configural-weight-range model to an interval scale in the sense that only a linear transformation of the values when computed according to the model's algebra will reproduce the order of the data points shown in figure 2.³⁶

assessed by following projections of the dashed line in each panel in figure 2 from a 7 on the y-axis to its intersection with the curve that corresponds to the source of interest, and dropping vertically from that point on the curve to the x-axis; the projected value on the x-axis then provides the upper-limit cost figure for achieving a "high chance" of having yearly mammography for the women in each panel.

For example, the mammography cost limit in figure 2C for a non-adherer who believes her risk is high is about \$65 if a doctor makes the recommendation and \$50 if an organization makes the recommendation. Thus, this model predicts that non-adherers will even pay for mammography if they believe their risk is high and they have a recommendation. The model predicts that adherers who perceive their risk to be high (figure 2F) have a mammography cost limit of about \$90 with a doctor's recommendation and about \$65 (the same as non-adherers with a doctor's recommendation) with an organization's recommendation; higher costs would jeopardize their continued adherence, and, without a recommendation, mammography would have to be free to reach this chance-of-adherence level (bottom curve in figure 2F). If perceived risk is low for non-adherers (figure 2A), they require a doctor's recommendation and free mammography to achieve this level.

If adherence expectations are dropped to a 6 on the y-axis (dash/dot horizontal line intersecting the curves in each panel), an organization might prompt adherence in non-adherers who believe their risk to be low if mammography were free (figure 2A). If non-adherers believe their risk to be high (figure 2C), this level can be achieved with mammography costs as high as \$60.

From figure 3C, we see that the non-adherers had a wider psychological range associated with the cost dimension than did the adherers, as well as different psychological spacing among the cost-factor levels. For the adherers, the difference between \$100 and \$50 is about the same as the difference between \$50 and \$0. For the non-adherers, the difference between \$100 and \$50 is the largest difference; \$50 is closer in value to \$0 than to \$100. The psychological range is less for the adherers, because they placed a higher value (less negative) on the higher mammography costs. Both groups placed about the same value on free mammography and valued \$100 about as little as \$200. Table 2 shows that cost was the second most important factor in this barrier-factor set for both adherers and non-adherers, with greater weight placed on cost by the non-adherers than by the adherers.

Source of a recommendation. Cost is not the only story. Table 2 shows that source of the recommendation to get yearly mammography was the most im-

portant factor in women's judged decisions. The bottom curves in the top three panels of figure 2 show that, even if mammography were free, non-adherers would have been very unlikely to have yearly mammography without a recommendation. Adherers, on the other hand, would be somewhat likely to comply without a recommendation, but only if they believed their risk to be high (bottom curve in figure 2F). In fact, when perceived risk is high, adherers would be just as likely to have yearly mammography and pay \$100 if they had a doctor's recommendation as to have free mammography without a recommendation (compare rectangles in figure 2F).

The top two curves of figures 2D–2F show that the adherers were clearly influenced more by a doctor's recommendation than by an organization's. Exceptions were when mammography was free and their perceived risks were medium to high. This was not the case, however, for non-adherers. An important finding is that the non-adherers were influenced about equally by recommendations from a doctor or a known cancer organization (the top two curves in each of figures 2A through 2C). A comparison of the top with the bottom line of figure 3B shows the difference in psychological spacing between a doctor's and an organization's recommendation for non-adherers and adherers. Also, the non-adherers placed a lower value on the absence of a recommendation than did the adherers, and the non-adherers placed a higher positive value on a recommendation from either an organization or a doctor.

Although there has been much speculation in the literature about the importance of a doctor's recommendation in mammography adherence, the influence of a well-known cancer organization on these decisions has been neglected.

Risk. The bottom line of figure 3A shows that perceived risk for contracting breast cancer was the factor dimension with the largest range of scale values for the adherers. This is due to the very high value they placed on a high risk level. The psychological difference between a high risk level and a medium risk level was substantially larger than the difference between a medium risk level and a low risk level for both groups, but this difference was much greater for the adherers. Despite the large range in psychological values for this factor, perceived risk became relatively unimportant when the women considered other factors such as mammography cost or source of a recommendation in their decisions, as indicated by the low weight they placed on this factor (compare weights across barrier factors in table 2). The adherers, especially, placed a very low psychological weight on this factor, indicating their willingness to trade it off for other mammography features.

A PREDICTIVE VALIDITY TEST OF THE CONFIGURAL-WEIGHT-RANGE MODEL

The psychological values shown in table 2 and figure 3 were computed in the configural-weight-range model to obtain a predicted mammography adherence score for each woman. These were correlated with her reported mammography adherence to test the predictive validity of the configural-weight-range model as a mammography model for these elderly Latinas. To compute a predicted score for each woman, we assigned each one a factor level associated with each of the model's factors: risk, source, and cost. To do this, we used her answers to some of the survey questions. The rules we used for selecting the factor levels for each woman are as follows.

Risk. To estimate a woman's perceived risk level, we used her rating on this item in the survey questionnaire. We assigned the level "low" to ratings of none or low, the level "medium" to ratings of medium, and the level "high" to ratings of high and very high.

Source. If a woman reported having a recommendation from her doctor to have mammography annually or every other year, she was assigned the level "doctor." Women who reported a doctor's recommendation every three years or more were counted as not having a doctor's recommendation (these consisted of two non-adherers). These and other women reporting not having a doctor's recommendation were assigned a factor level of "organization" or "none," based on another survey question that asked the women how often they thought they

should have mammography. If a woman reported having no recommendation from a doctor but nevertheless thought she should have mammography annually or every other year, she was assigned the level "organization" by default. When this assumption is incorrect, it works against the model for a non-adherer and in favor of the model for an adherer. If the woman reported that she did not know how often she should have mammography or that she should have mammography only if she had symptoms of breast cancer, she was assigned the level "none."

Cost. Level of cost of mammography was more difficult to estimate for some women. In the survey, we asked the women three questions pertaining to cost: 1) how much she would have to pay out-of-pocket if she were to have mammography today, 2) whether she had insurance coverage for mammography, and 3) the strength of her agreement with a statement that she would have mammography every year if it was free.

Using their answers to these questions, we assigned the women to categories as follows: If a woman reported a dollar amount in response to the first question, that amount was used in the equation.^{†††} If she reported that she did not know the cost of mammography and agreed she would have mammography annually if it were free, she was as-

^{†††}To the first question, 26 adherers and six non-adherers reported "free," two adherers reported \$5.00; one non-adherer report \$60, and two adherers and 15 non-adherers reported they did not know.

FIGURE 4. Histograms depicting percentages of adherers (white bars) and non-adherers (black bars) assigned, as defined in the body of the paper, to the experimental factor levels.

FIGURE 5. Predictive-validity test of the configural-weight-range model. Reported mammography adherence is plotted on the y-axis as a function of the model's predicted adherence. The validity coefficient is 0.85.

signed a cost level of "\$50." This choice was based on the assumption that she believed mammography was too costly to have every year and that the "high" cost she was considering was *at least* \$50.00.††† If a woman answered that she might not or would not have yearly mammography even if it was free, she was assigned a cost level of "\$0," which was the most attractive situation she could be in, given our factor levels.

Percentages of women in the defined factor levels. Figure 4, panel A, shows that 82% of the non-adherers and 70% of the adherers rated their risks for breast cancer as low to none.

Panel B shows that 22 of the 30 adherers (70%) reported a doctor's recommendation to have mammography yearly or every other year, compared with two of 22 non-adherers (9%). Seven of the adherers (23%) who reportedly did not have a doctor's recommendation to have mammography reported they should have mammography every year or every other year, and also reported having mammography at this frequency. This may be compared with three non-adherers (14%) who made the same reports but were not having mammography at the frequencies they reportedly thought they should (see clear and filled histograms, respectively, under "organization" on the x-axis). Seventeen non-adherers (73%) and one adherer who reported not having a doctor's recommendation also reported that they did not know how often they should have mammography or that

Table 3 • Rules for Scoring Reported Mammography Adherence

	Total Number	and/or	Frequency	Score
Non-adherers	0			1
	1	or	once every >5 years	2
	2-10	and	once every 3-5 years	3
	>10	and	once every 3-5 years	4
Adherers	2-4	and	once every other year	5
	2-4	and	once a year	6
	5-10	and	once every other year	6
	5-9	and	once a year	7
	>10	and	once every other year	7
	>10	and	once a year	8

they should have it only if they experienced symptoms of breast cancer; these frequencies are labeled "none" on the x-axis.

Panel C shows the frequencies of adherers and non-adherers in two cost categories. However, when the women reported their actual mammography costs, we used these values for predicting their reported mammography adherence.

The predictions of the configural-weight-range model. We assigned each woman a factor level for each experimental factor using the procedures described above. We then obtained a predicted score for each woman from the configural-weight-range model and its parameter values shown in table 2 and figure 3. Figure 5 plots these model predictions on the x-axis; the y-axis plots the reported mammography adherence scores, as computed in table 3. The correlation between these two scores (the predictive-validity coefficient for the configural-

†††A woman who fell into this category may actually have had mammography insurance coverage and reported that she did not have it. One adherer and seven non-adherers on Medicare mistakenly reported having no mammography coverage.

weight-range model) was 0.85. The largest *misprediction* by this model was for a woman who had a doctor's recommendation, mammography insurance coverage, and a low perceived risk, but was a non-adherer, reportedly because she did not believe that breast-cancer treatments were efficacious, and would not have them if she had breast cancer; therefore she did not want to know.

Discussion

The major purpose of this study was to develop a mathematical measurement model of elderly Latinas' mammography decisions to provide information about what factors causally affect this decision and how they independently and interactively affect it, and to measure those effects.

A basic idea in developing the model was to include both adherers and nonadherers so that model predictions could be used to assess how changes in factors might positively or negatively affect adherence in both groups, and the magnitudes and directions of changes in single factors and factor combinations that would increase adherence in non-adherers while maintaining adherence in present adherers.

The use of factorial designs that varied the number of factors used to construct the mammography scenarios made it possible to test among hypothesized mathematical decision-making theories to account for their judgment data and reject the models (and the models' parameter values) that failed their tests.

THE CONFIGURAL-WEIGHT-RANGE MODEL

In this study, the configural-weight-range model did well in accounting for these women's judged mammography decisions and explained that the difference between adherers and non-adherers was not in the mathematical formulation of the decision-making model, but in the model's parameters, such as the psychological weights and scale values the women placed on the factors and factor levels. This model, combined with its parameter values for non-adherers and adherers, can serve as a tool for measuring magnitudes of tradeoffs among the factor levels manipulated in the experiment. It can also be used to measure tradeoffs among levels of risk and recommendation source along the entire cost continuum, thus serving to predict mammography decisions in numerous scenarios not presented in the study. Model predictions under this array of scenarios provide insights into educational and screening interventions that could well increase compliance rates in non-adherers while maintaining compliance in present adherers.

The configural-weight-range model, using two different sets of parameter values for adherers and non-adherers, did well in predicting women's *reported* mammography adherence, accounting for over 72% of the variance in their reported mammography-adherence scores. Thus, we found evidence for both the *internal validity* of this model in its ability to account for women's judgment data where other models failed and the *predictive validity* of this model in its ability to predict reported mammography usage.

TOWARD DEVELOPING A MORE GENERAL THEORY OF MAMMOGRAPHY DECISIONS

Configural-weight-averaging models have received support for interactions found in a wide variety of judgment tasks and domains, including military command and control,²² IQ predictions,²⁴ personality impressions,²⁶ estimates of the value of used cars,²⁷ ratings of attitudes and likely behaviors toward a group,²⁹ morality judgments,³⁰ perceived risk and attractiveness of lotteries,³¹ utility measurement and judgments under uncertainty,²⁸ numerical prediction,³² and, in this study, mammography decisions. Because this type of model has been successful in many different decision contexts, it would be fruitful to examine its generalizability as a mammography-decision-making theory to other groups of women and to use the model to better explain the factors that influence mammography decisions.

Generalizability. Are the types of implications for interventions to increase mammography frequencies in underserved populations the same for other groups of women as for the elderly Latina respondents in this study, or do the mammography decision-making factors play different roles for different groups of women? It is initially instructive to ask whether the configural-weight-range model predicts judged mammography decisions of other samples of Latinas aged 65 and over. Further investigations could extend to younger Latinas (for example, ages 50–65), other racial/ethnic groups, and women in higher educational and income levels than those of the respondents who participated in this study.

It would also be instructive to know how well this configural-weight-range theory can account for actual mammography behaviors. If we conducted a "real-world" experiment and randomly assigned elderly Latinas to receive different information about cost and recommended frequency of mammography, would their behaviors follow those predicted by this model? For example, if mammography facilities were convenient for participants, mammography were free, and women received recommended mammography frequencies from a recognized cancer organization such as the National Cancer Insti-

tute or the American Cancer Society, would subsequent mammography adherence follow the predictions of the model, given women participants' reported levels of perceived risk? What if another group had mammography costs of \$50? Would the difference in mammography adherence between the two groups agree with that predicted by the model?

Decision-making factors. The factor of convenience of the mammography facility was held constant in this study because, in our focused interaction sessions, this variable affected the women's mammography decisions. It would be instructive to manipulate this variable to test its causal independent and interactive effects on decisions. This investigation is more easily accomplished in a judgment experiment than in a behavioral experiment. Questions of interest are: How *inconvenient* do facilities have to be (for example, in terms of time to travel to and from the facility and transportation needs) to discourage adherers? Does a more or less convenient facility change the types of tradeoffs adherers and non-adherers make among cost, source, and risk?

Does convenience play different roles for women of different educational and income levels in the different racial/ethnic groups? The same question can reasonably be asked for the cost factor. It may well be that the psychological-scale values or weights of these factors and the tradeoffs among these and the other mammography-decision-making factors could be different for women of higher educational and income levels than for the lower-income, less-educated women used in this study. Differences would need to be incorporated into the configural-weight-range model.

The perceived-risk factor used in the present study has a special theoretical problem associated with it. To make mammography predictions using the configural-weight-range model requires knowing only women's reported risk levels; the model transforms them to psychological or perceived risk values. However, little is known about how risk information provided by physicians or cancer organizations affects women's psychological risk values. Information can be presented numerically (e.g., 1 chance in 10) or as a description (e.g., "The risk of breast cancer increases with age"). The important question to answer is how this information translates into levels of risk perceptions. There is a need for a theory of risk perception to better elucidate how accurately women perceive their breast-cancer risk levels and why, and what is being communicated to intended audiences. With this information, cancer organizations and health providers could disseminate risk information more effectively.

IMPLICATIONS OF THIS RESEARCH

A number of studies have pointed to the impact of a doctor's recommendation on mammography utilization rates. However, many women do not have doctors or have doctors who do not recommend regular breast-cancer screening. §§§ Knowing that a recommendation from a recognized cancer organization has a strong influence on non-adherers' decisions to have regular mammography screening is encouraging and carries with it important implications for well-known cancer organizations such as the NCI and the ACS—the organizations used as examples in this study.

The non-adherers in this study reported seeing or hearing breast-cancer-screening advertisements. All but two stated that the ads did not pertain to them. The major reasons given for this opinion were that they were old and Latina, with no symptoms and a low risk for breast cancer. Since non-adherers do not consider themselves part of the intended audience, they are not getting breast-cancer-screening recommendations. This study has provided evidence that cost, perceived risk, and mammography-frequency recommendations from either a doctor or a recognized cancer organization play *causal* roles in women's decisions to have yearly mammography. Yet, over two thirds of the non-adherers reported that they did not know how frequently they should have mammography, had never received a mammography recommendation from any source, and didn't know how much mammography would cost if they were to have it done today. (None of the women had ever received "official" information about their risk levels.)

Thus, it could be that non-adherence with mammography recommendations is due in large part to the content of the breast-cancer-screening advertisements, which neither speak directly enough to this group of women nor convey important information about the cost, the frequency of breast-cancer-screening recommendations, the source of the recommendation, risk levels, or the location of facilities.

Our data suggest that mammography costs need to be kept low and that a well-known cancer organization is influential in women's decisions to have yearly mammography at all risk levels. Mammography recommendations tailored to these women, delivered by a recognized cancer organization, and containing information about the locations of low-cost or free breast-cancer-screening facilities could well produce a turnaround for non-adherers.

§§§Seventeen non-adherers reportedly had doctors; only two reported that their doctors had recommended having mammography every year or every other year.

JUDGMENT EXPERIMENTS ALLOW INFORMED INTERVENTION

Decisions about implementing interventions, changing policies, or designing behavioral intervention studies are typically made without the assistance of results obtained from causal experiments or predictions from a tested decision-making theory. There are a number of advantages to preceding behavioral intervention studies with controlled judgment experiments. First, judgment experiments make it possible to explore causal factors associated with many more scenarios than can be entertained practically in a behavioral study; we explored 79 scenarios in the present study. Thus, results from judgment experiments can provide a guide for selecting factors and factor levels to use in an intervention study. Second, judgment experiments can explore the effects of factors that would be difficult to manipulate in a behavioral experiment, such as perceived risk or capabilities of advanced mammography technologies that provide more definitive diagnoses at earlier stages of breast-cancer development.

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APPENDIX

Three Hypothesized Models

The mathematical formulation of a weighted-additive model, a constant-weight-averaging model, and a configural-weight-range model are presented in this appendix. The mathematical basis for distinguishing between adding and averaging models is described. The three models are written with a linear judgment transformation from the psychological response to the respondent's numerical response. The logistic function that we tested against this linear judgment function is also presented in this appendix.

Weighted-Additive Model

$$J = a[w_C s_{Ci} + w_S s_{Sj} + w_R s_{Rk}] + b \quad (A1)$$

where J represents the woman's judged decision to have an annual mammogram; s_{Ci} , s_{Sj} , and s_{Rk} represent the scale values associated with the i^{th} level of cost of a mammogram, j^{th} level of the source of the recommendation to have a yearly mammogram, and the k^{th} level of perceived risk of breast cancer, respectively; w_C , w_S , and w_R are the weights, or measures of importance, she associates with these factors; and a and b are linear constants that map the subjective judgment onto the response scale used in the experiment.*

*The weighting parameters (w values), or "measures of importance," shown in equation A1 have a different meaning in psychological measurement from that in statistics. In statistics, these values are often interpreted as representing relative-effect sizes. In additive models, such as the multiple regression model, use of weighting parameters as indicators of effect sizes can lead to incorrect conclusions about the relative "importance" of factors, especially when the factors are correlated.¹⁸ A further problem occurs with additive models formulated with weights that multiply scale values, as in equation A1: the model cannot be used to separate estimates of scale values from estimates of weights in the data.¹⁹

Constant-weight-averaging Model

$$\begin{aligned}
 J &= a[(w_0 s_0 + w_C s_{Ci} + w_S s_{Sj} + w_R s_{Rk}) \\
 &\quad / (w_0 + w_C + w_S + w_R)] + b \\
 &= a \left[\frac{w_0}{w_0 + w_C + w_S + w_R} (s_0) \right. \\
 &\quad + \frac{w_C}{w_0 + w_C + w_S + w_R} (s_{Ci}) \\
 &\quad + \frac{w_S}{w_0 + w_C + w_S + w_R} (s_{Sj}) \\
 &\quad \left. + \frac{w_R}{w_0 + w_C + w_S + w_R} (s_{Rk}) \right] + b \quad (A2)
 \end{aligned}$$

where w_0 and s_0 are the weight and scale value of the initial impression (what the judged mammography decision would be in the absence of specific information about the scenario, such as level of cost, source of a recommendation, and risk); the other terms are as defined above.

Distinguishing Additive from Averaging Models

Additive and averaging models can be distinguished by varying the number of factors included in a mammography scenario, assuming that, when a factor is not presented for judgment, its weight is zero. We can follow this prediction from the different predictions of these two models that correspond to changes in the number of factors presented for judgment. As an example, we follow the effect of cost on mammography decisions for mammography scenarios described by three factors, two factors, and one factor.

For three factors, cost, source of a recommendation, and perceived risk, the prediction of an averaging model follows equation A2; the effect of cost on judged mammography decisions is: $w_c/(w_0 + w_c + w_s + w_r)$. The prediction of an additive model is shown in equation A1. In this equation, the effect of cost on judged mammography decisions is w_c .

For two factors, cost of mammography and source of a recommendation, the prediction of an averaging model is

$$J = a[(w_0s_0 + w_cs_{ci} + w_ss_{sj})/(w_0 + w_c + w_s)] + b \quad (A3)$$

where the terms are as described above. The effect of cost on judged mammography decisions in equation A3 [$w_c/(w_0 + w_c + w_s)$] has increased, since the numerator has stayed the same but the denominator has decreased by the size of the weighting factor for risk, w_r . In contrast, the additive model predicts that the effect of cost on judged mammography decisions is w_c —the same effect as for the scenario described by three factors.

This same reasoning continues for presenting a single factor for judgment—cost, for this example. Thus, as the number of factors describing a mammography scenario increases, the averaging model predicts that the effect of any one of the factors on judgments will decrease; the additive model predicts that the effect of any one of the factors on judgments will remain the same, independent of the number of factors describing the mammography scenario. Thus, these two models can be distinguished when the experimental design varies the number of factors describing the scenario.

Configural-weight-range Model

One form of the configural-weight model predicts that people place a weight on the range of scale values associated with factor levels describing a scenario. The form of this model is as follows:

$$J = a \left[\frac{(w_0s_0 + w_cs_{ci} + w_ss_{sj} + w_rs_{rk})}{(w_0 + w_c + w_s + w_r)} + \omega(s_{\text{MAX}} - s_{\text{MIN}}) \right] + b \quad (A4)$$

where the weights and scale values are as defined above; s_{MAX} and s_{MIN} are the highest- and lowest-valued factor lev-

els describing the mammography scenario; ω is the configural weight of this range term; and a and b are linear constants.

When ω is positive, the scale value associated with the highest-valued factor level describing the scenario being judged receives an *increase* in relative weight; when ω is negative, the scale value associated with the highest-valued factor level describing the scenario receives a *decrease* in relative weight; when ω is zero, i.e., s_{MAX} and s_{MIN} are equal, this range term goes to zero and the configural-weight-range model becomes the averaging model of equation A2.

Linear and Nonlinear Transformations of the Responses

In equations A1–A4, a and b represent the linear constants; that is, a linear transformation is assumed to map the psychological response (the response that occurs before the respondent selects a number as a response) onto the nine-point response scale used in the experiment. Using Ψ to represent the psychological response, the linear transformation can be written: $J = a\Psi + b$.

Some response scales create a nonlinear mapping from psychological responses to the experimental response scale. For example, the magnitude-estimation-response scale, typically used for ratio-judgment tasks, produces an approximate exponential transformation from psychological responses to the numerical magnitude-estimation-response scale (see, for example, Veit³³ and Birnbaum³⁴). When judgments resemble probabilities, as in the present study, the lowest and highest values in a category-rating scale ("for certain I would not," "for certain I would") are often used for a number of judgment scenarios in addition to those created to represent the "worst" and "best" scenarios from the factor-level combinations. When this occurs, a logistic (s-shaped) transformation often successfully maps the subjective responses onto the response scale. The form of the logistic function we used in this study to test against a linear transformation is

$$J = 8\{1.0/[1.0 + \exp(-b\Psi) + c]\} + 1 \quad (A5)$$

where the numbers 8 and 1 act to map the psychological response, Ψ , onto the nine-point scale, b is the spread parameter in the ogive, or s-shaped curve, that represents the steepness of the s-shape, and c is the location parameter (i.e., the location of the midpoint of the ogive curve that corresponds to a Ψ value of zero).