Patients' anticipated compliance: a functional measurement analysis

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Abstract *This study examined how patients with long-term diseases expressed anticipations about complying with medication recommendations. Patients were asked to project their compliance to hypothetical medications with specific side-effects. Patients with the following diseases were studied: iron deficiency anaemia, hypothyroidism, epilepsy, inactive tuberculosis, non-insulin dependent diabetes, bronchial asthma, hypertension, coronary artery disease, and chronic obstructive pulmonary disease. These illnesses were selected because they could be arranged in a naturalistic factorial design, in which symptom severity and prognosis were factors characterizing diseases. It was hypothesized that the information about the disease factors and side-effects would combine according to a multiplicative model. Functional measurement procedures were utilized to analyze the data. The results indicated that disease prognosis and medication side-effects combine multiplicatively to influence compliance projections. Further analysis of the data showed stronger support for a multiplicative combination of disease severity and side-effects.*

When Macbeth exclaimed 'Throw physic to the dogs: I'll none of it', he was asserting the patient's ultimate control over the treatment process. At least 50% of patients requiring long-term therapy do not follow the prescribed regimen (Stone, 1979). Over the past few decades, researchers have explored many variables thought to be related to compliance. Considerable attention has been paid to three kinds of factors identified by Meichenbaum and Turk (1987): patient characteristics, the relationship between patients and health care personnel, and the organization and structure of the health care system. Less attention has been given to two other categories, treatment characteristics and illness characteristics, particularly with regard to the patient's perspective.

Treatment characteristics include a range of variables such as financial considerations, length and convenience of treatment, and side-effects. The present study will examine side-effects, since these phenomena are relevant to most regimens and are independent of the patient's economic situation.

The patient's perspective on compliance may well be different from that of the health care worker. The physician assumes that the patient's investment in the treatment process makes noncompliance irrational, while the patient confronts the reality of the impact of the treatment, as well as that of the disease, on everyday living. Clearly, compliance increases the

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probability of disruptive side-effects (Green *et al.*, 1984). Greenberg *et al.* (1984) found that physicians expected patients to comply with medical testing and treatment if the illness was serious and treatable. On the other hand, Donovan and Blake (1992) concluded that patients carry out a cost-benefit analysis of each recommendation. Patients' perceptions of treatment efficacy, as well as personal and social circumstances, were found to be important in compliance decisions. The reason most often reported by patients for not taking medications, or for taking a lower dose than recommended, was adverse effects from the medications. Compliant patients also reported fear of side-effects, but the fears were outweighed by their arthritis pain.

In contrast to Haynes's (1979) summary evaluation that few patients fail to comply because of side-effects, more recent investigations have found adverse reactions to decrease adherence considerably. Patients undergoing hormone replacement therapy weighed the risks, such as increased likelihood of cancer, against gains such as relief from hot flashes (Logothetis, 1991; Rothert *et al.*, 1990). Patients with a variety of medical conditions reported modifying the prescribed regimen in order to control their symptoms without major disruption in their lifestyle (Hunt *et al.*, 1989). Noncompliance among children has also been attributed to side-effects (Cromer & Tarnowski, 1989). The adolescent patients of Korsch *et al.* (1978) blamed their noncompliance on adverse medication reactions, as did the children with cancer treated by Dolgin *et al.* (1986).

The characteristics of the disease itself may affect adherence to medical recommendations. On intuitive grounds, one might expect a patient suffering severe symptoms to be strongly motivated to comply (Weiss, 1989). This intuition is consistent with the available evidence. Asymptomatic diseases such as hypertension (Miller *et al.*, 1992; Morisky, 1986), anaemia (Galloway & McGuire, 1994) and inactive tuberculosis (Lange *et al.*, 1986) are notorious for poor compliance. Among patients with asthma, those who experience fluctuating symptoms comply better when their symptoms are extreme (Deaton, 1985). Among patients with epilepsy, those with the more severe grand mal form are more adherent than those experiencing the less regular symptoms associated with the milder forms such as petit mal (Muclow & Dollery, 1978; Peterson *et al.*, 1982).

Conflicting intuitions prevail for the other disease characteristic explored in the current study, disease prognosis. Extreme peril should inspire high compliance (Taylor *et al.*, 1984). Comparisons across diseases with differing prognoses have not appeared, although a study using cancer patients found a correlation between increasingly poor prognosis (in terms of estimations given by physicians to patients) and extent of compliance (Dolgin *et al.*, 1986). On the other hand, if the disease seems unconquerable, a patient may surrender to the inevitable and forego the duress of treatment. Compliance is expected to be poor when the patient does not believe in the efficacy of the regimen (Becker & Rosenstock, 1984), so an incurable disease should generate poor compliance.

In everyday response to illness, patients are influenced by multiple considerations. It would be useful to understand the cognitive processes by which these elements combine to affect the patient's anticipations of compliance with treatment recommendations. Although anticipation is not identical to behavior, it is a logical precedent (Becker, 1985; DiNicola & DiMatteo, 1984), and has been shown to be strongly related to actual compliance (Kaplan & Simon, 1990). As a first step, we examine the joint impact on anticipated compliance of two disease factors, symptoms and prognosis, along with a treatment factor, side-effects. In our study, the disease factors enter the judgement implicitly, as the diagnosis is part of the patient's life. The treatment factor enters the judgement explicitly; we present a variety of side-effects within the experiment.

Our anticipation is that these factors will combine in a multiplicative manner. The import of multiplicative combination is that the effect of one variable magnifies the effect of the other variable. For example, if the symptoms are mild enough, then even a poor prognosis may have little effect on compliance. This differs from additive combination, which implies that variables operate independently. A prediction of multiplicativity was advanced because disease elements combined in this manner in a previous study exploring the impact of disease prognosis and transmissibility on nurses' fear of contagion (Rundall & Weiss, 1994). The intuition there was that probabilistic elements should combine multiplicatively, as though expected values are involved (Anderson & Shanteau, 1970). Similar intuitions apply with the current factors, since medical information is usually given to patients in a probabilistic format.

In order to study the three influences experimentally, we established a factorial design in which symptoms, prognosis, and side-effects were crossed. In the real world of illness, symptoms and prognosis may not be independent; for some diseases, as a patient's symptoms become more severe, the prognosis worsens. However, we can assess the independent contributions by using a between-subject design and judiciously choosing diseases that afford orthogonal combinations of the disease factors. Patients were sought who had the specific diseases characterized by our factorial combinations.

We selected side-effects impinging upon various aspects of life, such as appearance, discomfort and functional ability, that have been associated with poor compliance (Stoudemire & Thompson, 1983). This factor was crossed with the disease characteristics. Crossing dictates that all subjects evaluate all side-effects, even those that would not normally accompany their own specific medication. In the interest of veridicality, we asked patients to envision hypothetical medications. This allowed subjects to consider side-effects outside of their personal experience, and also avoided possible psychogenic reactions if we were to tell patients their own medicines had unexpected negative consequences.

In the real world of illness, a particular side-effect such as sexual dysfunction or weight gain may not distress all patients equally. A group design glosses over these individual differences. It may be possible to associate this kind of variation with classifications such as gender and age. In principle, demographic predictors could be additional grouping factors in the experimental design. Arguing against such attempts is the difficulty of finding patients satisfying the requirements as the number of factors increases. Not only does the design become unwieldy, but some cells of the design may be impossible to fill because particular diseases are age- or sex-linked. A regression-based approach to exploring predictors is subject to similar limitations.

A cognitive model and a factorial design are the hallmarks of functional measurement methodology (Anderson, 1981). Functional measurement has been recommended for the medical domain (Froberg & Kane, 1989) because it offers a way to validate the response instrument. The establishment of a correct model also provides validated subjective measures of the independent variables.

Algebraic cognitive models are evaluated statistically by analysis of variance and graphically with factorial plots. Significant main effects are needed to support any model. A multiplicative combination of two factors implies interaction, all of which is concentrated in a single degree of freedom component, the bilinear term. Therefore, the statistical test requires that the bilinear component of the interaction be significant and the remaining components of the interaction be non-significant. Contrast coefficients needed to determine these comparisons are estimated (Weiss & Shanteau, 1982) using subjective spacing (marginal means). The graphical counterpart is that the factorial plot shows a linear fan configuration (Anderson, 1981).

Here we extend the approach with the use of a novel group design in which patients are nested under their disease characteristics. The nesting arises because patients experience only their own diseases, and so can appear only in specific design cells. In contrast to the usual goal of evaluating a model of the individual subject's cognition, here we define the model at the overall group level. The model is descriptive of the cognitive behaviour of the group as a whole; it does not purport to describe what transpires within a single mind. There are statistical complications caused by nesting. In standard repeated measures designs, each source is tested against its interaction with subjects; in a nested design, sources must share error terms. Nested designs, as well as fully crossed designs, for additive and multiplicative models may be analyzed with the computer program FUNCTIONAL MEASUREMENT (Weiss, 1997).

The functional measurement paradigm has been employed in a similar context by Wills and Moore (1994), in which the judgement was of hypothetical medication acceptance. Wills and Moore asked college students to imagine they were experiencing three levels of clinical depression. The students estimated how likely they would be to comply with suggested medication regimens for each level. Other factors varied within the scenarios were medication efficacy and side-effects. Wills and Moore argued for an averaging model as the combining rule for the effects of these variables. Their use of functional measurement methodology increased the internal validity of this study, in that the consistent pattern within the set of responses enhanced the credibility of any single judgement.

However, the use of healthy persons imagining themselves to be ill raises the question of external validity. Just as health care workers have difficulty appreciating the compliance problems of patients (Greenberg *et al.*, 1984; Rothert, 1982; Rothert & Talarczyk, 1987), so one might expect students to apply a model they deem theoretically appropriate but which would not necessarily be used by someone with that illness.

In order to manipulate experimentally factors that characterize diseases, specifically symptom severity and prognosis in the present study, it is necessary to identify diseases which vary in these respects. These diseases were identified from a medical text (Berkow, 1987) that provides information about symptom severity as well as the likely prognosis. Choosing three levels of each of these factors generated a design with nine long-term diseases. The selection of diseases whose characteristics yield a naturally occurring factorial design was a feature employed by Rundall and Weiss (1994).

There is a risk that subjective experiences across diseases are not truly comparable. According to the Health Belief Model, patients may be more influenced by their perceived severity of illness than by the medical diagnosis (Becker, 1985). A similar risk applies to the comparability of experiences among individuals who have the same illness. Variability in how diseases are perceived among patients placed within a single design cell decreases analytic power. We attempted to reduce the variability by furnishing each subject with a prototypical description of the disease, but a patient's personal experience may limit our control.

Method

Subjects

Patients with long-term illnesses were recruited via physician referral. We sought out physicians in private practice, at Veterans' Administration outpatient clinics, and at community health clinics. These sites were chosen to find patients with the diseases called for by the factorial design. The protocol was approved by the institutional research boards for both of the authors' home institutions, as well as one for the Veterans' Administration. Patients were deemed eligible for the study on the basis of the diagnostic information in their charts.

Cognitive competence was assessed through chart review and a brief assessment of mental status; all subjects were coherent, literate and able to complete the questionnaire on their own. Subjects were asked to participate in the study during a visit to the physician or they were contacted by telephone and/or mail (by the first author). Of the patients initially recruited, almost all agreed to participate in the study, but only about 50% completed the two replications requested of them.[1]

It was common for patients to have more than one of the diseases being examined in this study. In such instances, subjects were assigned to the disease cell that needed more subjects. Patients were asked to consider their judgements in light of only the designated illness. The final sample consisted of 180 patients, 20 per disease cell. The patients varied in age from 18 to 91 (mean = 53). There were 106 men and 74 women. The patients were grouped into the following ethnicities, in accord with self-identification: 115 Caucasians, 31 Latinos, 15 Asians and ten African-Americans. Nine patients did not specify their ethnicity.

Design

A 3 by 3 factorial design was constructed using diseases varying in symptom severity and prognosis. The levels for the symptom factor were: asymptomatic or mild symptoms, moderate symptoms, severe symptoms; while those for prognosis were: favourable, doubtful, unfavourable. Thus there were nine diseases for which patients were sought. Since each disease was defined by symptom severity and prognosis, the subject factor was nested under both of these factors. The diseases were iron deficiency anaemia, hypothyroidism, epilepsy, inactive tuberculosis, diabetes mellitus (Type II), bronchial asthma, primary hypertension, coronary artery disease, and chronic obstructive pulmonary disease (COPD) (see Appendix I). Gender and age information for the sample are included for each disease.[2] Symptom and prognosis severity levels were determined from information in *The Merck manual of diagnosis and therapy* (Berkow, 1987).

The symptom levels were associated with the disease rather than the patient. They did not necessarily correspond to the actual severity experienced by patients when they responded. Logistically, it would be difficult to estimate the momentary, or even the typical, severity felt by an individual patient. The goal was to choose design levels sufficiently far apart that variability among patients within a level was small relative to the variability across levels.

Medication side-effects were considered as follows. The side-effects were chosen to allow for differences in how they affected an individual's lifestyle. The five side-effects levels were: (1) constipation, (2) facial blotches, (3) sexual dysfunction, (4) fatigue and lethargy, and (5) no side-effects.

Procedures and instruments

Patients who agreed to participate signed a written consent form. They were assured that non-participation or failure to complete the study would not affect their medical care. Patients agreeing to participate received a written description of the study and instructions. In addition, they received a questionnaire containing a brief description of their specific disease symptoms and prognosis (see Appendix 2). Information about the diseases was provided to ensure that all patients had the same basic information, and to guard against the possibility of patients not being knowledgeable about their disease. For each medication side-effect, the subjects were asked to estimate their likelihood of compliance. The questionnaire contained two practise examples. Then patients rated five hypothetical medications,

each with a specific hypothetical side-effect. The side-effects were presented in a random order. Two replications, separated by approximately two weeks, were obtained.

A graphic rating scale (Weiss, 1980) for each medication side-effect was provided on the questionnaire (see Appendix 3). The projected compliance decision was measured on a 100 mm continuous scale with two extreme end markings. The left end of the scale represents the smallest possible level of anticipated pill-taking. The right end of the scale represents the maximum compliance. The responses were recorded as the distance from the left end of the line to where the participant slashed the line. The rating was measured to the nearest millimetre, so that a response is a number between zero and 100.

A Spanish version of the instruments was also constructed. The Spanish version was needed only for the inactive tuberculosis patients, who were recruited from the county health clinic.

Results

The first analysis we carried out produced only limited support for the proposed multiplicative model. However, the data showed patterns suggesting that a reformulation would yield a more descriptive model; the second analysis yielded moderate support for a slightly different multiplicative structure.

First analysis

The first 20 sets of questionnaires completed for each of the diseases were analyzed. The initial factorial analysis examined a 3 (symptoms) $\times$ 3 (prognosis) $\times$ 5 (side-effects) $\times$ 2 (replicates) $\times$ 20 (patients) design, with patients nested under symptoms and prognosis. The multiplicative model was not supported in the manner expected, in that the symptoms' main effect proved non-significant. The expected multiplicative relationship between prognosis and side-effects was obtained, though, so the model did gain limited credibility.

Table 1 shows the group ANOVA results for the first analysis. The main effects for prognosis and side-effects are significant, but that for symptoms is non-significant. The interaction between prognosis and side-effects is also significant. Factors may be said to combine multiplicatively if their main effects and pairwise interaction are significant, and the interaction is concentrated in the bilinear component. Quantitatively, the requirement is that the bilinear component is significant and the remaining single df components of the interaction are not. Each of these other components (linear $\times$ quadratic, linear $\times$ cubic, ..., quadratic $\times$ linear, quadratic $\times$ quadratic... as available for each interaction) was tested individually against shared error terms, following an algorithm based on Myers (1979, p. 456). According to the functional measurement criteria, only side-effects and prognosis combine multiplicatively.

Graphically, a multiplicative relationship yields a plot of lines diverging from a common origin, usually referred to as a zero point. Figure 1 shows the mean responses for prognosis $\times$ side-effects. Although the divergence is mild, the expected pattern is visible. The natural 'zero point' here is the anticipated high compliance rate ('zero' noncompliance) when there are no side-effects. Responses are moderately disparate for sexual dysfunction and are maximally divergent for facial blotches. No prediction of the ordering of the various side-effects on the abscissa was made. Instead, subjective values (marginal means) determine the spacing. Joint consideration of the statistical and graphical analyses provides support for the multiplicative combination of prognosis and side-effects.

Table 1. *ANOVA: multiplicative test of symptoms × prognosis × side-effects*

Source	df	SS	MS	*F*	*p*
Symptoms	2	12420.91	6210.45	1.15	0.319
Prognosis	2	43396.13	21698.07	4.02	0.019*
Sym × Prog	4	93880.50	23470.12	4.35	0.003*
Linear × Linear	1	105.87	105.87	< 1	0.884
Side-effect	4	894289.53	223572.38	177.80	< 0.001*
SE × Sym	8	21743.90	2717.99	2.16	0.028*
Linear × Linear	1	10546.56	10546.56	7.29	0.008*
SE × Prog	8	24333.60	3041.70	2.42	0.014*
Linear × Linear	1	11428.18	11428.18	7.90	0.006*
SE × Sym × Prog	16	56122.48	3507.66	2.79	< .001*
Lin × Lin × Lin	1	720.41	720.41	< 1	0.512

*$p < 0.05$.

Note: The table has been abbreviated in that only main effects, interactions and bilinear and trilinear components are shown; other components and error terms have been omitted. For SE × Prog, none of the seven additional single-df components was significant at the 0.05 level. A full version of the table may be obtained from the second author.

Although the main effect for symptoms was non-significant, symptoms did interact with the other two substantive factors and thus did play a role in the judgements made by patients. A second analysis was proposed, one which eliminated symptoms as a separate factor. The goal was to establish a model affording a more cogent description of the judgements. In carrying out this second analysis, we acknowledge the limitation of the original model in predicting compliance projections as a function of symptoms and prognosis. The naturally occurring factorial design did not adequately capture the impact of these disease features on compliance.

Second analysis

A newly constructed factor with nine levels was created by combining symptoms and prognosis. This new factor was labeled Disease Severity. The new factor could have been

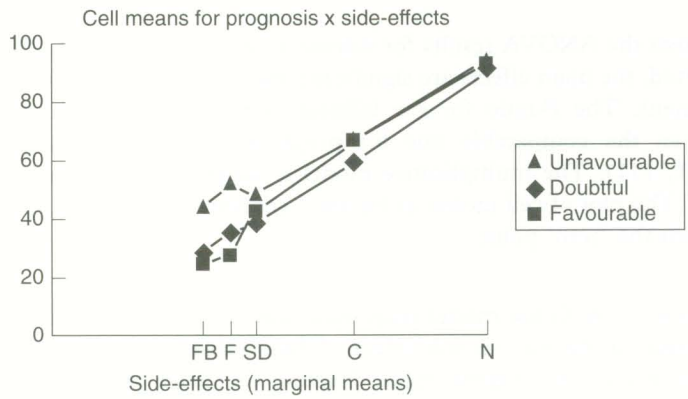

FIG. 1. *Factorial plot of mean anticipated compliance for disease prognosis × side-effects. Letters along the horizontal axis denote the different side-effects (FB: facial blotches; F: fatigue; C: constipation; SD: sexual dysfunction; N: no side-effects). The three curves represent the three prognosis levels. Spacing on the horizontal axis reflects subjective values.*

Table 2. *Multiplicative test of disease severity × side effects*

Source	df	SS	MS	F	p
Disease	8	149697.54	18712.19	3.47	0.001*
Side-effect	4	894289.53	223572.38	177.80	< 0.001*
SE × Disease	32	102199.98	3193.75	2.54	< 0.001*
Linear × Linear	1	62146.00	62146.00	42.96	< 0.001*

*$p < 0.05$.

Note: The table has been abbreviated in that only main effects, interactions and bilinear components are shown; other components and error terms have been omitted. Of the 31 single-df tests of the other components of the SE × Disease interaction, only one yielded significance at the 0.05 level. A full version of the table may be obtained from the second author.

labeled 'diseases', but the diseases had originally been selected to reflect differences in severity from a medical perspective. Thus, diseases chosen to vary in symptoms and prognosis vary at the same time in disease severity. The new design was a 9 (disease severity) × 5 (side-effects) × 2 (replicates) × 20 (patients) design, with patients nested under disease severity.

Since prognosis and symptoms in the first analysis were collapsed to form disease severity in the second, the sum of the sums of squares for prognosis, symptoms, and prognosis × symptoms (from the first analysis) is equal to the sums of squares for disease severity (from the second analysis); the df may be summed similarly. Although the second analysis was not planned in advance, the statistical confirmation was not performed as a *post hoc* test because the nested group design is sufficiently novel that we considered the first analysis exploratory.

Before undertaking this effort we explored the stability of the data. It was important to be sure that the data were sufficiently reliable to justify a second analysis. Stability was examined via the main effect of replications. This factor yielded a non-significant F-ratio of 1.81, (df = 1, 171). Visual inspection confirmed the concordance between replications, in that the cell means were superimposed. The individuals responded differentially to the various side-effects presented, but responded consistently to the same stimuli even though the responses were made two weeks apart. Since the replicates factor is orthogonal to all others, stability is not affected by the collapsing of symptoms and prognosis in the second analysis.

Table 2 shows the ANOVA results for disease severity × side effects. The multiplicative model is supported, the main effects are significant and the interaction is concentrated in the bilinear component. The F-ratio for the bilinear component is much larger ($F = 42.96$, df = 1, 171) than the comparable one for prognosis × side-effects in the first analysis ($F = 7.90$, df = 1, 171). The multiplicative model is supported much more strongly in the second analysis. The plot of cell means in Figure 2 confirms the picture. The means fan out considerably from the 'zero' point.

Side-effect evaluation. With the model supported, the marginal means provide estimates of the subjective values of the various side-effects. These values may be seen as the spacing in Figure 2. As expected, the highest value (highest projected compliance) is for the no side-effects level. The lower values are for facial blotches, fatigue and sexual dysfunction. In comparison to the other side-effects, the compliance rating is highest for constipation and there is less divergence among the different diseases. Although constipation is an uncomfort-

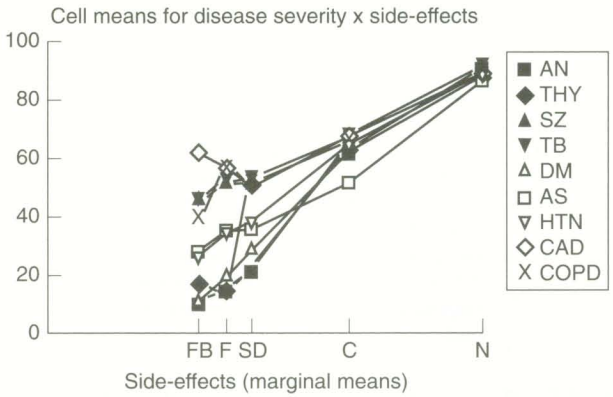

FIG. 2. *Factorial plot of mean anticipated compliance for disease severity × side-effects. Letters along the horizontal axis denote the different side-effects (FB: facial blotches, F: fatigue, SD: sexual dysfunction; N: no side-effects). The nine curves represent the nine diseases (AN: anemia; THY: hypothyroidism; SZ: epilepsy; TB: inactive tuberculosis; DM: diabetes mellitus; AS: asthma; HTN: hypertension; CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease). Spacing on the horizontal axis reflects subjective values.*

able side-effect, it can be prevented or treated with relative ease by dietary regulation or with over the counter medications. Apparently when a side-effect can be managed, it is not expected to greatly disrupt compliance.

Patient characteristics. Although patients were selected for their diseases and not for gender or age, we explored the possible explanatory value of these demographic characteristics. As may be seen in Figure 3, there is a consistent gender difference, in that males predict higher likelihood of compliance than do females across all side-effects. The pattern in Figure 3 looks strikingly like that in Figure 1. Thus the gender difference may merely reflect the fact that men in our sample tend to have the more serious diseases.

We also examined the connection between age and anticipated compliance, reasoning that some side-effects might seem less burdensome to patients of particular ages. Correlations

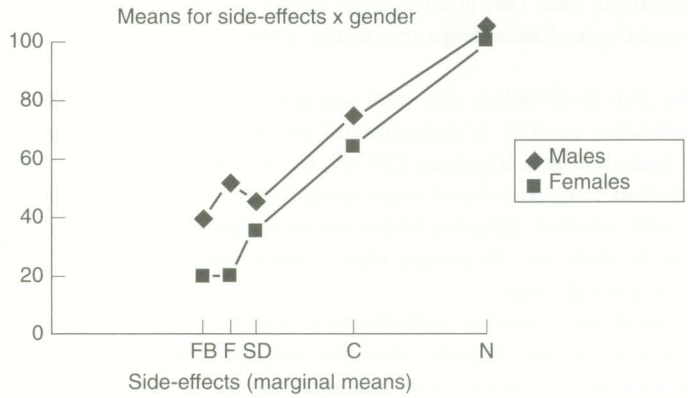

FIG. 3. *Factorial plot of mean anticipated compliance for gender × side-effects. Letters along the horizontal axis denote the different side-effects (FB: facial blotches, F: fatigue, C: constipation, SD: sexual dysfunction; N: no side-effects). Spacing on the horizontal axis reflects subjective values.*

Table 3. *Product-moment correlations between age and anticipated compliance*

Side-effect	Pearson r
None	0.063
Constipation	0.089
Sexual dysfunction	0.113
Fatigue	0.174*
Facial blotches	0.046

*Significantly different from zero at 0.05 level.

are shown for each side-effect in Table 3. All are small, and only that for fatigue was significantly different from zero.

Discussion

The evidence shown in Figure 2 and Table 2 confirm that a multiplicative model provides a reasonable description of anticipated compliance. The divergence seen in Figure 2 is of a sizeable magnitude. The judgements for the no side-effects cells are unrelated to disease severity. The means for constipation cover a small range (16.6), while those for facial blotches cover a large range (51.7).

Thus, a practitioner attempting to provide guidance to a patient needs to consider not only the disruptive nature of the side-effect, but also how that side-effect interacts with disease severity. A patient with a mild disease may not be willing to tolerate disruptive side-effects, while one with a severe disease is more likely to be compliant irrespective of the potential interference with lifestyle associated with the treatment. The mathematical model affords the practitioner a compact way to summarize a complex pattern of anticipated compliance problems.

The responses shown in Figure 2 span almost the entire possible range. The lowest mean anticipated compliance is 10.48, the highest 95.33. Subjects are responding differentially to the various side-effects, and the diseases have a marked impact. Reflective of the marginal means, main effects can be seen. With no side-effects, respondents anticipate high compliance; with constipation, less compliance; and with sexual dysfunction, fatigue and facial blotches the expected compliance drops markedly. Those with more severe diseases expect to comply more.

Although the plot is crowded, the data are quite orderly. In laboratory investigations evaluating multiplicative models of judgemental processes, such as those of Anderson and Weiss (1971) or Anderson and Shanteau (1970), the linear fan is more dramatic because the lines appear more clearly separated and more straight. Such studies are characterized by small numbers of precisely selected stimulus levels whose subjective counterparts are likely to be distinct. In Figure 2, there are 45 points; nine disease levels appear, and their spacing was predictable only in a rough way.

The most cogent statement of orderliness is given by the statistical support for the model. A multiplicative model requires that the bilinear component of the interaction be significant. Thus, although the error terms in a nested group design incorporate between-subjects variability, there is sufficient power in the present data to confirm bilinear trend.[3]. Furthermore, as the replications analysis showed, individual subjects are consistent in their responses.

The failure of the first proposed model emphasizes the limit imposed by variability in subjective experience, in that the hypothesized symptom factor did not have a consistent impact. It seems unreasonable that symptoms do not affect compliance (Hunt *et al.*, 1989; Meichenbaum & Turk, 1987). Our obtained result, the non-significance of symptoms, is attributed to the grouping of people with different diseases under common levels. Our grouping was based upon textual information, as we (unsuccessfully) sought to take advantage of the naturally occurring factorial design. In retrospect, it might have been more effective to employ self-ratings of symptom severity as a blocking variable. If patients with different diseases do indeed have symptoms of comparable severities, a factorial structure could be achieved. One would have to ensure that the rating instrument defined symptom severity in a general, not a disease-specific, way.

There is also likely to be variation in symptoms among people with the same disease. The resulting variability in anticipated compliance would show itself in the error term for the disease main effect in the second analysis. While the disease F-ratio, 3.47, is rather small, its significance does provide evidence that separating subjects by disease yields predictive power.

Variation in ages also characterized our subjects. It may seem surprising that we found little relationship between age and anticipated compliance for the various side-effects. One might expect, for example, younger patients to be more disturbed by facial blotches than older ones (Dolgin *et al.*, 1986). However, the characteristics of our sample mitigate against the conclusion that age doesn't matter, because in general our older patients have more serious diseases, and severity enhances anticipated compliance. Similar confounding weighs against the result suggested by Figure 3, that males anticipate higher compliance than females. Males in our study tend to have more severe illnesses, and severity appears to be the crucial variable.

The variation in anticipated compliance across the range of diseases can perhaps be seen as an explanation for the corresponding variation across a range of drugs prescribed for regular, long-term administration noted by Inui *et al.* (1980). In that study, the focus was on compliance as a function of the particular medication. Their analysis found that drugs that would be likely to be prescribed for milder diseases, such as Mylanta, Maalox and multiple vitamins, generated much lower compliance rates than drugs likely to be prescribed for more severe illnesses, such as Digoxin, Furosemide and Phenobarbital. The account offered by the authors was that despite prescriptions to the contrary, the drugs associated with low compliance were treated by patients as though they were to be taken only as needed. The Inui *et al.* (1980) data are consistent with the findings of the present study, in that better compliance is expected for more serious diseases, at least if side-effects are in the picture.

Although a group design is unfamiliar for analyzing a cognitive process, it offers a way to study real-world problems quantitatively. One must get used to the idea that description is at the level of the group. For the clinician, though, this group analysis provides a pragmatic advantage. A successful model summarizes the patients' perspective for the benefit of the practitioner. Here, we can predict that side-effects will affect compliance, and that their impact will be more pronounced on patients with milder diseases.

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Notes

[1] All patients received the second questionnaire by mail, and we subsequently attempted telephone calls reminding them to respond. Those patients whom we were able to reach by telephone were more likely to return the second questionnaire.

[2] The inactive tuberculosis patients are considerably younger than the others. They were recent immigrants whom we recruited from the county health clinic. While the disease strikes across ages, it seems that people who enrol for preventive treatment tend to be young. We did not consider age in recruitment, so long as the patients were over 18 and literate in English or Spanish.

[3] Statistical power is central to model analysis. Without sufficient power, no model can be rejected. However, no standard method for power assessment appears applicable to functional measurement analyses. For the multiplicative model, a practical approach is available. It seems plausible that if there is sufficient power that the bilinear component emerges as significant, then there is enough to evaluate the remaining components as well.

References

ANDERSON, N.H. (1981). *Foundations of information integration theory*. New York: Academic Press.

ANDERSON, N.H. & SHANTEAU, J.C. (1970). Information integration in risky decision making. *Journal of Experimental Psychology, 84*, 441–451.

ANDERSON, N.H. & WEISS, D.J. (1971). Test of a multiplying model for estimated area of rectangles. *American Journal of Psychology, 84*, 543–548.

BECKER, M.H. (1985). Patient adherence to prescribed therapies. *Medical Care, 23*, 539–555.

BECKER, M.H. & ROSENSTOCK, I.M. (1984). Compliance with medical advice. In: A. STEPTOE & A. MATHEWS (Eds), *Health care and human behaviour* (pp. 175–208). London: Academic Press.

BERKOW, R. (Ed.) (1987). *The Merck manual of diagnosis and therapy*, 15th edition. Rahway, NJ: Merck, Sharp, and Dohme Research Laboratories.

CROMER, B.A. & TARNOWSKI, K.J. (1989). Noncompliance in adolescents: a review. *Developmental and Behavioral Pediatrics, 10*, 207–215.

DEATON, A.V. (1985). Adaptive noncompliance in pediatric asthma: The parent as expert. *Journal of Pediatric Psychology, 10*, 1–14.

DINICOLA, D.D. & DIMATTEO, M.R. (1984). Practitioners, patients, and compliance with medical regimens: a social psychological perspective. In: A. BAUM, S.E. TAYLOR & J.E. SINGER (Eds), *Handbook of psychology and health: volume IV: Social psychological aspects of health* (pp. 55–84). Hillsdale, NJ: Lawrence Erlbaum.

DOLGIN, M.J., KATZ, E.R., DOCTORS, S.R. & SIEGEL, S.E. (1986). Caregivers' perceptions of medical compliance in adolescents with cancer. *Journal of Adolescent Health Care, 7*, 22–27.

DONOVAN, J.L. & BLAKE, D.R. (1992). Patient non-compliance: deviance or reasoned decision-making. *Social Science Medicine, 34*, 507–513.

FROBERG, D.G. & KANE, R.L. (1989). Methodology for measuring health-state preferences—I: Measurement strategies. *Journal of Clinical Epidemiology, 42*, 345–354.

GALLOWAY, R. & MCGUIRE, J. (1994). Determinants of compliance with iron supplementation: supplies, side effects or psychology? *Social Science Medicine, 39*, 381–390.

GREEN, L.W., MULLEN, P.D. & STAINBROOK, G.L. (1984). Programs to reduce drug errors in the elderly: direct and indirect evidence from patient education. In: *Improving medication compliance: proceedings of a symposium* (pp. 59–70). Reston, VA: National Pharmaceutical Council.

GREENBERG, D.B., EISENTHAL, S. & STOEKLE, J.D. (1984). Affective aspects of clinical reasoning: their importance in assessment of behavioral diagnoses in medical patients. *Psychological Reports, 55*, 143–149.

HART, J.D. (1982). Failure to complete treatment for headache: a multiple regression analysis. *Journal for Consulting and Clinical Psychology, 50*, 781–782.

HAYNES, R.B. (1979). Introduction to compliance in health care. In: R.B. HAYNES, D.W. TAYLOR & D.L. SACKETT (Eds), *Compliance in health care* (pp. 1–7). Baltimore: Johns Hopkins University Press.

HUNT, L.M., JORDAN, B., IRWIN, S. & BROWNER, C.H. (1989). Compliance and the patient's perspective: controlling symptoms in everyday life. *Culture, Medicine, and Psychiatry, 13*, 315–334.

INUI, T.S., CARTER, W.B., PECORARO, R.E., PEARLMAN, R.A. & DOHAN, J.J. (1980). Variations in patient compliance with common long-term drugs. *Medical Care, 18*, 986–993.

KAPLAN, R.M. & SIMON, H.J. (1990). Compliance in medical care: reconsiderations of self-predictions. *Annals of Behavioral Medicine, 12*, 66–71.

KORSCH, B.M., FINE, R.N. & NEGRETE, V.F. (1978). Noncompliance in children with renal transplants. *Pediatrics, 61*, 872–876.

LANGE, R.A., ULMER, R.A. & WEISS, D.J. (1986). An intervention to improve compliance to year-long Isoniazid (INH) therapy for tuberculosis. *Journal of Compliance in Health Care, 1*, 47–54.

LOGETHETIS, M.L. (1991). Women's decisions about estrogen replacement therapy. *Western Journal of Nursing Research, 13*, 458–474.

MEICHENBAUM, D. & TURK, D.C. (1987). *Facilitating treatment adherence: a Practitioner's Guidebook*. New York: Plenum Press.

MILLER, P., WIKOFF, R. & HIATT, A. (1992). Fishbein's model of reasoned action and compliance behavior of hypertensive patients. *Nursing Research, 41*, 104–109.

MORISKY, D.E. (1986). Nonadherence to medical recommendations for hypertensive patients: problems and potential solutions. *Journal of Compliance in Health Care, 1*, 5–20.

MUCLOW, J.C. & DOLLERY, C.T. (1978). Compliance with anticonvulsant therapy in a hospital clinic in the community. *British Journal of Clinical Pharmacology, 6*, 75–79.

MYERS, J.K. (1979). *Fundamentals of experimental design*, 3rd edition. Boston: Allyn and Bacon.

PETERSON, G.M., MCLEAN, S. & MILLINGEN, K.S. (1982). Determinants of patient compliance with anticonvulsant therapy. *Epilepsia, 23*, 607–613.

Physician's Desk Reference (1986). Oradell, NJ: Medical Economics Company.

ROTHERT, M.L. (1982). Physicians' and patients' judgments of compliance with a hypertensive regimen. *Medical Decision Making, 2*, 179–195.

ROTHERT, M.L. & TALARCZYK, G.J. (1987). Patient compliance and the decision-making process of clinicians and patients. *Journal of Compliance in Health Care, 2*, 55–71.

ROTHERT, M., ROVNER, D., HOLMES, M., SCHMITT, N., TALARCZYK, G., KROLL, J. & GOGATE, J. (1990). Women's use of information regarding hormone replacement therapy. *Research in Nursing and Health, 13*, 355–366.

RUNDALL, C.S. & WEISS, D.J. (1994). Nurses' fear of contagion: a functional measurement analysis. *Medical Decision Making, 14*, 40–45.

STONE, G.C. (1979). Patient compliance and the role of the expert. *Journal of Social Issues, 35*, 34–59.

STOUDEMIRE, A. & THOMPSON, T.L. (1983). Medication noncompliance: systematic approaches to evaluation and intervention. *General Hospital Psychiatry, 5*, 233–239.

TAYLOR, S.E., LICHTMAN, R.R. & WOOD, J.V. (1984). Compliance with chemotherapy among breast cancer patients. *Health Psychology, 3*, 553–562.

WEISS, D.J. (1980). Note on choosing a response scale. *Perceptual and Motor Skills, 50*, 472–474.

WEISS, D.J. (1989). Potential methodological contributions of mathematical psychology to patient compliance research. *Journal of Compliance in Health Care, 4*, 95–100.

WEISS, D.J. (1997). *A practical guide to analysis of variance and functional measurement*. Los Angeles: Department of Psychology, California State University.

WEISS, D.J. & RUNDALL, C.S. (1996). Using nested group designs to examine subject characteristics in cognitive models. Paper presented at the Mathematical Psychology Meeting, Chapel Hill, North Carolina, August.

WEISS, D.J. & SHANTEAU, J.C. (1982). Group-individual POLYLIN. *Behavior Research Methods and Instrumentation, 14*, 430.

WILLS, C.E. & MOORE, C.F. (1994). Judgement processes for medication acceptance: self-reports and configural information use. *Medical Decision Making, 14*, 137–145.

Appendix 1

Disease factorial design, with patient characteristics

	Prognosis		
Symptoms	Favourable	Doubtful	Unfavourable
Asymptomatic or mild	Iron deficiency anaemia Mean age: 41 Females (20); males (0)	Inactive tuberculosis Mean age: 29 Females (13); males (7)	Hypertension Mean age: 62 Females (8); Males (12)
Moderate	Hypothyroidism Mean age: 59 Females (18); males (2)	Diabetes mellitus (Type II) Mean age: 57 Females (7); males (13)	Coronary artery disease Mean age: 61 Females (5); males (15)
Severe	Epilepsy (grand mal seizures) Mean age: 54 Females (1); males (19)	Severe bronchial asthma Mean Age: 53 Females (6); males (14)	COPD Mean Age: 64 Females (0); males (20)

Appendix 2

Questionnaire

According to your medical history, you have been diagnosed with hypertension. Another name for this is high blood pressure. This condition places a lot of pressure on blood vessels throughout the body. This medical condition usually does not have any symptoms, or the symptoms can be mild such as a headache. When hypertension is not treated, there is a high risk that the condition can cause a heart attack and death. Treatment for hypertension can include taking daily medication that has been prescribed by your doctor. The medication prescribed by your doctor may have some side-effects.

In the next few pages, you will be asked to rate your likelihood of taking a prescribed medication for hypertension, if the medication has certain side-effects.

Appendix 3

Questionnaire

A medication is being developed that has a strong likelihood of producing facial blotches as a side-effect. The facial blotches will be large and red. This side-effect will remain for as long as you take this medication.

Imagine that your doctor has prescribed this medication for you. As mentioned earlier, it is common for people to have difficulty taking prescribed medications for various reasons. Given the above illness description and medication side-effect, please rate the likelihood that you will take this medication every day.

Will not take it. Will take it everyday.