

Complex systems model of dietary choice with implications for improving diets and promoting vegetarianism¹⁻³

Carl V Phillips

ABSTRACT An important step toward improving nutrition and promoting vegetarianism in the general population is to understand how consumers make dietary choices. Researchers from many clinical and social sciences are interested in dietary choice but have not combined their research into a comprehensive model to explain consumer actions. No one model has offered a good explanation for the fact that, although many people successfully change their diet significantly (often toward health-improving, plant-based diets) and are happy with the change, the public and health professionals often perceive dietary change as being difficult and unlikely to succeed. I have termed these observations "the paradox of dietary change." The present computer model uses the emerging science of complex systems analysis, which offers an intuitive method for studying evidence about dietary choice from many fields, including public health, clinical science, economics, sociology, marketing, and genetics, and for combining individual choice with social interaction. The results suggest an explanation for the paradox and methods for helping society shift toward healthier and more plant-based diets. In particular, they suggest how and why major changes might be easier to make than incremental ones, and why this makes dietary change seem more difficult to consumers than it actually is. *Am J Clin Nutr* 1999;70(suppl):608S-14S.

KEY WORDS Dietary choice, vegetarian diet, diet, economic models, utility, consumer behavior, complex systems analysis, computer simulation

INTRODUCTION

An important step toward influencing the dietary choices people make or toward promoting vegetarianism is to gain a better understanding of what motivates individuals to choose or change their diet. Social science is as important as biological or clinical research for the purposes of understanding and influencing dietary choice. However, social science is typically less well understood by health policymakers and clinicians, and attempts to promote dietary change tend to be based only on natural science data rather than an exploration of human motives.

In many ways, dietary choice does not seem to follow the standard rules of consumer behavior that are studied in economics and the allied sciences. However, a complete model of dietary choice should be capable of considering a variety of economic influences on behavior, rather than ignoring them or dismissing

them as inadequate. In particular, we would expect dietary choice to follow the fundamental rule of consumer behavior: individuals try to make choices that optimize their outcomes within the bounds of the constraints they face. The present analysis offers a first step toward simultaneously modeling many of the factors involved in consumer dietary choice. No attempt is made at precise quantification because the inputs to the model are of necessity arbitrary, and the outcomes should be seen as metaphors for actual behavior rather than as scientific data. However, some of the implications are robust across elements in the model, and offer some compelling implications for understanding behavior and trying to influence it. In particular, they suggest that encouraging and facilitating large changes in diet may be more promising than the more common conservative, incremental approaches.

MODELS OF DIETARY CHOICE

The study of dietary choice can draw on data and observations from many fields. Nutrition researchers try to determine what is healthy. Economists look at consumer and supplier responses to prices in a general context (1) and at the development of preferences (2). Public health researchers look at the availability and perception of certain foods (3). Medical and nutrition researchers examine subjects' tastes, biochemical pathways, and the psychologic effects of food (4-7). Evolutionary biologists offer further insight into the development of and reasons for preferences (8). Sociologists look at the interactions of culture (9). Marketers, business analysts, and scholars look at various aspects of individual preferences and total consumption (10).

All of these approaches to understanding consumer behavior and diet are valuable, but additional value can be found by combining them. Most studies of dietary choice focus on only 1 or 2 of these various inputs, and often do not even acknowledge the others. Traditional modes of analysis typically focus on either

¹From the Division of Environmental and Occupational Health, University of Minnesota School of Public Health, Minneapolis.

²Supported by the Robert Wood Johnson Foundation. The views expressed here do not necessarily represent those of the Robert Wood Johnson Foundation.

³Reprints not available. Address correspondence to CV Phillips, Division of Environmental and Occupational Health, University of Minnesota School of Public Health, Box 807 Mayo, 420 Delaware Street SE, Minneapolis, MN 55455. E-mail: carlp@cccs.umn.edu.

single individuals or the social aggregate, and therefore cannot model the interactions of individuals and society. A more complete model of dietary choice should attempt to incorporate many behavioral influences and allow for the interaction of individual decisions and the social context. Simple, generalizable explanations for the observed complicated behavior should also be sought by modelers. It is tempting to create “just-so stories” to explain any given detail of social phenomena. But such stories make inference and policy applications very difficult and they obscure the fact that some outcomes may just be random events. We should strive to increase parsimony and generalizability.

Many models of dietary choice can explain why there are different dietary patterns across cultures and among individuals within a society. The changing dietary patterns of a given individual across time are more difficult to explain, however, particularly for models that are static in time.

The complex systems analysis offers an explanation for the 2 conflicting observations I have labeled “the paradox of dietary change.” First, many people make major changes in their food choice, stick with the changes, and do not want to change back. This includes changing from an omnivorous diet to a vegetarian or vegan diet, adopting intervention diets in response to disease (11–12), or eliminating certain foods or changing nutrient intakes to improve general health. There is empirical evidence of satisfaction among those who have made imposed dietary changes (13–16), as well as countless anecdotes and the observation that many new vegetarians become extremely committed to their diet. However, this contrasts with a second observation, that most consumers believe that changing their diet would be painful and a permanent burden, and that health professionals who would like to improve diets of their patients or the general public often believe it is hopeless to try to encourage changes. Even people who are happy about one major transition they have made, such as becoming vegetarian, often think that making another change, such as reducing fat intake or becoming vegan, is too daunting to even attempt. These 2 sets of observations appear contradictory on their face.

The plea, “try it—you’ll like it” is used in attempts to persuade children to eat. But this message, which is in keeping with the stylized facts (real-world observations that are converted into simplified, model-level descriptions) of the paradox, is absent from public health messages about how to improve diet. This absence may be due to the lack of an underlying model to explain why the message might be true for healthy adults, and why they might actually be perfectly happy with an alternative to their longtime practices. The model presented here offers such an explanation.

METHODS

The modeling method known as *complex systems analysis* allows the many threads of dietary choice research to be drawn together. In this method, the interaction of many separate actors, each represented individually, is simulated with use of a computer that can keep track of a multitude of characteristics and actions. The complex systems approach contrasts with models that aggregate individuals into a few equations, statistics, or stories that summarize all of society, ie, population-level statistical analyses or culture-level anthropologic research. It also contrasts with studies that focus on individuals and set aside social aggregations, ie, most ethnographic and psychologic studies. As with

any model, complex systems analysis makes simplifications in some areas to gain insight into others. By using a simplified picture of psychology and the economy, we can avoid making assumptions about the representativeness of individuals or the significance of observed social outcomes before running the model. This offers a picture of how social dynamics work over time without assuming that certain outcomes are inevitable or ignoring variance in favor of averages.

In a complex system, each simulated individual, or actor, follows certain rules, and the aggregate result comes from the interaction of the actors and their local actions rather than some set of global rules. In the natural sciences, this approach can model a chemical process by simulating individual atoms or biological evolution by simulating individual genes. In the social sciences, complex systems analysis allows us to model society by simulating the actions of individuals and businesses over time. Several books offer more details on complex systems analysis (17, 18).

Complex systems analysis offers important advantages over traditional social science methods for modeling dietary choice. By using individual consumers and suppliers as the units of analysis, decision-making is modeled at the level of the actual decision-makers. The decision rules of the actors follow simple and intuitively plausible behavior. The complexities of society emerge from the massive number of interactions of individual decision-makers, as they do in real life. This is an alternative to modeling social patterns or epidemiologic trends directly with very complicated equations that can obscure the underlying behaviors. Because the decision rules are the relatively simple rules used by consumers, it is possible to incorporate many of the influences from various fields of research, which is much more difficult with aggregating models.

Complex systems analysis allows the modeling of non-ergodic systems, in which a particular set of inputs can lead to many different outcomes, including those with increasing returns to scale. (In the present context, *increasing returns* refers to systems in which more people acting in a certain way makes acting that way more desirable.) For example, as more people eat tofu or a particular brand of coffee, those foods become more widely available and less expensive, to the advantage of all who consume them. This is difficult to model in closed form (19). Perhaps most importantly, complex systems analysis allows the discovery of emergent properties—outcomes for which the sum of the parts produces results that cannot be understood or predicted when looking at either individuals or aggregations alone.

The present model consists of simulated consumers and suppliers interacting in a virtual n-space of possible dietary choice (ie, the choice can be represented by a point in an n-dimensional graph, which we can call the *choice space*, or by a value of an n-dimensional vector). A simple version of the model is presented here because it is sufficient to show the implications that are important in the case being made. Many generalizations of the model yield similar results. These include adding more influences on behavior, increasing the number of dimensions of the choice space, and introducing more complicated social networks. (Details about the model, including generalizations, parameter values, functional forms, and programming techniques are available from the author.)

Simulated decision-makers

Simulated consumers (actors) in the complex systems model make their food choices on the basis of 4 factors: 1) the healthfulness of a particular diet, 2) the availability (including price) of



the diet, 3) their personal history, including habits and inculcation, and 4) *simple taste*, a construct that includes physical preferences and can include other matters of taste, such as convenience. The influences of the surrounding culture are intentionally omitted from these 4 basic inputs because cultural effects can be shown to be emergent properties of independent individual actions, as discussed below.

The 4 influences on choice enter additively into a function that determines how happy an actor is about his or her diet (or would be about any alternative considered). In economics, this is known as a *utility function*: consumers want to achieve a higher level of utility, but must trade off among competing preferences in so doing. Such tradeoffs among competing desires are the essence of welfare economics (the branch of economics that studies individual decisions and well-being; 20–21), but have only recently been discussed with much sophistication in nutrition research.

In the version of the model presented in this paper, simulated consumers are homogeneous in their underlying sources of utility and their tradeoffs among them. Differences in their current preferences stem from their current and past choices rather than exogenous heterogeneity. This is obviously not a realistic characterization of the world, nor is it necessary in the model. Homogeneity is imposed to show the generalizability of the present results, which can be made stronger by introducing heterogeneity. By choosing a particular pattern of heterogeneity, a modeler can generate virtually any result, creating a just-so story for observed results. Such use of underlying differences in tastes can lead to tautologies in social science research, because every action can simply be attributed to the actor preferring to take that particular action. In response to this, there is a long tradition in economics of modeling preferences as the same until life experiences make them different (22). A perfect model of social behavior would measure and incorporate every difference in preference, but given our inability to measure such differences, trying to include them can undermine the power of modeling to produce inference or testable hypotheses.

The second group of players in the model is the suppliers of various foods. These suppliers follow a simplified market behavior. They are interested in greater profit, which is provided by offering a product that many customers want (increasing sales) and that relatively few other suppliers provide (letting them increase the price).

Thousands of simulated consumers and suppliers interact, each pursuing their own goals, and each individual choice has some effect on other consumers' and suppliers' utility. Whatever a consumer wants to buy has an effect on what suppliers want to provide, creating network externalities (wherein individuals participating in an activity create a network of support that makes the activity cheaper, provides higher quality, or otherwise generates more net value for everyone in the network) (23). If a supplier adjusts its actions to respond to consumer demand, the availability and price of various foods will change. This will affect consumer choice and the profitability of other suppliers. Consumer choices also have a direct influence on other consumers, because one consumer may consider changing his or her diet to imitate that of a friend. A consumer's choice has a direct influence on his or her own preferences, with an immediate effect on what the consumer is used to and more comfortable with.

Choice space

Each consumer's dietary choice and what each supplier supplies is described by the individual's position in an n -dimensional

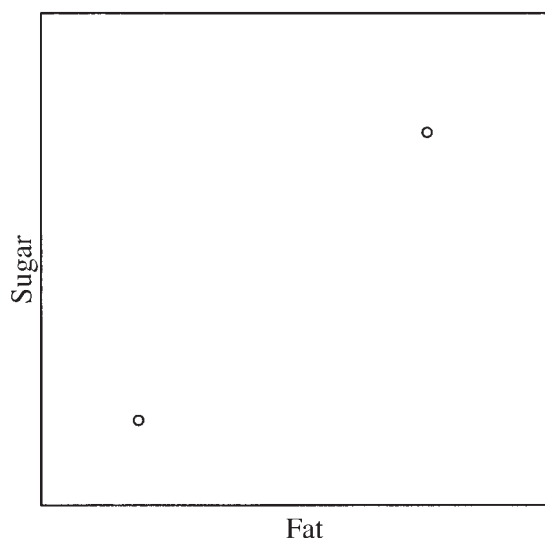


FIGURE 1. Virtual choice space.

space (or equivalently, a value of an n -dimensional vector), like a point on a map or a graph. Overlaying that n -space is an additional dimension (for a total of $n + 1$) that represents consumer utility (or supplier profitability). The method of representing a multiattribute behavior by using a spatial metaphor has a long history in population genetics (24) and political science (25), and has found powerful applications in more recent social science (26).

A complete model would include hundreds or thousands of dimensions, each representing the consumption of a particular food. For example, someone's position in the first dimension might be quantity of apples eaten, whereas the 500th dimension might be the quantity of butter consumed. A more practical version of the model will have considerably fewer dimensions, with each representing some summary of eating patterns, such as those concerning fruit or dairy products. The present version of the model is extremely abstract, using only 2 dimensions, which is the minimum necessary to show the most interesting properties of the model (and has the added advantage of being possible to represent on the printed page). Adding more dimensions would, of course, increase realism, but it would make the model more difficult to understand, and would not change the key results discussed here.

To introduce some concreteness into the abstraction we can label the 2 dimensions in question *sugar* and *fat*, representing the amount of each in a chosen diet. This 2-dimensional choice space is illustrated in Figure 1. Note that this choice of labels is merely illustrative—the results of the model should be interpreted only as general implications rather than information about sugar, fat, or any other specific dietary element. A typical American diet would be represented by a point toward the upper right, whereas a point to the lower left is a healthier diet (keeping in mind that this is a very simplified model, and does not try to capture the complexities of eating healthfully). Any individual's behavior, or any alternative they might consider, is represented by a unique point on the graph. The utility function would be represented by a third dimension extending out of the page, like hills and valleys in a landscape.

A consumer's utility for a particular position in this space is determined by the Euclidian distance (basically the distance between 2 points in a graph) between it and various other points. Each consumer will have an optimal point for healthfulness and an optimal

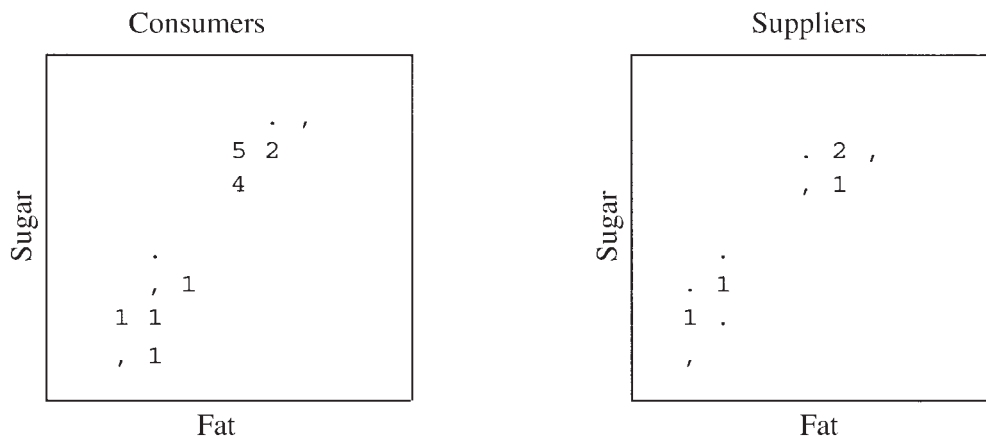


FIGURE 2. Model output—representative case of a population in quasiequilibrium.

point for taste. Because of the assumption of homogeneity, these will be common to all consumers, and can be represented by the lower left and upper right points marked in Figure 1. The closer a consumer's choice is to an optimum point, the higher the contribution to utility is from that source of preference. Thus, consumers will have a tendency to move toward the axis that connects these points.

The other 2 elements of utility will vary endogenously. A simulated consumer's history will vary on the basis of that individual's behavior in previous periods; that individual's utility will be higher for choices that are close to those from recent history. (Consumers grow accustomed to what they have eaten in the past, and so like it better.) Thus, consumers are inclined to maintain past dietary patterns and to resist big changes. The availability and price of a particular choice will vary depending on how many suppliers and other consumers are near a particular point, with more suppliers increasing a consumer's utility. Thus, consumers will tend to seek out concentrations of suppliers.

Model dynamics

As time passes, consumers will try to adjust their behavior to improve their utility. This process can be described as *imperfect hill climbing*, with the hills representing higher levels of utility and the imperfection generated by the limits of consumer optimizing behavior (27). During each period, each consumer considers a single alternative to his or her present practice. They compare the utilities of the 2 choices, and move if the alternative is better than the current choice. The alternative considered can either be some other consumer's choice (trying a friend's diet) or a random nearby point (an incremental adjustment of present practice). The "friendship" of 2 individuals is independent of how similar their diets are (in particular, it is random). Thus, imitating a friend may lead to a large change in consumer's diet, though such a change cannot lead to exploration of a point no one has ever tried because the friend must already be there.

This obviously does not represent real-world behavior perfectly, but it offers certain improvements over many social science models of behavior change. Most economics-influenced models of consumer choice effectively assume that every consumer can simultaneously consider all alternatives and choose the best possible choice, not restricted to a local neighborhood, or the *global optimum*. Any change in that global optimum results in an immediate shift by the consumer to the new optimum. Some models go

further and suggest that consumers will calculate the influence of current choices on future utility and determine their lifetime optimal choices from the start. Other models that do not assume such omniscience and instant adjustment suggest that consumers solve differential equations for the current slope of their utility function and adjust on that basis. Needless to say, the decisions of real humans come much closer to considering a small number of alternatives and choosing the one that seems best. Aside from being heroic assumptions about our omniscience and shrewdness in decision-making, the standard economic assumptions tend to assume away a key feature of dietary choice: the possibility of getting stuck on one utility hill unable to get to another. This possibility is apparent in results of the present model.

Model results

The model is inherently non-ergodic, so there can be no single result. This in itself is interesting because it suggests that a diet that is common in a particular region, community, or social group—and the fact that it is different from diets elsewhere—can be explained by random chance, suggesting that the common urge to explain why the outcome was inevitable may be misguided. There is a good reason why some common diets emerged for a group of people, but there may be no particular reason why a particular diet emerged. Whereas this does not eliminate the value of finding a specific explanation, should it exist, it does suggest that the common assumption that there must be an explanation that makes a particular dietary pattern inevitable may be in error.

There are features common to all outcomes or within a small number of families of outcomes. One such outcome, of a typical run of the model after it has reached quasiequilibrium, is illustrated in Figure 2. The results of interest for the present purposes are well illustrated by this outcome, so it will be used as the representative example for the remainder of this article. The continuous choice space is represented by a 10×10 grid. At any grid position, a digit represents the number of consumers that are located within an area (with higher numbers representing a greater concentration), a dot represents fewer people, and blank spaces indicate very few or none. For the run illustrated here, consumers and firms started in a random scatter across the choice space, and reached the pattern shown after 200 periods of hill-climbing. The key result is that consumers and firms move to a small number of clusters—2 in this case. A 2-dimensional



run of the model will almost always result in either 1 or 2 clusters. A run with 2 clusters is used here because it is the minimum needed to illustrate the interesting results. In the real world, of course, there are many more clusters of behavior among many more dimensions of choice. The present model, being a highly abstract metaphor for behavior, does not attempt to determine the right number of clusters. It only describes the emergence of clusters and the dynamics of a multiple-cluster world.

The basic result that one or more clusters form somewhere is not sensitive to the starting arrangement or a wide variety of changes in the input parameters or decision rules. Consumers follow suppliers and suppliers follow consumers, forming clusters that are local utility maximums owing to supply and demand. This is further reinforced by consumers growing used to their particular choices over time. The exact positions, shapes, and sizes of the clusters cannot be predicted before the model is run because of the complexity and random elements in the model. The number of clusters may be 1 or it may be more (with a greater number becoming more likely as the number of dimensions increases, especially if some of the dimensions have less effect on consumers' healthfulness or taste than others).

The behavior of each individual does not become permanently static. Over time, each makes small moves and occasionally even large ones. But the configuration is described as a *quasiequilibrium* because the clusters tend to remain stable even as individuals adjust (or are born and die, if that complication is added to the model).

Once the quasiequilibrium is reached, various interventions can be simulated. Returning to the simplified labels for the 2 dimensions, the 2 clusters pictured in Figure 2 could be thought of (again, recognizing the extreme abstraction) as a typical high-fat, high-sugar American diet, and a healthy, plant-based diet. The goal of public health policymakers would be to shift consumers from the upper-right cluster toward the lower-left cluster. The clusters in the

model are resistant to perturbation by simulated policy interventions, not unlike the limited effectiveness of such policies in the real world. For example, one might think that an educational campaign to increase the relative importance of healthfulness to consumers (rating healthfulness higher than other components when calculating utility) would cause a major shift toward the lower left. If the change is introduced into the model before the clusters coalesce and reach quasiequilibrium, there will indeed usually be a major shift toward a more healthy diet, often with all consumers clustering in the lower left near the optimum health point. However, once the clusters form, representing established dietary patterns, they are very resistant to this change. An increase in the relative importance of health will cause a small shift from the upper-right cluster toward the lower left, but until the relative importance of healthfulness is much higher (approximately half of total consumer preference), there will be no collapse of the "unhealthy" cluster and wholesale shift toward the more healthy.

To understand why the clusters are so resistant to perturbation, it is necessary to look at the preferences of a single consumer after quasiequilibrium is reached. **Figure 3** is an iso-utility contour map of the preferences of one particular consumer whose current practice puts that consumer near the center of the upper-right cluster.

The contour lines in Figure 3 represent regions of constant utility (like a topographic map), and they describe a global maximum peak in the upper right and a second hill to the lower left. Between the 2 lies a region of lower utility that forms a saddle, dropping off lower still to the upper left and lower right. Every consumer has a different utility map of the space on the basis of his or her unique history. This particular individual (say her) prefers a point on the "unhealthy" hill because it is close to her physical taste preferences and is convenient; there are a lot of suppliers providing food of this type (and thus prices are good); and she is used to preparing and eating this type of food. It is not particularly healthy, but there are always tradeoffs. This individual would also be reason-

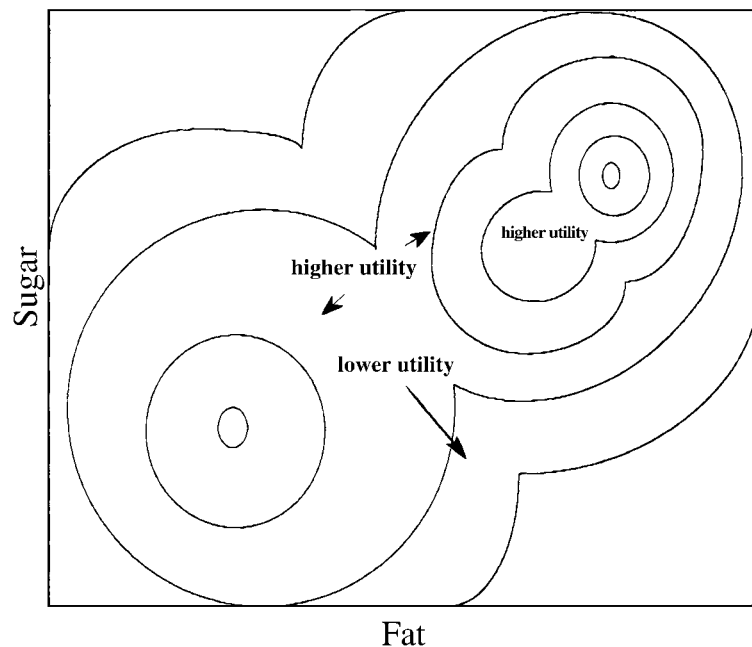


FIGURE 3. A particular individual's iso-utility curves.



ably happy toward the top of the hill to the lower left, where there is another cluster of suppliers and healthfulness is improved. The alternative hill, which is the global optimum for some of the consumers, appeals less to the individual in Figure 3 because of its reduced utility from taste and convenience, and importantly, because it is not what she is used to.

IMPLICATIONS

These contours govern the behavior of a simulated consumer in the model and provide insight about how people act in reality. Imagine an intervention in which a public health message or clinical intervention nudges the consumer in Figure 3 toward the lower left. She has now moved down the slope of her preference hill. If the pressure to change is removed, the consumer finds herself standing downslope of her old preferred choice, and small adjustments to improve her utility will tend to lead back up the utility hill, toward her starting point. This manner of retrogressing is very likely in the model and seems to represent behavior observed in the real world.

Consider an alternative intervention in which the consumer is persuaded to try a diet that is represented by a point further to the lower left, somewhere across the utility valley on the slope of the healthier utility hill. (This might include trying the diet of a friend who is on the healthier hill.) The simulated consumer in the model is not likely to jump back across the valley to the original diet. Instead, she is likely to adjust toward the top of the healthier hill. The utility valley in between local maximums makes it difficult for someone to spontaneously transition from a diet that lies on one hill to one that is on another. At the same time, it makes it easier to stay with the new diet once a change is made. This result conforms to empirical evidence about changing substance abuse patterns, in which moving to a clear alternative far away from a starting point—particularly quitting cold turkey—can be effective when incremental changes result in backsliding. Unfortunately, similar data for dietary interventions (except for restricted-energy weight-loss diets, which are very different from the changes represented here) are limited, but the results are suggestive.

To the extent that the results represent the real world, they offer an immediate explanation for the paradox of dietary change. We often try to make minor changes in our behavior, like eating a bit more healthfully. Making a small change seems like the right way to start moving in the right direction. But minor changes can leave us down the slope of our utility hill with the urge to retrogress. A major change seems very daunting, then, because our heuristics suggest that making the change will be 100 times as unpleasant as making a change that is 1% as large. However, a well-chosen, large change may be no less pleasant in the short run than the smaller change, and it may be easier to avoid backsliding.

Furthermore, although it is not illustrated in Figure 3, after a simulated consumer moves to an alternative local maximum, her utility for the new choice increases over time (and the utility she would get from the old choice decreases). Recent past practice has a direct effect on utility, representing a growing appreciation for the new diet and its physiologic effects, and getting used to obtaining and preparing the new foods. Within the model, a consumer who moved to a new hill might have still preferred the old diet if she could have simply jumped back to it in a single step without spending time in the utility valley. But over time, she will frequently come to like the new hill better and not want to move back. The real-world embodiment of this tendency is

apparent in the empirical evidence and anecdotes that support the second half of the paradox.

The model offers several tentative implications for public health, the effectiveness of which can be tested in future empirical research. The model suggests that the most common policy approaches for encouraging healthy diets, which rely on incremental change and disseminating health information, might be expected to fail. It is not surprising that attempts to nudge people in the right direction have proven fairly ineffective because of backsliding. Furthermore, the “if you teach them, they will change” approach—in which we provide information about the healthfulness of certain foods and expect that to be sufficient to prompt a consumer response—may be trying to teach the wrong lesson. Simply convincing people that certain foods are better has a limited effect on the established clusters in the model. However, teaching people about the system dynamics might be helpful. When people find a small change unpleasant and difficult to maintain, their natural extrapolation, based on a narrowness of vision, will keep them from attempting a larger change. It might be useful to teach them that a larger change might be easier to maintain, and furthermore that their preferences are likely to change to follow their practice. Determining an effective way to convey this message, should it prove accurate, could prove extremely useful in both clinical practice and public health policy.

The model has tentative implications for the practice of vegetarianism in particular. Attempts to convince people to consider vegetarianism, for their health or for ethical reasons, could be more successful if they taught the dynamics of change. Becoming vegetarian, like other improvements in diet, may be much easier than people think, for all the reasons noted above. Vegetarianism also may offer a particularly promising alternative diet to change to. There are suppliers in place to support vegetarians, including restaurants, specialty marketers, and social groups with specialized knowledge. This creates a high-utility alternative hill. A change to a vegetarian diet will involve a major shift for most people, moving them across a utility valley where incremental backsliding is harder. In addition, if people are slow in becoming used to a new diet, vegetarianism offers a bright-line definition that is not offered by such quantitative goals as “eat less fat.” As a result, it may be easier to resist retrogressing a few percentage points each week, thereby giving consumers more time to become committed to their new utility hill.

Naturally, any implications of an abstract model like this cannot be considered conclusions about how the world actually works or what actions we should take. Instead, the model should be seen as suggesting these implications about the real world and generating hypotheses that can be tested in further work.

The model also offers some more definitive technical conclusions. It shows, albeit as a highly simplified first step, that more of the multiple influences on dietary choice can be captured in a single model. It also serves as proof that certain simple, robust, plausible inputs can be sufficient explanations for certain outcomes.

The model shows that almost identical starting points can produce dramatically different outcomes, and thus that any particular dietary pattern might be an accident with no intrinsic merit and no exogenous support. This in itself might prove persuasive to consumers. If they can understand that but for certain accidents of history they would be eating a very different diet, the thought of changing to an alternative might be less daunting.



Individual heterogeneity can be generated from small differences in starting points, even with homogeneous tastes. "Cultures" can evolve as an emergent property of individual market behavior without any appeal to social motives. Of course, this does not preclude an important role for individual heterogeneity or the influence of culture. However, it implies that anyone who wants to include these in their model of how dietary choices are made faces a burden of proof that the inputs should be included, rather than allowing an unstated assumption that they must be considered. Whereas complicated outcomes can only be explained perfectly by using complicated inputs, Occam's razor should apply to social science research: simple, common explanations should be given precedence over just-so stories. A focus on the complexities of human psychology and cultural differences, although useful and necessary in many contexts, can obscure a deeper understanding of mathematically tractable systems.

CONCLUSION

In any model such as this, in which the inputs are mostly stylized facts with unknown magnitudes and functional forms, no quantitative conclusions can be drawn without experimental or empirical research. However, this analysis does show that broad-based models of dietary choice can be created and that certain outcomes might be explained by simple inputs and historical accidents. Furthermore, the model is suggestive of ways in which dietary advice, through policy and counseling, could effectively recommend larger rather than smaller changes. If applied research bears this out, it could lead to improved practice.

One immediate test of the potential of the model is how it is met by those who work in dietary health policymaking or clinical counseling. To the extent that such experts find the story plausible (and feedback on this research suggests that many do), the model provides a powerful tool for structuring thinking about complex social patterns and a possible starting point for educating consumers about their potential to improve their diet and be happy about it. 

I thank Ginny Messina, Carl Simon, participants in the University of Michigan Program for the Study of Complex Systems, and 2 anonymous referees for their helpful comments.

REFERENCES

- Kreps DM. A course in microeconomic theory. Princeton, NJ: Princeton University Press, 1990.
- Becker GS. Human capital. Chicago: University of Chicago Press, 1993.
- Levy AS, Raymond CS. Effects of a health promotion advertising campaign on sales of ready-to-eat cereals. *Public Health Rep* 1987; 102:398–403.
- Birch LL. Children's preferences for high-fat foods. *Nutr Rev* 1992; 50:249–55.
- Drewnowski A, Rock CL. The influence of genetic taste markers on food acceptance. *Am J Clin Nutr* 1995;62:506–11.
- Logue AW, Smith ME. Predictors of food preferences in adult humans. *Appetite* 1986;7:109–25.
- Drewnowski A. Intense sweeteners and the control of appetite. *Nutr Rev* 1995;53:1–7.
- Nesse RM, Williams GC. Why we get sick; the new science of Darwinian medicine. New York: Vintage Books, 1994.
- Sanjur D. Hispanic foodways, nutrition, and health. Boston: Allyn and Bacon, 1995.
- Block G, Dresser CM, Hartman AM, Carroll MD. Nutrient sources in the American diet: quantitative data from the NHANES II survey. *Am J Epidemiol* 1985;122:27–40.
- Gould KL, Ornish D, Kirkeeide R, et al. Improved stenosis geometry by quantitative coronary arteriography after vigorous risk factor modification. *Am J Cardiol* 1992;69:845–53.
- Ornish D, Scherwitz LW, Doody RS, et al. Effects of stress management training and dietary changes in treating ischemic heart disease. *JAMA* 1983;249:54–9.
- Rolls B. Change the preference for fat in foods. *Nutr Rev* 1994;5:21–3.
- Barnard ND, Akhtar A, Nicholson A. Factors that facilitate compliance to lower fat intake. *Arch Fam Med* 1995;4:153–8.
- Barnard ND, Scherwitz LW, Ornish D. Adherence and acceptability of a low-fat, vegetarian diet among patients with cardiac disease. *J Cardipulmonary Rehab* 1992;12:423–31.
- Kristal AR, White E, Shattuck AL, et al. Long-term maintenance of a low-fat diet: durability of fat-related dietary habits in the Women's Health Trial. *J Am Diet Assoc* 1992;92:553–9.
- Holland JH. Hidden order: how adaptation builds complexity. Reading, MA: Helix Books, 1995.
- Waldrop MM. Complexity. New York: Touchstone, 1992.
- Arthur WB. Increasing returns and path dependence in the economy. Ann Arbor, MI: The University of Michigan Press, 1994.
- Browning EK, Browning JM. Microeconomic theory and applications. 4th ed. New York: HarperCollins, 1992.
- Nicholson W. Microeconomic theory: basic principles and extensions. 3rd ed. Chicago: The Dryden Press, 1985.
- Becker GS, Stigler GJ. De gustibus non est disputandum. *Am Econ Rev* 1977;67:76–90.
- Katz ML, Shapiro C. Network externalities, competition, and compatibility. *Am Econ Rev* 1985;75:424–40.
- Wright S. Character change, speciation, and the higher taxa. *Evolution* 1982;36:427–43.
- Downs A. An economic theory of democracy. New York: Harper, 1957.
- Laver M, Shepsle K. Making and breaking governments: cabinets and legislatures in parliamentary democracies. New York: Cambridge University Press, 1996.
- Kauffman S, Levin S. Towards a general theory of adaptive walks on rugged landscapes. *J Theor Biol* 1987;128:11–45.

