The New Science of Pleasure

Consumer Behavior and the Measurement of Well-Being

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ABSTRACT: Economists since the days of Adam Smith and Jeremy Bentham have traditionally viewed consumers as driven by relentless and consistent pursuit of self-interest, with their choices in the marketplace providing all the measurements needed to reveal their preferences and assess their well-being. This theory of the consumer is empirically successful, and provides the foundation for most economic policy. However, the traditional view is now being challenged by new evidence from cognitive psychology, anthropology, evolutionary biology, and neurology. This paper surveys this evidence and what it implies for the measurement of consumer choice behavior and well-being.

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"Illusion, Temperament, Succession, Surface, Surprise, Reality, Subjectiveness – there are threads on the loom of time, these are the threads of life. I dare not assume to give their order, but I name them as I find them on my way."

Ralph Waldo Emerson, Experience, 1844

"Let there be granted to the science of pleasure what is granted to the science of energy, to imagine an ideally perfect instrument, a psychophysical machine, continually registering the height of pleasure experienced by an individual, exactly according to the verdict of consciousness, or rather diverging therefrom according to a law of errors. From moment to moment the hedonimeter varies; the delicate index now flickering with the flutter of the passions, now steadied by intellectual activity, low sunk whole hours in the neighbourhood of zero, or momentarily springing up toward infinity."

Francis Y. Edgeworth, Mathematical Psychics, 1881

I. Introduction

At the bottom of the food chain of economic analysis is the consumer, whose behavior and well-being motivate the whole gauntlet of questions from mechanism design to incentive theory to project evaluation. Understanding and modeling consumer well-being was central in early economics, and remains so, with continuing tension between the elements of illusion, temperament, and subjectiveness in consumer behavior, and the demand for stable, predictive hedonic indicators. The neoclassical model of the individualistic utility-maximizing consumer that forms the basis of most economic analysis is largely a finished subject, but new studies of consumer behavior and interesting new measurements challenge this model. This behavioral revaluation suggests new paths for the continuing development of consumer theory, and has implications for current policy discussions, such as initiatives to place more reliance on the self-interest of individuals and less on a publically provided safety net.

This paper surveys the history of measurement of consumer behavior and well-being, with particular attention to the lessons and opportunities afforded by new measurement methods coming into economics from cognitive psychology, anthropology, market science, and neurology. This paper will focus on the perceptions, emotions and behavior of individual consumers, and omit important related issues of interpersonal comparisons, social choice, and economic policy evaluation. In outline, I will start with the views of some of the classical economists on happiness and utility. I will discuss first attempts at measurement, followed by the flowering of demand analysis in the age of Sir Richard Stone. I will then turn to expansions of neoclassical demand measurement, and finally to the new frontiers of measurement shared by economics and other disciplines.

II. Pleasure, Pain, Utility

Systematic study of consumer motivation and well-being started with Jeremy Bentham, who still sits in University College London, and is reputed to still be the life of any party of economists that he joins. In Introduction to the Principles of Morals and Legislation, published in 1789, Bentham laid out the concepts of consumers driven by self-interest to increase pleasure and reduce pain: "My notion of man is that ... he aims at happiness ... in every thing he does." Bentham and his successors explored the economic implications and moral content of utilitarianism, but despite their quantitative rhetoric, they were not much concerned with the actual measurement of happiness. It is not that they considered utility unmeasurable. Quite the opposite: utility existed, by introspection, but its practical measurement was not needed for drawing out the broad principles of utilitarianism. Choice was viewed as an automatic consequence of self-interest, not as behavior that could put utilitarianism to test. Pursuit of happiness explained everything, and predicted nothing. A comment by Frank Taussig (1912), at the end of the classical era, summarizes nicely the utilitarian attitude:

> "An article can have no value unless it has utility. No one will give anything for an article unless it yield him satisfaction. Doubtless people are sometimes foolish, and buy things, as children do, to please a moment's fancy; but at least they think at the moment that there is a wish to be gratified. Doubtless, too, people often buy things which, though yielding pleasure for the moment, or postponing pain, are in the end harmful. But here ... we must accept the consumer as the final judge. The fact that he is willing to give up something in order to procure an article proves once for all that for him it has utility, – it fills a want."

While the writings of the utilitarians do not focus on the measurement of well-being, they do provide insight into what one is trying to measure, and the reach of utilitarianism. Bentham thought about the pursuit of happiness in ways that did not fit into the later neoclassical synthesis, but which resonate with contemporary behavioral studies. Bentham's utility was attached to the experience or sensation that objects and actions produced, their pleasure-increasing or pain-reducing effect. Later, utility became identified with a state of being, with the consequences of actions rather than the processes producing these consequences. The behavioral revaluation supports the earlier view that attaches utility to process rather than to consequence. Bentham almost always distinguished increased pleasure and reduced pain as two distinct sources of happiness. Perhaps this was just his disposition to say anything worth saying more than once, or perhaps he recognized that people respond differently to perceived gains and losses from a current reference point.

Bentham laid out four critical dimensions that determine the utility of an experience: intensity, duration, certainty or uncertainty, and propinquity or remoteness. Clearly, Bentham's first two dimensions anticipated the utility of an episode as an integral of intensities over some duration, although formalization of that idea would not come until

Edgeworth a century later. The third dimension anticipated a utility theory for risky prospects, and the fourth, intertemporal preferences and discounting.

Elements that are clearly present in classical economics are allowances for reciprocity and altruism in the determination of happiness. Bentham (1776) observed:

> "By the self-regarding principle, the more urgent the need a man feels himself to have of the kindness and good will of others, the more strenuous and steady will be his exertion for the obtaining it. ... The stronger a man's need of the effective benevolence of others, the stronger the inducement he has for the manifesting effective benevolence as towards them."

Adam Smith (1853) noted the importance of altruism, particularly within families,

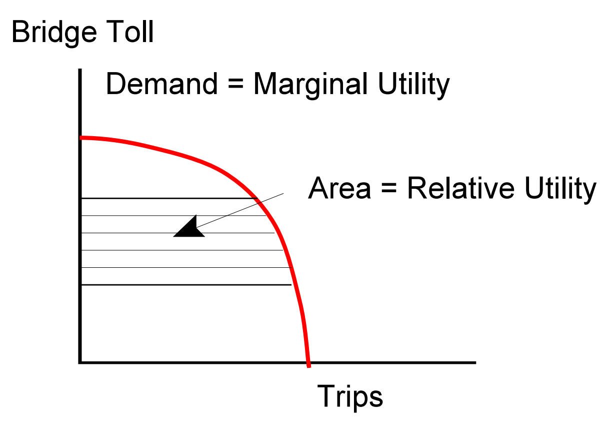
> "Every man feels [after himself, the pleasures and pains] of the members of his own family. Those who usually live in the same house with him, his parents, his children, his brothers and sisters, are naturally the objects of his warmest affections. "

Edgeworth (1881) noted that

> "... efforts and sacrifices ... are often incurred for the sake of one's family rather than oneself. The action of the family affections 'has always been fully reckoned with by economists', especially in relation to the distribution of the family income between its various members, the expenses of preparing children for their future career, and the accumulation of wealth to be enjoyed after the death of him by whom it has been earned."

Classical economics came slowly to the problem of recovering utility from observed behavior, Adam Smith (1776) described how "haggling and bargaining in the market" would achieve "rough equality" between value in use and value in exchange. Working at the fringes of mainstream economics, Jules Dupuit (1844) and Hermann Gossen (1854) deduced that consumers exhibiting diminishing marginal utility would achieve maximum utility by equalizing across various goods the marginal utility per unit of expenditure. Dupuit was remarkably prescient, recognizing that the demand curve can be identified with a marginal utility curve for a good, provided the marginal utility of money remained constant, and showing that the area behind the demand curve then gave a measure of "relative utility", or in Marshall's later terminology, *consumer surplus*. The primary limitation of Dupuit's analysis was that he did not distinguish demand at the individual level from that at the market level, or take account of heterogeneity in individual tastes.

Figure 1. Dupuit's Inverse Problem



Dupuit's idea of solving the inverse problem, recovering utility from demand, was brought into the mainstream by Jevons, Edgeworth, John Marshall (1899), and Vilfredo Pareto (1900) at the end of the 19^{th} century, and with the refinements introduced by John Hicks (1939) remains today the standard approach to measuring and predicting consumer welfare. At that time, economists also began to step back from introspective explanations of utility, instead treating it as a black box whose inner workings were not their concern. Irving Fisher (1892) makes the argument:

> To fix the idea of utility, the economist should go no further than is serviceable in explaining economic facts. It is not his province to build a theory of psychology.

> Whether the necessary antecedent of desire is "pleasure", or whether independently of pleasure it may sometimes be "duty" or "fear" concerns a phenomenon of the second remove from the economic act of choice.

The emphasis on characterizing utility solely by the demand behavior it produced became the centerpiece of neoclassical consumer theory, perfected by Eugen Slutsky (1915), John Hicks (1939) and Paul Samuelson (1947), and in its purest statement forming the theory of revealed preference. This was a great logical achievement, but the demands of the analysis also narrowed and stiffened the way economists thought about preferences. The domain of utility moved from activities or processes to the commodity vectors that were their consequences. Self-interest was defined narrowly to include only personally purchased and consumed goods; the complications of reciprocity and altruism were ignored. The Hicks-Samuelson formulation was fundamentally static, with the consumer making a once-and-for-all utility-maximizing choice of market goods. Utility in this static formulation is usually interpreted as the felicity produced by flows of non-durable goods and services from durable goods. However, from the time of Fisher's Theory of Interest (Fisher, 1930), there were also neoclassical models of intertemporal utility and the dynamics of choice. I will discuss these in more detail in Section IV.4.

The remainder of this section sets notation with an abbreviated restatement of the core of neoclassical demand analysis and the welfare calculus; more complete statements are given in standard textbook treatments; e.g., Varian (1992, Chap. 7, 10), Mas-Colell, Whinston, and Green (1995, Chap. 3E,F,G,I). I will use the theory of duality, with indirect utility functions and expenditure functions linked to demands through Roy's identify and Shephard's identity, respectively. Major features of these dual functions follow from the envelope theorem, developed by Rudolph Auspitz and Richard Lieben (1889), and applied to consumer theory first by Irving Fisher (1892), and later by Harold Hotelling (1935), Rene Roy (1942), Paul Samuelson (1947), and Lionel McKenzie (1957). The full power of dual methods for derivation of demand systems or recovery of utility in econometric applications was not realized until the end of the 1950's, after the circulation of Fenchel's unpublished lecture notes on convexity, and the demonstration by Ron Shephard (1953) of the formal duality of input requirement sets and cost functions. I myself was taught by Leonid Hurwicz, John Chipman, Marc Nerlove, and Hirofumi Uzawa how dual methods could be used to develop demand systems and implement econometric models of production and utility; see Hurwicz and Uzawa (1971).

Let $\mathbf{p} = (p_1,\ldots,p_n)$ denote a market good price vector in a non-negative cone **P** and $\mathbf{x} = (x_1,\ldots,x_n)$ denote a corresponding consumption vector in a closed, bounded-below consumption set **X**.[2] Let **Z** denote a set of points **z** that describe the consumer's environment, and **R** denote a set of points **r** that predetermine tastes. The reason for introducing **z** is as a placeholder for later analysis of attributes of market or non-market goods, and of the consumer's experience, information, and social environment. The introduction of **r** will facilitate analysis of unobserved taste heterogeneity. The arguments (**z**,**r**) are suppressed in most textbook treatments, but are implicit in the neoclassical theory and can be developed to accommodate some important behavioral phenomena.

Suppose a consumer has a continuous utility index $U(\mathbf{x},\mathbf{z},\mathbf{r})$ defined on $\mathbf{X}\times\mathbf{Z}\times\mathbf{R}$.[3] In this setup, **r** is interpreted as the primitive characteristics of the individual (e.g., genetic endowment) that determine tastes. The fundamental consumer sovereignty assumption of neoclassical theory requires that **r** not depend on opportunities or choice. Depending on the application, **z** may be interpreted as predetermined experience that can influence the utility of current choice, or as part of the current choice. For example, **z** might characterize a predetermined state produced by previous experience, learning, and durables purchases, or alternately might characterize a location choice that determines the markets that are operating.[4]

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[2]When it is useful to make **X** compact in the finite-dimensional case, this can be accomplished by imposing a bound that is not economically restrictive. Most of the results of duality theory continue to hold when prices **p** are points in a convex cone $\mathcal{P}$ in a locally convex linear topological space **S**, and **X** is a compact subset of the conjugate space S^* of **S**. This extension is useful for applications where the consumer is making choices over continuous time, over risky prospects with a continuum of uncertain events, and/or over objects in physical or hedonic space.

[3]The existence of a continuous utility index is somewhat more than is needed for most duality and demand analysis purposes, but is useful for welfare analysis. Consider the following preference continuity axiom: Suppose consumers with tastes defined by points **r** in a compact topological space **R** have preferences over objects (**x**,**z**) in a compact topological space $\mathbf{X}\times\mathbf{Z}$, with $(\mathbf{x}',\mathbf{z}') \succeq_{\mathbf{r}} (\mathbf{x}'',\mathbf{z}'')$ meaning $(\mathbf{x}',\mathbf{z}')$ is at least as good as $(\mathbf{x}'',\mathbf{z}'')$ for a consumer with tastes **r**. *Suppose* $\succeq_{\mathbf{r}}$ *is a complete, transitive preorder on* $\mathbf{X}\times\mathbf{Z}$, and has the continuity property that if a sequence $(\mathbf{x}'^{\mathbf{k}}, \mathbf{z}'^{\mathbf{k}},\mathbf{x}''^{\mathbf{k}}, \mathbf{z}''^{\mathbf{k}},\mathbf{r}^{\mathbf{k}})$ *converges to a limit* $(\mathbf{x}'^{\mathbf{0}}, \mathbf{z}'^{\mathbf{0}},\mathbf{x}''^{\mathbf{0}}, \mathbf{z}''^{\mathbf{0}},\mathbf{r}^{\mathbf{0}})$ *and satisfies* $(x'^k,z'^k) \succeq_{r^k} (x''^k,z''^k)$ *, then* $(x'^0,z'^0) \succeq_{r^0} (x''^0,z''^0)$.

McFadden and Train (2000), Lemma 1, establishes that if this axiom holds, then there exists a utility function $U(\mathbf{x},\mathbf{z},\mathbf{r})$, continuous in its arguments, that represents $\succeq_{\mathbf{r}}$ for $\mathbf{r} \in \mathbf{R}$; see also Bridges (1988).

[4]In the case of discrete or mutually exclusive choice, an alternative is to write $\mathbf{x} = (\mathbf{x}_1,\ldots,\mathbf{x}_J)$, where $\mathbf{x}_j$ is subvector of commodities purchased under discrete choice j. If $\mathbf{x}_j$ includes a dummy variable, its price is then the direct cost of alternative j. The exclusivity of the choices is specified through the consumption set **X**. In this setup, utility maximization may be treated as a joint discrete-continuous decision, or the maximization can be done in stages, typically with the discrete choice modeled as the second stage.

Suppose the consumer seeks to maximize utility subject to a budget constraint $y \geq \mathbf{p}\cdot\mathbf{x}$, where y is an income level higher than the minimum necessary to make at least one vector in **X** affordable.[5] Suppose the configuration of utility and the consumption set **X** are such that in the relevant range, local non-satiation holds; e.g., at least one commodity is available in continuous amounts and always desired. Assume that **Z** and **R** are compact topological spaces.[6] Let **U** denote the range of U.[7] In general, we do not require that **X** be a convex set, or that preferences be convex (i.e., we do not require that U be a quasi-concave function). Define the *expenditure function*

(1) $y = M(\mathbf{p},u,\mathbf{z},\mathbf{r}) \equiv \min_{x\in\mathbf{X}}\{\mathbf{p}\cdot\mathbf{x} \mid U(\mathbf{x},\mathbf{z},\mathbf{r}) \geq u\}$,

and the *Hicksian (compensated) demand function*

(2) $\mathbf{x} = H(\mathbf{p},u,\mathbf{z},\mathbf{r}) \equiv \text{argmin}_{x\in\mathbf{X}}\{\mathbf{p}\cdot\mathbf{x} \mid U(\mathbf{x},\mathbf{z},\mathbf{r}) \geq u\}$,

which is in general a upper hemicontinuous correspondence for $\mathbf{p} \in \mathbf{P}(u,\mathbf{z},\mathbf{r})$ and $(u,\mathbf{z},\mathbf{r}) \in \mathcal{U}\times\mathbf{Z}\times\mathbf{R}$, where $\mathbf{P}(u,\mathbf{z},\mathbf{r})$ is the cone of prices where the minimum in (1) is attained; the interior of this cone is the positive orthant, and its closure is the non-negative orthant.[8] The expenditure function is strictly increasing in u, and concave and linear homogeneous in **p**, and consequently almost everywhere twice continuously differentiable in **p** with symmetric second derivatives.[9] Its epigraph

(3) $\mathbf{A}(u,\mathbf{z},\mathbf{r}) = \{(\mathbf{p},y)\in\mathbb{R}^{n+1} \mid y \leq M(\mathbf{p},u,\mathbf{z},\mathbf{r})\}$

is a closed cone, and a vector **x** is a support of $\mathbf{A}(u,\mathbf{z},\mathbf{r})$ at **p** (i.e., $\mathbf{q}\cdot\mathbf{x} \geq M(\mathbf{q},u,\mathbf{z},\mathbf{r})$ for all $\mathbf{q} \in \mathbf{P}(u,\mathbf{z},\mathbf{r})$), with equality for $\mathbf{q} = \mathbf{p}$, if and only if **x** is in the convex hull of $H(\mathbf{p},u,\mathbf{z},\mathbf{r})$.[10]

[5] If **X** has a bliss point, then y is restricted to be less than the cost of the bliss point. It is possible to assume that **X** is a (Hausdorff continuous) function of **r**, but we will not need this generalization.

[6] When it is useful to have **X** compact, this can be accomplished by imposing a bound that is not economically restrictive. Most of the results of duality theory continue to hold when prices p are points in a convex cone in a locally convex linear topological space $\mathcal{P}$, and **X** is a compact subset of its conjugate space $\mathcal{P}^*$. This extension is useful for applications where the consumer is making choices in physical or hedonic space.

[7] We omit a generalization that makes **U** a function of **r**.

[8] The cone $\mathbf{P}(u,z,\mathbf{r})$ is not necessarily convex.

[9] This property holds only when **p** is finite-dimensional.

[10] See, for example, McFadden (1966,1978abc), Diewert (1974,1982).

Define the *indirect utility function*

$$(4)\qquad u = V(\mathbf{p},y,\mathbf{z},\mathbf{r}) = \max_{x\in\mathbf{X}}\{U(\mathbf{x},\mathbf{z},\mathbf{r}) \mid y \geq \mathbf{p}\cdot\mathbf{x}\}$$

for positive $\mathbf{p}$ and $y > \min_{x\in\mathbf{X}} \mathbf{p}\cdot\mathbf{x}$, and the *market demand function*

$$(5)\qquad \mathbf{x} = D(\mathbf{p},y,\mathbf{z},\mathbf{r}) = \operatorname{argmax}_{x\in\mathbf{X}}\{U(\mathbf{x},\mathbf{z},\mathbf{r}) \mid y \geq \mathbf{p}\cdot\mathbf{x}\},$$

where in general D is a upper hemicontinuous (in $\mathbf{p}$,y,$\mathbf{z}$,$\mathbf{r}$) correspondence.

The expenditure function and indirect utility function satisfy the identities

$$(5)\qquad y \equiv M(\mathbf{p},V(\mathbf{p},y,\mathbf{z},\mathbf{r}),\mathbf{z},\mathbf{r}) \equiv \mathbf{p}\cdot H(\mathbf{p},V(\mathbf{p},y,\mathbf{z},\mathbf{r}),\mathbf{z},\mathbf{r})$$

$$D(\mathbf{p},y,\mathbf{z},\mathbf{r}) \equiv H(\mathbf{p},V(\mathbf{p},y,\mathbf{z},\mathbf{r}),\mathbf{z},\mathbf{r}),$$

$$H(\mathbf{p},u,\mathbf{z},\mathbf{r}) \equiv D(\mathbf{p},M(\mathbf{p},u,\mathbf{z},\mathbf{r}),\mathbf{z},\mathbf{r})$$

$$V(\mathbf{p},y,\mathbf{z},\mathbf{r}) \equiv U(D(\mathbf{p},y,\mathbf{z},\mathbf{r}),\mathbf{z},\mathbf{r}).$$

Shephard's identity establishes that when M is differentiable in $\mathbf{p}$,

$$(6)\qquad H(\mathbf{p},u,\mathbf{z},\mathbf{r}) \equiv \nabla_{\mathbf{p}}M(\mathbf{p},u,\mathbf{z},\mathbf{r}),$$

while Roy's identity establishes that when V is differentiable in $\mathbf{p}$ and in y,

$$(7)\qquad D(\mathbf{p},y,\mathbf{z},\mathbf{r})\nabla_y V(\mathbf{p},y,\mathbf{z},\mathbf{r}) \equiv -\nabla_{\mathbf{p}}V(\mathbf{p},y,\mathbf{z},\mathbf{r}).$$

When U($\mathbf{x}$,$\mathbf{z}$,$\mathbf{r}$) is quasi-concave and non-decreasing in $\mathbf{x}$, the dual mappings

$$(8)\qquad U(\mathbf{x},\mathbf{z},\mathbf{r}) = \min_p V(\mathbf{p}\cdot\mathbf{x},\mathbf{p}) = \max\,\{u|\mathbf{p}\cdot\mathbf{x} \geq M(u,\mathbf{p}) \text{ for all } \mathbf{p}\}$$

recover the direct utility function; otherwise, they recover the closed quasi-concave free-disposal hull of the direct utility function.

Substituting the indirect utility function into the expenditure function gives a monotone increasing transformation that is again a utility function, now denominated in dollars and termed a *money-metric utility function*,

$$(9)\qquad u = \mu(\mathbf{p}',\mathbf{z}';\mathbf{p},y,\mathbf{z},\mathbf{r}) \equiv M(\mathbf{p}',V(\mathbf{p},y,\mathbf{z},\mathbf{r}),\mathbf{z}',\mathbf{r}),$$

where ($\mathbf{p}'$,$\mathbf{z}'$) determine the metric and ($\mathbf{p}$,y,$\mathbf{z}$) determine the utility level. This function behaves like an expenditure function in $\mathbf{p}'$ and an indirect utility function in ($\mathbf{p}$,y), and satisfies $\mu(\mathbf{p},\mathbf{z};\mathbf{p},y,\mathbf{z},\mathbf{r}) \equiv y$; see Hurwicz and Uzawa (1971), Hammond (1994), McFadden (1999).

Consider a change from $(\mathbf{p}',y',\mathbf{z}')$ to $(\mathbf{p}'',y'',\mathbf{z}'')$. The *Compensating Variation* or *Willingness-to-Pay* (WTP) for this change is the net reduction in final income that makes the consumer indifferent to the change,

$$(10)\quad CV = \mu(\mathbf{p}'',\mathbf{z}'';\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r}) - \mu(\mathbf{p}'',\mathbf{z}'';\mathbf{p}',y',\mathbf{z}',\mathbf{r}) \equiv y'' - \mu(\mathbf{p}'',\mathbf{z}'';\mathbf{p}',y',\mathbf{z}',\mathbf{r})$$

$$\equiv \{y'' - y'\} - \{\mu(\mathbf{p}'',\mathbf{z}'';\mathbf{p}',y',\mathbf{z}',\mathbf{r}) - \mu(\mathbf{p}'',\mathbf{z}';\mathbf{p}',y',\mathbf{z}',\mathbf{r})\} - \{\mu(\mathbf{p}'',\mathbf{z}';\mathbf{p}',y',\mathbf{z}',\mathbf{r}) - \mu(\mathbf{p}',\mathbf{z}';\mathbf{p}',y',\mathbf{z}',\mathbf{r})\}.$$

The last identity decomposes the compensating variation into the increase in money income, less the net increase in income necessary at final prices and initial utility level to offset the change in non-market attributes, less the net increase in income necessary to offset the change in prices at the initial non-market attributes and utility level. The final term can be written

$$(11)\quad \mu(\mathbf{p}',\mathbf{z}';\mathbf{p}',y',\mathbf{z}',\mathbf{r}) - \mu(\mathbf{p}'',\mathbf{z}';\mathbf{p}',y',\mathbf{z}',\mathbf{r}) = \int_0^1 H(\mathbf{p}(t),u',\mathbf{z}',\mathbf{r})\cdot\nabla_t\mathbf{p}(t)dt,$$

the *Hicksian net consumer surplus* from the change in prices from p' to p'', where $u' = V(\mathbf{p}',y',\mathbf{z}',\mathbf{r})$ is the initial utility level. This integral is taken over any rectifiable path $\mathbf{p}(t)$ from $\mathbf{p}(0) = \mathbf{p}''$ to $\mathbf{p}(1) = \mathbf{p}'$, and is independent of path.

The *Equivalent Variation* or *Willingness-to-Accept* (WTA) the change is the net addition to initial income that makes the consumer indifferent to the change,

$$(12)\quad EV = \mu(\mathbf{p}',\mathbf{z}';\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r}) - \mu(\mathbf{p}',\mathbf{z}';\mathbf{p}',y',\mathbf{z}',\mathbf{r}) \equiv \mu(\mathbf{p}',\mathbf{z}';\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r}) - y'$$

$$\equiv \{y'' - y'\} - \{\mu(\mathbf{p}'',\mathbf{z}'';\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r}) - \mu(\mathbf{p}'',\mathbf{z}';\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r})\} - \{\mu(\mathbf{p}'',\mathbf{z}';\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r}) - \mu(\mathbf{p}',\mathbf{z}';\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r})\}.$$

Again, the final decomposition is into the increase in money income, less the net increase in income necessary at final prices and utility level to offset the change in non-market attributes, less the net increase in income necessary to offset the change in prices at the initial non-market attributes and final utility level, with the last term expressible as a Hicksian consumer surplus integral analogous to (11), but with Hicksian demand evaluated at the final utility level $u'' = V(\mathbf{p}'',y'',\mathbf{z}'',\mathbf{r})$. The expressions (10)-(12) represent the full neoclassical elaboration of Dupuit's characterization of changes in well-being, with Hick's refinement of compensating for the effect of income on marginal utility.

In addition to the question of interpreting the static neoclassical utility described above when consumers are making dynamic choices over time and under uncertainty, there is the question of whether the utility function, or the components of it needed to predict WTP or WTA, can be identified and recovered from observations on market demands of individuals. It is possible with observations on choice from the *same* utility function at different prices and incomes to recover exactly or bound the Hicksian net consumer surplus associated with price variations; see Henrick Houthakker (1950), Robert Willig

(1976), Hal Varian (1982). This leaves the middle term in (10) to be identified. I will argue later that this requires either that choice be observed in which the environment **z** is determined at an active margin, for example because **z** and **p** influence utility in a known interaction, or because discrete choices are made that select the environment, or that some non-market information on well-being be collected and used; McFadden (1986, 1994, 1999, 2004) gives detailed discussions of identifying and bounding WTP and WTA using both revealed and hypothetical choice data.

III. First Measurements

In the days before digital computers, data on consumer behavior was limited and statistical computation was laborious. Consequently, empirical measurement of utility came slowly. One of the first serious attempts was made by Ragnar Frisch (1926, 1932), specializing a framework initially proposed by Irving Fisher (1892, 1918, 1927). Frisch used 31 monthly observations from Paris starting in 1920 on income, and the price and consumption of sugar. Frisch's formulation now seems restrictive and a little awkward, but it was suited to the computational limits of the day and contained several important ideas, notably separable utility and composite commodities. In modern terminology, Frisch postulated that the demand for sugar could be written as the inverse of the marginal utility of sugar divided by the marginal utility of money:

$$(13) \qquad x = X(y/P,p/P) \equiv f'(p/P)/g'(y/P),$$

where p was the price of sugar, y was income, P was a price index for a composite of the remaining commodities, g' was a decreasing function interpreted as the marginal utility of money, and f' was a decreasing function interpreted as the inverse of the marginal utility of sugar. This demand function has an associated indirect utility function that is additively separable in income and the price of sugar,

$$(14) \qquad u = V(y/P,p/P) = g(y/P) - f(p/P),$$

and the property that the marginal utility of money is independent of the price of sugar. This form satisfies the quasi-convexity requirement on indirect utility functions on a domain where the function g is less concave than the function f.[11] The Frisch demand function allows the relative utility associated with two different sugar prices to be computed (up to scale) by the Dupuit-Marshall device,

[11]The Firsch expenditure function, $y = P\cdot g^{-1}(u + f(p/P))$ is concave in p if and only if $f'' \le x^2\cdot g''$, a condition that may restrict the (y,p) domain. For example, if $g(y/P) = y/P$ and f is any concave function, the condition holds for all positive (y,p), while if $g(y/P) = (y/P)^{1-\alpha}/(1-\alpha)$ and $f(p/P) = (p/P)^{1-\beta}/(1-\beta)$, where $\alpha,\beta \ge 0$, the condition holds when income is sufficiently high relative to the price of sugar, specifically $(p/P)^{1-\beta}/\beta \le (y/P)^{1-\alpha}/\alpha$.

(15) $$V(y/P,p'/P) - V(y/P,p''/P) = g'(y/P)\cdot\int_{p'}^{p''} X(y/P,p/P)dp/P.$$

The compensating variation (10) for a change from (**p**′,P,y′) to (**p**″,P,y″) is

(16) $$CV = y'' - y' + g'(y'/P)^{-1}\cdot\int_{p'}^{p''} X(y/P,p/P)dp/P.$$

The equivalent variation differs only a formua that differs from (15) only in scaling. , and the compensating and equivalent variations are proportional.

IV. The Stone Age

Econometric demand analysis flowered in the 1960's, as improved data and digital computers made serious empirical work possible. The real starting point was the contribution of Richard Stone (1954), who worked with demand systems linear in income that were derived from Cobb-Douglas demands, translated to allow committed expenditures,

(17) $$x_i = C_i(\mathbf{p}) + \theta_i(y - C(\mathbf{p}))/p_i .$$

Here, i = 1,...,n indexes the commodities, y is income, **p** is a vector of commodity prices, C(**p**) is a committed expenditure, concave and linear homogeneous in prices, and $\theta_1,...,\theta_n$ are positive parameters summing to one. The Stone system is a special case of Terance Gorman's polar form,

(18) $$x_i = C_i(\mathbf{p}) +(y - C(\mathbf{p}))/P_i(p)/P(\mathbf{p}),$$

derived from an indirect utility function

(19) $$u = (y - C(\mathbf{p}))/P(\mathbf{p}),$$

of income net of committed expenditure C, divided by a price index capital P.[12] Both C and P in the Gorman form are concave, non-decreasing, conical functions of prices, and the

[12]The Gorman polar form reduces to the Stone system when the index P(**p**) is Cobb-Douglas, $P(\boldsymbol{p}) = p_1^{\theta_1} \cdots p_n^{\theta_n}$.

domain is restricted to y $\geq$ C(**p**). The Gorman polar form can be generalized to allow more general Engle curves by introducing a monotone transformation of deflated income[13],

(20) $$u = g(y/P(\mathbf{p})) - C(\mathbf{p})/P(\mathbf{p}).$$

Frisch's original solution for analysis of the demand for sugar is of this generalized Gorman polar form.

In the 1960' and 1970's, a variety of econometric demand systems were proposed, many derived from specifications of expenditure or indirect utility functions. A number of these econometric demand systems were developed at Berkeley by students working under me and my colleagues Dale Jorgenson and Robert Hall. Erwin Diewert developed one of the first, in 1963, from a cost function that was quadratic in square roots of prices; see, for example, Diewert (1971), Blackorby and Diewert (1979). I pointed out that this system could be interpreted as a second-order Taylor's expansion of any smooth cost function, so that it had the nice property that at the approximation point it could reproduce all the own and cross-price elasticities of the original. We named this the flexible functional form property, and it became one of the criteria guiding subsequent developments. Dale Jorgenson and Larry Lau devised the translog system, another flexible functional form; see Christensen-Jorgenson-Lau (1975). Another major contribution to the specification of demand systems, influenced by both the Berkeley tradition and by Terance Gorman, was the Almost Ideal Demand System proposed by Angus Deaton and John Muellbauer (1980ab). This is a Gorman generalized polar form with translog committed expenditures and a Cobb-Douglas price index. While these models were derived from the theory of the individual consumer, they were typically applied to cross-section observations on individuals, or to market aggregates, by assuming a representative consumer. Except under special circumstances (see for example John Chipman and James Moore, 1980, 1990), this presumed homogeneous preferences, or in the later work of Dale Jorgenson, Larry Lau, and Tom Stoker (1980, 1997) and Arthur Lewbel (1992), observable and parameterizable preference heterogeneity.

The utility-consistent demand systems introduced in the 1960's and 1970's generally worked well to explain demand at the market level despite the representative consumer restriction. A recent paper by Lester Taylor (2005) estimates neoclassical demand systems using U.S. Consumer Expenditure Survey quarterly expenditure data and ACCRA Cost of Living indices across urban areas in six expenditure categories. Table 1 gives price and expenditure elasticities for an Almost Ideal Demand System fitted to these data. An example of the use these results is calculation of excise tax structures that maximize well-being subject to budget and distributional constraints. Taylor points out that there are substantive aggregation, quality, and taste heterogeneity issues in the use of such data, but his results are generally consistent with other studies, and consistent across different

[13] If g is not convex, then the requirement that the indirect utility function be quasi-convex restricts the curvature of g and/or the domain of the function.

functional forms. He finds that Stone, indirect addilog, and direct addilog systems give qualitatively similar results.

Table 1. Price and Total Expenditure Elasticities

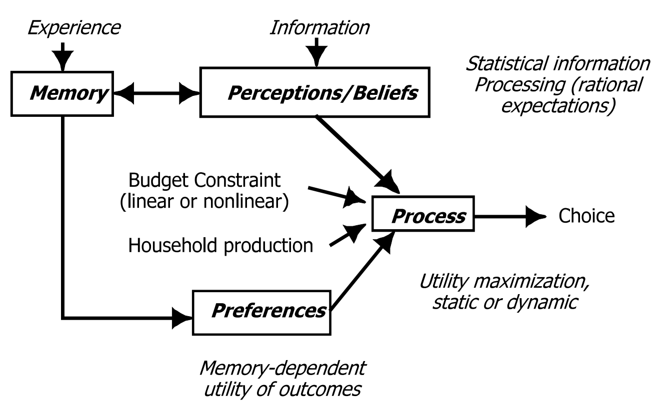
Almost Ideal Demand System, 1995 CES-ACCRA Surveys, from Lester Taylor (2005)

	food	shelter	utilities	trans	health	misc	total exp
food	-0.2981	0.6644	0.0599	-0.0013	0.1400	-0.5044	0.4469
shelter	-0.1105	-0.8285	0.1909	0.1902	0.2782	-0.5777	0.8876
utilities	-0.1071	0.1638	-0.7222	0.0523	-0.0669	0.1783	0.4612
trans	-0.6134	-0.2520	-0.2471	-1.3739	-0.7627	1.5824	1.7250
health	-0.7813	0.0023	0.4260	-0.0129	-0.9375	0.8318	0.6338
misc	0.4395	-0.2179	-0.2267	-0.0154	0.0470	-1.1448	1.2150

V. Expansions

As microdata on individuals have expanded, neoclassical econometric demand systems predicated on linear budget sets and representative consumers proved uncomfortably restrictive. They could not deal easily with preference heterogeneity, acquired tastes, shifting hedonic attributes of commodities, non-linear budget sets, time, space, or uncertainty, and the frequent cases of zero and lumpy purchases. It was necessary to expand the domain of the theory. This was done initially by retaining the central elements of standard neoclassical consumer theory, and bringing back some of the broader components of utilitarianism in a way that was consistent with the neoclassical core. This meant preserving the tenets of consumer sovereignty, rational perceptions, and preference maximization, but admitting the influence of (observed and unobserved) experience and memory on perceptions and on current preferences, leading to heterogeneity across consumers, and allowing household production, non-linear budget constraints, and utility maximization that may involve

Figure 2. The Extended Neoclassical Model



strategic optimization over time, with recalculation as events unfold.

V.1. Preference Heterogeneity. The extension of neoclassical consumer theory to handle both unobserved preference heterogeneity and tastes acquired as the result of observable experience and history was just a reaffirmation of circumstances admitted in the neoclassical model, but pushed aside to facilitate econometric estimation. In the summary of the neoclassical model given in the previous section, I wrote utility U(**x**,**z**,**r**) as a function of observed experience **z** and unobserved tastes **r**, and these effects carry into the demand functions as arguments. Observed distributions of demands then restrict or identify the underlying distributions of unobserved effects. The primary problems in application are practical; how to measure and fold into the utility function all the varied experiences of consumers, and how to embed within the system and characterize the distribution of unobservable components of tastes. My original treatment of the discrete choice problem (McFadden, 1974) illustrates a parametric solution. Modern developments allow both flexible parametric and nonparametric estimation; see ,for example, Horowitz, and. Savin (2001), Horowitz (1992), Huang and Nychka (2000), Ichimura and Lee (1991), Ichimura and Thompson (1998), Matzkin (1992, 1993), Pagan and Ullah (1999), Signorini and Jones (2004).

There are conceptual issues in utility measurement in the presence of unobserved preference heterogeneity. Is unobserved taste variation a permanent individual effect, or is there a component that varies with time or choice opportunity? The neoclassical presumption is that tastes within an individual are fixed. This is the setup of revealed preference theory, which envisions a sequence of budgets offered to an individual whose tastes are uninfluenced by by the experience of previous offers, or by whims. Alternately, individual tastes may have a time varying component. This is in itself not inconsistent with classical utilitarianism, which left room for utility to reflect "a moment's fancy". However, the presence of taste variations across a revealed preference sequence undermines the main revealed preference result that the convex hull of preferences can be recovered from observed demands. If instead preferences are treated as stochastic, interesting possibilities open for models with both intra-individual and cross-individual heterogeneity. Employing the theory of stochastic revealed preference (Marschak, 1960, Block and Marschak, 1960, Luce and Supes, 1965, McFadden and Richter, 1971, 1991, McFadden, 2005), and panel data on demand, one could ask for conditions under which the distributions of the unobserved taste heterogeneity can be nonparametrically identified. Is it possible to untangle state-dependence and unobserved individual effects in consumer panels, the Heckman initial-values problem? Is it possible to separate heterogeneity in perceptions from heterogeneity in tastes when choice alternatives are risky or ambiguous? Is it possible to identify the distribution of preferences from market-level demand observations?[14]

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[14]The answer to this question depends on what one knows about the resources available to individuals; see Debreu (1974), McFadden-Mas Collel-Mantel-Richter (1974), Matzkin (2005).

In general, it would be useful to consider identification and measurement of WTP in a population of consumers that is heterogeneous in tastes, income, and environment. Suppose the population faces common market prices **p**. Let $\Psi(\mathbf{r})$ denote the distribution of tastes, which under the classical assumption of consumer sovereignty is independent of income and the hedonic environment, and invariant under changes in income, market, and non-market conditions. Let $\Gamma(y|\mathbf{r})$ denote the distribution of income, conditioned on tastes. This distribution may also depend on incomes policy parameters. Let $\Phi(\mathbf{z}|\mathbf{r},y,\zeta)$ denote the distribution of environments, conditioned on tastes, income, and environmental policy parameters ζ. In applications, the **z** might be hedonic attributes of commodities such as durability or reliability, and the ζ might be regulations on product quality. Alternately, the **z** might be environmental attributes such as air pollution level or proximity to a hazardous waste site, and the ζ might be environmental regulations. In some cases, the **z** are exogenous to the consumer, and thus independent of income and tastes. For example, a product attribute such as durability may be uniform for all consumers. In other cases, the **z** are an *endogenous* consequence of consumer choice, such as residential location in response to air pollution levels, and thus have a distribution that depends on income and tastes. A satisfactory model for WTP in the presence of endogenously determined environmental attributes requires specification of the structure of supply as well as demand, and determination of an equilibrium allocation in both market goods and the non-market environments. WTP is then defined on an equilibrium trajectory from old to new environmental, income, and price management policies.[15]

The distribution of WTP in the population is obtained by convolving (10) with respect to the three distributions Φ, Γ, and Ψ. Even without the weighting for income and environmental circumstance that might be dictated by a social welfare function, this distribution is potentially difficult to obtain, requiring recovery of individual money metric utility from individual demands, including tastes for non-market goods, and identification of the conditional distributions taking into account the possible correlation of income and tastes and the possible endogeneity of **z**. One approach to managing this problem is to restrict preference fields in ways that allow aggregation over consumers, concentration on subsets of commodities or commodity aggregates, and simplification or sparse parameterization of money-metric utility.

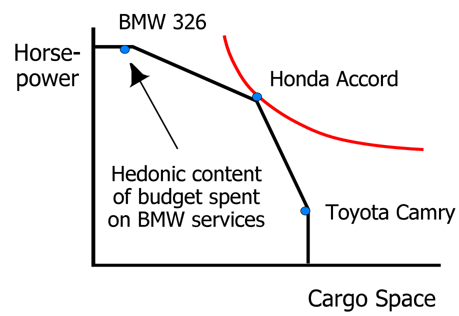
V.2. Nonlinear Budget Sets. The neoclassical focus on linear budgets and convex preferences neglected a range of consumer behavior that is apparent at the level of the individual, the lumpiness and mutual exclusivity of many consumer choices such as school, job, and brand of automobile. It also neglected the important economic area of nonlinear pricing, arising from two-part and nonlinear tariffs, and progressive taxes. Extending econometric consumer theory to handle these applications required attention to the role of taste heterogeneity, and to the characterization of budget alternatives. The duality methods that are so useful in linear budget problems are hampered here, but still valuable, for example in Hausman (1985) and Dubin and McFadden (1984). One important

[15]In the terminology of the statistical and econometric literature on treatment effects, the final state in the welfare comparison is a fully consistent equilibrium counterfactual.

observation for measurement of consumer well-being is that non-linear budget sets are a powerful tool for identification. For example, when budgets are restricted to binary comparisons, one recovers preferences directly.

V.3. Hedonic Goods. Economists moved in the 1970's from treating commodities as objects with fixed attributes to hedonic models in which consumers care about generic attributes that can be met through various quantities and combinations of market goods. The simplest hedonic model, dating to Andrew Court (1939) and Kevin Lancaster (1966), allowed the hedonic content of a unit of a market good to vary with the design of its manufacturer, and assumed in implementation that these dimensions of content could be measured. Thus, consumers desire horsepower and cargo space in cars, and automobile brands carry these attributes in various amounts determined by their design.

Figure32. Hedonic Preferences



Hedonic regressions of product prices on attributes were introduced by Zvi Griliches (1961) as a method of adjusting price indices to control for product quality.[16] These regressions were later connected by Sherwin Rosan (1974) to the theory of utility maximization in hedonic space; see also Makoto Ohta (1971), Ohta and Griliches (1986), and Ivar Eckland (2005). Using our earlier notation, consumers with indirect utility functions $V(\mathbf{p},y,\mathbf{z},\mathbf{r})$, where $\mathbf{z}$ describes the attributes of commodities, face price functions $\mathbf{p}(\mathbf{z})$ and are price-takers maximizing this utility by choice of $\mathbf{z}$ in a feasible set $\mathbf{Z}^0$. In general, the price function is determined through hedonic market equilibrium, and is not necessarily linear or log-linear in $\mathbf{z}$. To simplify exposition, assume that only the first commodity is heterogeneous, with hedonic attributes $\mathbf{z}$. Suppose that the indirect utility has a "factor augmenting" form, $V(p_1(\mathbf{z})\cdot\exp(-\mathbf{z}\beta),p_2,\ldots,p_n,y,\mathbf{r})$, where the hedonic taste weights β are common to all consumers. Then, all products that have positive demand, and hence can be seen in the market, achieve the minimum of $p_1(\mathbf{z})\cdot\exp(-\mathbf{z}\beta)$ over the available designs. This implies that $\log p_1(\mathbf{z}) = \alpha + \mathbf{z}\beta$, and if unobserved attributes are orthogonal to observed ones, the conditions for recovery of the hedonic taste parameters by least squares are met.[17]

An alternative econometric implementation of hedonic analysis was introduced in the case that the feasible set $\mathbf{Z}^0$ in the notation above is finite. Then, consumers are making

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[16] The typical hedonic regression for, say, housing (commodity 1) is $\log p_1(z) = \mathbf{z}\beta$, where $\mathbf{z}$ includes observed attributes such as square footage, age, number of baths, and proximity to schools, jobs, and environmental nuisances, and unobserved attributes combine into a disturbance.

[17] A similar linearity result for the price function is obtained when the profit functions of competitive suppliers have a common "factor augmenting" form.

discrete choices among these alternatives, and the resulting choice probabilities depend on tastes for the attributes of the alternatives. This setup, with a linear parametric specification for indirect utility, was used in my initial formulation of discrete choice models (Domencich and McFadden, 1972, 1975; McFadden, 1974, 1975, 1976).

Both hedonic regression and hedonic discrete choice have had wide application, and have been generalized to nonlinear, semiparametric, and nonparametric specifications; see, for example, Anderson, de Palma, and Thisse (1992), McFadden and Train (2000), Yatchew (1998, 2003). An econometric issue, tacit in both hedonic regression and discrete choice models, is that the orthogonality or independence of observed hedonic attributes and unobserved disturbances is problematic. Traditional instrumental variables methods usually suffice for linear hedonic regression, but nonlinear models are more challenging, and have been the subject of a large literature; see, for example, Berry-Levinsohn-Pakes (1995, 2004), Berry-Linton-Pakes (2004), Blundell and Powell (2004), Matzkin (200x,200x).

Lack of observed variation in attributes of market goods, and issues of exogeneity, have led economists to use information obtained from hedonic preference experiments with hypothetical market choices. This is the method of conjoint analysis, adapted in market research from its psychophysical roots (Thurstone, 1931; Luce and Tukey, 1964; Carroll, 1969; Green et al, 2001), and tied to models of stochastic preferences as a result of econometric work on discrete choice models (McFadden, 1986; Morikawa, Ben-Akiva, McFadden, 2002). In a review of consumer demand experiments, Ivan Moscati (2004) gives a remarkable bit of intellectual history. The first conjoint experiment on consumer demand was done by the psychologist Leon Thurstone at the urging of his University of Chicago colleague Henry Schultz. Thurstone presented his paper at the 1932 meeting of the Econometric Society, with Ragnar Frisch and Harold Hotelling commenting from the audience on the critical differences between hypothetical and real choices. Thurstone's method was noted and dismissed by Nicholas Georgescu-Rogen (1936) and by Allen Wallis and Milton Friedman (1942), for three good reasons, the hypothetical nature of the offered choices, the difficulty of detecting indifference, and the difficulty of controlling experimentally for the effect of income and prices. Thurstone is not mentioned in the neoclassical treatises of Hicks and Samuelson, and there were no economists involved in the initial applications of conjoint analysis in marketing. However, truncated versions of conjoint analysis, termed contingent valuation, vignette analysis, or self-reported preference, later became popular among some applied economists and political scientists; see Rossi (1979), McFadden (1986,1994), Green et al (1998), Carson et al (2000), Frey et al (2002), King et al (2004). The use of hypothetical market decisions remains controversial among economists, with some reason, as it is difficult to achieve the verisimilitude of real markets in the laboratory, and cognitive inconsistencies that are not obvious in low-frequency real market choices may be glaring in high-frequency, repeated laboratory choices. However, stated preference methods have become a proven tool in marketing for designing and positioning new products. For example, experiments on automobile brand choice can determine with great predictive accuracy the distributions of preference weights that consumers give to various vehicle features; see Urban et al (1990, 1997); Dahan, Hauser, et al (2002); Train and Winston, (2005). In overview, experience seems to be that these methods work best when the task is choice among a small number of realistic and relatively familiar alternative products, ideally with some probability that the choice will be delivered and paid for. Stated preference methods are less reliable and less directly useful for predicting behavior when the task is to rate products on some scale, or to adjust some attribute (e.g., price) to make alternatives indifferent. They are also less reliable when the products are unfamiliar or incompletely described. Methods that require cardinal utility judgments, such as those of the Leiden school (van Praag and Kapteyn, 1994) and Frey and Stutzer (2002), have intuitive validity, but require strong behavioral axioms to be consistently predictive for choice; see Dagsvik (2005).

V.4. Household Production. Consumers may be thought of as obtaining various hedonic quantities through a combination of the hedonic content of market goods and household production of hedonic content. For example, an automobile contains as hedonic content "horsepower" and "cargo capacity", and requires the household production activities of driving and parking to facilitate foraging for food and satisfying hunger. Household production is a fact of life whose presence influences consumer's economic behavior, enriches the interpretation and complicates the measurement of utility, and provides additional measurement opportunities. Economists recognize this, and invoke household production ideas to explain time allocation, and facilitating activities like travel decisions. Nevertheless, textbook sections on household production are usually starred. I think the reason for this is that unless one has measurements on household production activities or hedonic products of the household production process, one cannot distinguish household technology from tastes. To illustrate, let $\mathbf{w} = (w_1,\ldots,w_K)$ denote hedonic quantities, $\mathbf{z}$ denote the consumer's environment, $\mathbf{x} = (x_1,\ldots,x_N)$ denote market goods, y denote income, and $\mathbf{p} = (p_1,\ldots,p_N)$ denote market good prices. Let $F(\mathbf{w},\mathbf{x},\mathbf{z}) \le 0$ denote the household production function, and $U(\mathbf{w},\mathbf{z},\mathbf{r})$ denote the direct utility function. Then, the consumer's indirect utility satisfies

$$(21) \qquad V(y,\mathbf{p},\mathbf{z},\mathbf{r}) = \max_{z,x} U(\mathbf{w},\mathbf{r}) \ \text{ s.t. } F(\mathbf{w},\mathbf{x},\mathbf{z}) \le 0,\ \mathbf{p}\cdot\mathbf{x} \le y$$

Given this indirect utility function, apply the duality mapping

$$(22) \qquad U^*(\mathbf{x},\mathbf{z},\mathbf{r}) = \min_p V(\mathbf{p}\cdot\mathbf{x},\mathbf{p},\mathbf{z},\mathbf{r})$$

to obtain a reduced form utility function of the market goods. Then U* has the conventional properties of a neoclassical utility function. This construction does not require convex preferences and household production possibilities, and leaves household production implicit. Then, by Occam's razor, if only market purchases are observed, one might as well model only U*, and treat household production as outside the province of economists.

However, there is potentially a great deal to be learned when it is possible to measure some post-household-production hedonic quantities. Variation in household production functions may be a source of apparent taste variation in utility, or may attenuate the impact of taste variations on market transactions. Structural models of household production and consumption can explain simply behavior that may otherwise be difficult to interpret, such as demand for education, exercise, work, and household appliances that have both consumption and production aspects. The hedonic measures **w** may be conventional economic ones, like horsepower and cargo space, or may be proximate to the organism; e.g., calorie intake or alleostatic load. Knowing something about the hedonic landscape, as in the work of Heckman-Matzkin-Neshelm (2002) on demand for jobs with different safety levels, or in my work on residential location when faced with environmental hazards (McFadden, 2003), it is often possible to recover the distribution of hedonic preferences when consumers operate at active margins, locating at observable points in hedonic space in response to tradeoffs between economic and non-economic factors. Careful analysis of household production, augmented by hedonic measurements from conjoint analysis and by physiological measures, is in my opinion one of the promising and relatively neglected frontiers in econometric study of consumer behavior.

V.5. Consumer Dynamics. When the consumer is considered in time, it is necessary to clarify what utility and utility-maximization mean. One concept is that of instant utility or felicity, a hedonic index of the sensation of well-being at a moment. Another is decision utility, an index of the desirability of choices that may be available at the moment and that determine current consumption and future options. A third is remembered utility, an index of current satisfaction with experiences in the past. Neoclassical economics focuses on decision utility as the operative driver of market behavior, and emphasizes that only its ordinal properties matter. In this view, instant utility and remembered utility are not directly relevant to economic behavior, even if they have psychological content.

The major issues in modeling intertemporal choice were the intertemporal structure of decision utility, and the timing, information, and calculus involved in utility maximization. Neoclassical consumer theory has handled these in two ways. A framework introduced by Fisher (1908, 1930), Edmund Malinvaud (1953), and Gerard Debreu (1959) dated commodities and made their delivery contingent on uncertain events. In Debreu's interpretation, utility spanned the lifetime of the consumer, with a single utility-maximizing choice determining the entire life course, specifying in advance the response to the realization of each contingency. This was a complete, logically elegant, and instructive implementation of consumer theory, with utility incorporating a complete system of perceptions and subjective probabilities, and including in the life plan of the consumer full allowance for the strategic impact of choice on later options and preferences. Nevertheless, the approach was unsatisfactory, first because it required the existence of a spanning set of contingent markets that in practice do not exist, but more fundamentally because it is clear from behavioral evidence that life plans are "incomplete contracts" that ignore many contingencies and are subject to continual updating and revision. The limits of the approach are obvious when one asks at what point in time the consumer's once-and-for-all life choice is made – at birth, the time of preparation for A-level exams, voting age?

The second approach to handling time and uncertainty in neoclassical consumer theory was to treat the utility of a life as the integral of discounted instant utilities, an idea that dates back to Bentham's depiction of utility as depending on intensity, duration, and propinquity or remoteness, and to Edgeworth's description in 1881 of the level of happiness associated with an experience as the integral of the intensity of pleasure over the duration of the event:

> "The continually indicated height [of felicity] is registered by photographic or other frictionless apparatus upon a uniformly moving vertical plane. Then, the quantity of happiness between two epochs is represented by the area contained between the zero-line ... and the curve traced by the index."

Edgeworth viewed felicity as a cardinal measure of sensation, with levels that were comparable across time and allowed utility to be expressed as an integral. The neoclassical formulation instead deduces felicities as a feature induced by a separability property of preferences (see Debreu, 1986). The formulation of decision utility as an integral of felicities is usually extended to decompose the utility of uncertain prospects into the expected utility of their outcomes under the axioms of von Neumann-Morgenstern (1953) and Savage (1954); see Arrow (1971). To complete the theory, it is necessary to describe how the utility function depends on memory and learning, how perceptions and subjective probabilities are formed and updated, and how choices are made and revised as time passes and events unfold. A typical implementation assumes that the consumer solves a dynamic stochastic program to maximize the expected present value of a discounted integral of future instant utilities, with subjective probabilities that satisfy the Muth-Lucas axiom of rational expectations, requiring that subjective probabilities of different consumers agree with objective frequencies, and hence with each other; see Muth (1992, 1994), Lucas (1975). The approach can accommodate experience and learning through state variables that enter instant utility, but often these effects are omitted or admitted in very restrictive form. The dynamic stochastic programming approach is again an elegant and instructive logical solution to the problem of consumer dynamics. However, the strongest form of the model, with a representative consumer and rational expectations, is vulnerable to behavioral rejection, because the solution of these programs involve levels of complexity and computation that fairly clearly exceed human cognitive capacity, because it is unrealistic to assume that historical experience and market discipline are sufficient to homogenize subjective expectations, particularly for rare events, and because the axiomatic foundations for utility jointly additively separable in time and uncertain outcomes are not persuasive; see Pollack (1970).

Intertemporally separable decision utility has difficulty explaining the smoothness of consumption in the presence of observed income shocks; e.g., Sundaresan (1989), Okubo (2002). This is most easily addressed within the neoclassical framework by letting felicity depend on state variables that summarize consumer history. In addition to observed states, such as holdings of consumer durables, one can introduce unobserved state variables, or hidden states, that carry the effects of intertemporal substitutability. By expanding the dimensionality of the state description, the utility maximization model can be represented as a dynamic stochastic program with Markov dynamics. A final generalization would be to reintroduce the idea of William Stanley Jevons that the same objective time may correspond to different *rates* of thought and feeling in different periods, so that two dimensions are required to characterize the elements of the utility of an episode, its felicity and *subjective time*. Then, decision utility at moment t would have the form

$$u = \mathbf{E}_{t|\mathbf{z}(t),\mathbf{s}(t)} \int_t^\infty U(\mathbf{x}(\tau),\mathbf{z}(\tau),\mathbf{s}(\tau),\mathbf{r})\delta(d\tau,t,\mathbf{z}(t)), \tag{23}$$

where $\mathbf{x}(\tau)$ is the vector of market goods purchased at time τ ,$\mathbf{z}(\tau)$ is the consumer's environment,,$\mathbf{s}(\tau)$ is a vector of observed and hidden state variables, and,$\mathbf{r}$ indexes tastes. The function $U(\mathbf{x}(t),\mathbf{z}(t),\mathbf{s}(t),\mathbf{r})$ is felicity at t, and $\delta(d\tau,t,\mathbf{z}(t))$ measures the subjective time at τ as viewed from the current moment t. In this formulation, subjective time may depend on the environment of the consumer. The measure δ also incorporates time discounting, which arises in the utilitarian view because, in the words of Edgeworth, "the bird in the bush may never come to hand". The operator $\mathbf{E}_{t|\mathbf{z}(t),\mathbf{s}(t)}$ denotes subjective expectation at t, conditioned on the consumer's environment and experience at that moment. The state s has an equation of motion

$$ds(t)/dt = h(\mathbf{x}(t),\mathbf{z}(t),\mathbf{s}(t)). \tag{24}$$

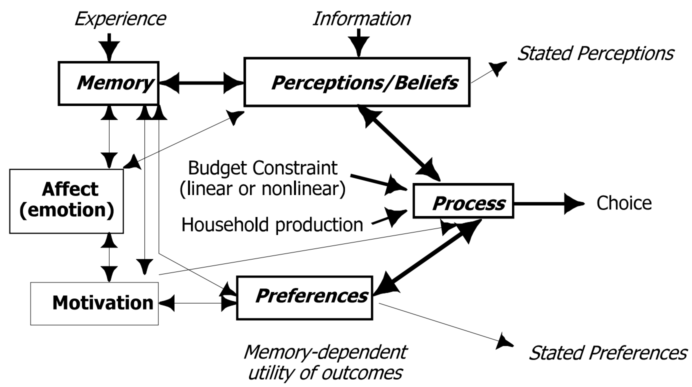
This formulation of decision utility, embedded in a dynamic stochastic program, and allowing heterogeneity in preferences and perceptions, and interactions between perceptions, tastes, and experience, is an extension of the neoclassical consumer model that can accommodate phenomena such as time-inconsistent discounting, time-inconsistent perceptions, and differences between an unweighted integral of felicities and either remembered or decision utility. This setup risks explaining too much, but can be given content by restricting the structure of felicity, subjective time, and subjective expectations,

VI. New Frontiers: A Behavioral Revaluation of the Consumer

Neoclassical consumer theory implies that rational calculation, we benefit from choice and trade. Then people should relish choice, and welcome all the alternatives offered by markets. Yet, people are challenged by choice. In the words of a Dutch proverb, He who has choice has trouble. We find choice uncomfortable, and often use procrastination, rules, pre-commitment, habit, suspicion, and imitation to circumvent conscious choice. The psychiatrists even have a word for it – agoraphobia, or fear of the market. There are two possible reasons for this behavior. First, while trade is calculated to advance our self-interest, the calculation may be burdensome, and the cost of mistakes substantial. We may simply be too lazy or timid to trade. Second, trade involves social interaction and the emotions that go with this. Choice alternatives and trades may be misrepresented in the market game, and suspicion may be justified. As a result, we evaluate economic activities not only cognitively, but also viscerally. This emotional aspect not only explains why economic choices can make us uncomfortable, but also why we sometimes make systematic mistakes – we do not approach economic decisions with a single mind.

A schematic for behavioral models of choice differs from the neoclassical schematic primarily by adding affect and motivation as factors in choice, relaxing the rigid requirement that preferences are sovereign and king of the sentiments, and adding possible feedbacks. However, there is a more fundamental difference. Neoclassically trained economists think of these behavioral elements as arising from the limits of memory and cognitive capacity that bound rationality, slips or anomalies that the individual will detect and correct if they become obvious. Many psychologists and biologists think of this instead as a product of evolution, the result of a rough correspondence between generalized self-interest and survival, a hodge-podge of rules, processes, and strategies that mimic rationality in circumstances where rationality increases survival value. Day-to-day economic choices are explained by either paradigm, but perception and choice in novel situations tests the neoclassical premise, and challenges easy transitions between conventional demand analysis and the effect of novel economic policy on consumer well-being.

Figure 4. The Behavioral Choice Model



Measurement of economic consumer behavior will continue to center on studies of revealed market behavior, with traditional consumer expenditure surveys augmented by electronic tracking of consumer purchases through scanner data, high frequency sampling through internet panels, and increasing exploitation of natural experiments. These measurements will be supplemented by conjoint analysis studies of choice behavior in hypothetical markets, and a great deal more data from microeconomic surveys, experimental economics, marketing science, and cognitive psychology. Perhaps the most interesting and challenging new measurements come from fields not commonly allied with economics, sociology, anthropology, evolutionary and cellular biology, and neurology. I will give an overview of this research, starting with more traditional experiments in cognitive psychology, then measurements and experiments in sociology and anthropology, and concluding with findings and experiments in biology and neurology.

VI.1. Measurements from Cognitive Psychology. There are now extensive experiments and insights from cognitive psychology that contradict the neoclassical model of rational choice, many originally conducted by Amos Tversky and Danny Kahneman. These suggest that preferences are malleable and context-dependent, that memory and perceptions are often biased and statistically flawed, and decision tasks are often neglected or misunderstood. Table 2 is a summary of major cognitive anomalies that appear in psychological experiments and surveys; for more details, see Rabin (1996), McFadden (1999).

Table 2. COGNITIVE ANOMALIES

EFFECT	DESCRIPTION
COMPREHENSION	
Completion/Substitution	Missing or ambiguous parts of question are reconstructed
Disjunction	Failure to reason through or accept the logical consequences of choices
Engagement/Awareness	Limited attention to and engagement in the cognitive task
Format/Mode	Availability influenced by format, visual or auditory presentation
Construal	Question interpreted as one the subject is able (or prefers) to answer
Translation	Question terminology translated into subject's personal vocabulary
RETRIEVAL OF FACTUAL AND AFFECTIVE MEMORY	
Affective attenuation	Affective memories are recalled with diminished intensity
Availability	Memory reconstruction is tilted toward the most available and salient information
Primacy/Recency	Initial and recent experiences are the most available
Reconstructed Memory	Imperfect memories rebuilt using contemporary cues and context, historical exemplars, commonly employed search criteria
Selective Memory	Coincidences are more available than non-coincidences
Telescoping/Temporal	Compression and attenuation of history, inconsistent time discounting
JUDGMENT AND THE FORMATION OF PERCEPTIONS AND BELIEFS	
Anchoring	Judgments are influenced by quantitative cues contained in the decision task
Context/Framing	History and framing of the decision task influence perception and motivation
Endowment	No action is the "safe" choice. "The devil you know is better than the devil you don't"
Extension	Representative rates are more available than integrated experience
Prominence/Order	The format or order of decision tasks influences the weight given to different aspects
Prospect	Inconsistent probability calculus, asymmetry in gains and losses
Regression	Attribution of causal structure to fluctuations; failure to anticipate regression to mean
Representativeness	Frequency neglect in exemplars
TASK DEFINITION, AND THE DECISION AND REPORTING PROCESSES	
Awareness	Recognition of choices, subjective definition of choice set
Construal/Constructive	Cognitive task misconstrued, preferences constructed endogenously
Prevarication/Projection	Misrepresentation for real or perceived strategic advantage or to project self-image
Suspicion/Superstition	Subjects mistrust offers and question motives of others in unfamiliar situations, avoid choices that "tempt fate"
Rule-Driven	Choice guided by principles, analogies, and exemplars rather than utilitarian calculus; rules induce *pro forma*, focal responses

VI.1.1. I will give four examples of anomalies that challenge the neoclassical model. The first is the *endowment effect*, a consumer aversion to trade from any given status quo, or *agoraphobia*. The endowment effect was beautifully illustrated in a classical experiment by Jack Knetsch (1989) in which a random assignment of coffee cups produced a large gap between WTP and WTA, with far less trading than should be needed to move from a random allocation to a Pareto efficient one; see also Kahneman, D.; Knetsch, J.; Thaler, R. (1990). I conducted a comparable experiment in an introductory microeconomics course at Berkeley, using pencils embossed with the course name. About half of the 345 students, 172, were randomly assigned a pencil. Then, a Vickery sealed-bid uniform price double auction was held to reallocate the pencils. The market cleared with 32 pencils traded, at a price of 35 cents. The median of the sealed bid prices was 10 cents, while the median of the sealed ask prices was 100 cents, the same large gap between WTP and WTA that appeared in the cup experiment.

The income effect of being endowed with a pencil is negligible, so that with random assignment the distributions of money marginal utilities of a pencil should be the same for buyers and sellers. Then if consumers are neoclassically rational, there should be no endowment effect. Consider a market with N participants with values $v_1 \geq ... \geq v_N$ drawn from a common value distribution F(v), and K randomly allocated pencils. In the incentive-compatible Vickery double auction, successful buyers pay v_{K+1}, and successful sellers receive v_K, with the market operator covering the difference. The number of pencils J initially allocated to the K highest value participants has a binomial distribution, b(K,K/N). The volume in the efficient auction is then K-J. The mean of K-J is K(N-K)/N, and its variance is $K^2(N-K)/N^2$. The probability of a volume below M, using a normal approximation to the binomial, is $\Phi((MN-K(N-K))/K(N-K)^{1/2})$. In the experiment, the expected volumn is 86.25, with a standard deviation of 6.56. The market clearing price is $v_{K+1} = v_K = 35$. The probability of 32 or fewer transactions is on the order of 10^{-16}. Further, a runs test confirms (T-Stat = 12.5) that buyers and sellers do not have the same value distribution. Thus, there is a strong, trade-suppressing endowment effect, generated instantaneously by a random allocation of pencils. Either tastes are changing endogenously, with quick habituation to the status quo, or agoraphobia is real -- consumers find trade an edgy experience, instinctively mistrust the market, and resist trading for small gains.

VI.1.2. Choice among lotteries often deviates from rationality. A stylized summary is that consumers display (i) an endowment effect, evaluating lotteries as changes from a reference point that may be sensitive to framing, (ii) an asymmetric loss aversion effect, in which the consumer is more sensitive to losses than to gains, displaying risk aversion for gains and risk seeking for losses, and (iii) a certainty effect in which sure outcomes are overvalued relative to lotteries. In addition, there are (iv) an isolation or cancellation effect in which common aspects of alternative lotteries are ignored when they are compared, (v) a segregation effect in which a riskless component of a lottery is evaluated separately from the risky component, and (vi) a mode effect in which pricing a lottery is treated as a qualitatively different task than choosing between lotteries. One of the consequences of these effects is that consumers will often refuse to take any share of either side of an offered lottery, a result consistent with the observed paucity of real-world wagers. Kahneman and Tversky attribute these effects to an editing process that determines the reference point and the perception of lottery outcomes as gains or losses, and to systematic mispreception of probabilities. An additional reason that individuals are ambigious about lotteries, and often avoid them, is the supersititious belief that there are hidden causal forces at work, interventions that place the lottery in ambigious relationship to the rest of life. People often have strong beliefs that they are lucky, or unlucky, or that their luck has to change. We have selective memory for coincidences. You remember running into a friend at a surprising place, or a particularly good night a poker; you forget all the times you did not encounter a friend or had an unremarkable night. Chance jolts the harmony of conscious belief; relief from this dissonance is gained by imposing an order over chaos, weaving a fabric of cause and effect, out of jumbled coincidences. The mind accepts and emphasizes those coincidences which reaffirm the perceived order of the universe, ignores and forgets inconsistent data, and shrouds each offered lottery in ambiguity regarding hidden effects. Superstition can arise and persist even when people are consistently Bayesian. Start with a prior that admits the possibility of complex, hidden causal paths. The experiments that life offers, and selective memory of outcomes, allows these cognitive castles in the air to survive; see McFadden, 1974; Hastie and Dawes, 2001.

These is experimental evidence that endowment effects are attenuated when traders are experienced; see Myagkov and Plott (1997), List (2004). Thus, the observed paucity of trades in lotteries may occur primarily for novel events and inexperienced traders. These facts are consistent with a proposition that learning by observing and by doing may be effective in selecting rational market behavior rules in arenas with sufficient repetitiveness to allow these effects to operate.

VI.1.3. Hyperbolic discounting occurs when individuals systematically underweight future consequences relative to contemporaneous ones, and make choices that gratify now and leave lasting regret, in patterns that cannot be explained by maximization of consistently discounted present value of instantaneous utility. If one thinks of the current instance as a reference point in time, then this phenomena resembles those surrounding the endowment effect, with the future neglected because it is ambigious and difficult to anticipate, and lacks saliency.

VI.1.4. The remembered utility effect occurs when memory of a painful or pleasurable episode is dominated by sensation at the peak and end of the episode, rather than being determined as an integral of experienced intensities over the duration of the episode. A related phenomenon in psychology is labeled the primacy/recency effect. We remember the first and last instances of some significant experience, less well the intermediate and integrated experience.

For example, a study by Kahneman and Varey (1991) of experienced pain during colonoscopies, and recall of the episode, finds that adding pain of reduced intensity at the end of an episode improves overall recall of the experience. Kahneman, Wakker, and Sarin (1996) document in a number of experimental settings this phenomenon of duration neglect and concentration on recent experience, what one might call hyperbolic memory.

A deeper reason for the phenomena of hyperbolic discounting and remembered utility is given by the psychologist George Lowenstein (1996) -- it is difficult to recall or anticipate affective or emotional state. We may remember being in pain, and have a strong aversion to the anteceedents of a painful experience, but we cannot relive the experience itself. Consequently, we may forget affective history, and fail to adequately protect ourselves against repeating it.

Both hyperbolic discounting and duration neglect can be recast in a neoclassical model with subjective time. Whether this is leads to parsemonious, predictive models, or experiments on these effects can be designed that give results inconsistent with any intertemporal utility model, remains an open question.

VI.2. The Sociality of Choice. Man is a social animal, identified with family and kin, and with troups, tribes, ethnicities, and nationalities. This has several consequences for economic choice behavior. First, individuals may look to their social networks for information. Second, they may look to social networks for approval, and use accountability to limit choice. Third, they may out of pure self-interest engage in mutually beneficial reciprocity, simple when the acts are syncronous, involving more complex elements of reputation and trust when they are not. Pursuing comparative advantage, with division of labor and trade, is a form of reciprocity. Fourth, they may engage in genetic altruism, making choices that are in the interest of their progeny rather than themselves as individuals. Fifth, they may exhibit altruistic behavior that does not obviously serve their personal or genetic self-interest, such as incurring costs to sanction greedy behavior.

There is a large literature in economics about the sociality of consumption, from Dusenberry on relative consumption and the sensitivity of savings behavior to relative income within a society and relative insensitivity to its absolute level of income, to conspicuous consumption, fads, and bandwagon effects. However, while sociality has been recognized as important, the mechanisms of its operation have been obscure, and it has not led to a simple formalization comparable to that for conventional demand theory.

VI.2.1. One major way sociality may work is simply through transmission of information, learning by imitation rather than learning by doing. People constantly make interpersonal comparisons, judging the desirability of options from the apparent satisfaction and advice of others. While personal experience is the proximate determinant of the utility of familiar objects, and may be extrapolated to similar objects, our primary sources of information on new objects come from others, through observation, advice, and association. McFadden & Train (1996) show that in innovation games with uncertain payoffs, it may pay to wait, and learn by observing rather than learn by doing. Manski (1991) has explored the possibility that individuals faced with dynamic stochastic decision problems that pose immense computational challenges may simply look to others to infer valuation functions to be used to judge the future payoff of current acts, or to infer satisfactory policies. An objection to such copycat behavior is that it fails to take account of the individual's idiosyncratic tastes, and correcting this quickly gets the individual back into the computational difficulties that imitation was intended to circumvent. But if tastes as well as perceptions are modified socially, the relevance and value of the lessons from others increases.

VI.2.2. Economic demographer Hans Peter Kohler (2001) has investigated the effect of word-of-mouth communication from friends on choice of contraceptive. He studies Korean peasant women, who have access to relatively little public information on efficacy, costs, and side effects of new contraceptives. Choices within villages show little diversity, but there is substantial, persistent diversity across villages. This pattern not explained by income, education, or price differences.

Word of mouth communication from friends was found to be the important explanation of most women's choices. Lack of inter-village mobility explained multiple equilibria, with persistent inter-village differences. Thus, some apparent taste heterogeneity is due to the boundedly rational practice of imitation in balkanized social networks. The moral is that no measurement system that fails to account for social network effects can be complete. The prescription for measurement is that stated perceptions and preferences should be conditioned on the behavior of members in an individual's social network, and the distribution of consumption in social equilibrium should be modeled as the (often non-unique) solution to a non-cooperative game in which choices of peers matter.

VI.2.3. In addition to providing information, social networks may discipline the behavior of members through concensus on social norms, accountability for choices, and sanctions for behavior that violates norms. The individual gains from affiliation with such networks if imitation and conformity save energy, if the "expectation that one will be called upon to justify one's beiielfs, feelings, or actions, to others" improves decision-making, and if approval is itself a source of pleasure. We engage in a great deal of automatic or intuitive thinking, or one might say semi-conscious or background thinking, in daily decisions. For example, an experienced driver does not go through a conscious process of deciding to change lanes. Automatic thinking saves energy, and time. The classical idea of herd mentality is that social animals find it easier and more comfortable to adhere to a group, accept group roles, and mimic group behavior than to act independently. Accountability reinforces herd mentality in fixed groups, and promotes safety in numbers. Individual membership may be voluntary, as in the pellaton of tightly packed riders in a bicycle race, with riders tighly clustered and constrained in order to save energy in preparation for "breakaways". The lack of well-defined measures for social norms and accountability are a significant barrier to modelling their influence on utility and on social equilibria, but clearly natural or laboratory experiments in which the social environment of market behavior is manipulated can be used to test for the effect of social pressures in various contexts.

VI.2.4. Reciprocity is a simple form of social interaction, present in economic trade and explained by self-interest. Reciprocity is simple to establish when it is synchronous, as in bilateral barter. However, asychronous reciprocity requires reputation and trust. In the words of Kenneth Arrow, "Trust is an element in every commercial transaction".

Norms for fair practice, and sanctions for bad behavior, may evolve in social networks to facilitate asychronous reciprocity, and individuals may by habit or internalization conform to these norms even in novel situations where the normal cycle of approval and reputation is suspended. Consider the single-shot ultimatum game with anonymous players: Player 1 proposes a division of a prize of 100 units. If Player 2 accepts, the players get the proposed shares; otherwise, they get nothing. It is rational for Player 2 to accept any positive amount, and thus rational for Player 1 to offer the minimum positive amount. However, if the probability of acceptance a(s) by player 2 is less than one when the share s offered by player 1 is low, then player 1's optimal strategy is to maximize $a(s)\cdot(1-s)$.

Students in a cross-section of developed countries play similarly, but not rationally. Offers are usually 42 to 50 percent of the prize, and offers less than 20 percent are rejected about half the time. These results are consistent with behavioral rationality for the first player if $a(s) = \min(1,2.5\cdot\min(s,0.2)+6\cdot\max(s-0.2,0))$, but acceptance probabilities of this shape are unlikely to be supported by observations.

VI.2.5. Isolated cultures offer natural experiments for testing the impact of social norms on trust and reciprocity. Sam Bowles and a team of experimental economists and ethnographers have conducted anonymous ultimatium game experiments in 15 isolated societies. Four of these are the Lamalera, a cooperative whale-hunting culture in Indonesia; the Ache, seasonal foraging bands in Paraguay; the Hadza, hunter-gatherer bands in Tanzania; and the Machiguenga, horticultural family groups in Peru. The research finds strong cultural differences, with large mean offers among the Lamalera, who have ritualized rules for cooperation and sharing, and low mean offers among the Machiguenga, who have little experience in interaction outside the family. Within a culture, lower offers generate more rejections, but willingness to incur the cost of rejecting an offer differs substantially across cultures. The research concludes that violation of the selfishness axiom is common across cultures, but with differences that are a product of the social and economic lives of the subjects. The more integrated and market-oriented the contacts between individuals, influenced by the technologies available for subsistence, the stronger a norm for "fair play", and the more willing respondents to punish selfish behavior at a cost to themselves.

Table 3. ULTIMATUM GAME OUTCOMES

Society	Mean Offer	Rejection Rate
Lamalera (communal hunting village)	57%	NC
Ache (seasonal foraging band)	48%	0.0%
Hazda (foraging band)	40%	19.2%
Machiguenga (subsistence farming families)	26%	4.8%

VI.2.6. Genetic Altruism is the phenomenon of self-sacrifice for the good of your family or kinship group. Genetic altruism appears to explain cooperation in most species, and appears to have a convincing evolutionary basis. William Hamilton (1964), an icon of sociobiology, wrote

> "The force of evolution favors "selfish" genes, those that promote their own reproduction. Individuals do not consistently do things for the good of their group, their family, or even themselves. They consistently do things for the good of their genes."

Matt Ridley (1996), in an entertaining account of the evolution of sociality, wrote "None of your ancestors died celibate."

The principle, although not the name genetic altruism, appeared early in classical economics. Adam Smith (1853) said,

> "Every man feels [after himself, the pleasures and pains] of the members of his own family. Those who usually live in the same house with him, his parents, his children, his brothers and sisters, are naturally the objects of his warmest affections. They are naturally and ususally the persons upon whose happiness or misery his conduct must have the greatest influence."

Edgeworth (1882) noted that

> "... efforts and sacrifices ... are often incurred for the sake of one's family rather than oneself. The action of the family affections 'has always been fully reckoned with by economists', especially in relation to the distribution of the family income between its various members, the expenses of preparing children for their future career, and the accumulation of wealth to be enjoyed after the death of him by whom it has been earned."

However, despite its recognized importance, particularly in economic models of the family and of intergeneral transfers, genetic altruism not been systematically studied as a determinant of economic behavior. The operation of genetic selection could be very indirect. Thus, the acquisition of language, the exploitation of comparative advantage, the formation of successful defences against mauraders and disease, and a disposition to "fair play" that reduces interpersonal conflict, may all arise from the selective advantage to group traits that promote sociality. Then altruistic behavior, including gifts to unrelated individuals with no possibility of personal gain, might be explainable as an indirect consequence of genetic self-interest. If so, the center of the original utilitiarian concept of relentless pursuit of pleasure could still hold, with group selection leading to the real, selfish pleasure we get from altruism to family and kin. Paul Samuelson (1994) demonstrated that group selection works if the advantages of altruism are sufficient to offset a Gresham's law of individual selection, in which altruistic traits are driven out by antagonistic selfish traits.

However, experimental studies of altruistic punishment collected and carefully interpreted by Ernst Fehr (2003) suggest that evolutionary pressure for group selection is not consistent enough, and the costs of altruistic punishment in large groups are too high, to explain the pervasive and distinguishing level of altruism in large human groups. His conclusion is that human altruism is a mystery that selfish genes and selection cannot fully explain, something about our wiring that may not fit the notion of utility calibrated to experience pleasure from genetic survival. What is important for a discussion of the measurement of well-being is to understand that whatever its roots, our perceptions of the well-being of others do affect our own behavior and well-being, in ways that may be simply explained by genetic altruism and group selection.

VI.3. Sensation and Neuroeconomics. Brain science offers a new frontier for consumer measurements, through identification of reward structures and neurotransmitters in the brain, and study of the impact of choice problems on the brain in the presence of experimental treatments. Brain measurements include maps of energy consumption (fMRI and PET tomography), electrochemistry (probes, peptides, and radionucleides), and physical intervention (gene manipulation, structural manipulation in animals, and natural experiments in brain-damaged humans). In tandem with behavior intervention (manipulation of the choice environment, measurement of response), brain measurements provide information on the cognitive processing structure, perceptions, and sensations associated with choice. They fall short of Edgeworth's wistful call for a hedinometer to measure pleasure, but they provide some of its functions and some insight into the sensations that economists call utility.

The early biologists observed that as the human embryo developed, it seemed to go through stages of evolution, from a simple one-celled creature to its complex final form. That view was superficial, but it does seem to be the case that human physiology, and in particular, the structure of the brain, is consistent with a layering of added functionality over a simpler and more primitive core. The aspects of brain function that we identify with being human – language, the cognitive processes of deduction and induction, the ability to empathize and interact with others, are primarily sited in frontal lobe of the cerebrum, the outer layer of the brain whose relative size and complexity in humans differentiate us from most other species. The more basic limbic system, buried at the base of the cerebrum, is heavily involved in emotion and the reward pathways that are associated with sensations of pain and pleasure. This system includes the amygdala, sometimes termed the "switchboard of the brain", which is particularly rich in reward pathways and is active in animal behavior at a visceral level: approach and avoidance, foraging, territory, and reproduction.

The brain is a potent chemical factory, producing peptides that act as neurotransmitters and neuromodulators that bind to receptors on neurons and act to either excite or inhibit neuron firing. A few examples of natural peptides and related molecules are Dopamine, a pleasure/reward transmitter and pain supresser; Epinephrine, a stress or threat transmitter; Bradykinin, a pain transmitter; and Oxytocin, a regulator of approach-avoidance behavior, promoting "tend and befriend" rather than "fight or flight". Oxytocin is sometimes called the "trust" or "love" hormone because it plays a primary role in sexual and maternal bonding.

Most people think of economic activity as quite cerebral, learned through lengthy education and shaped by culture. If the brain is the hardware, then the utilitarian calculus might be pictured as software, an operating system that is stored and run at various, possibly-relocatable hardware sites, and is modified, Linix-like, by experience and selection. In this view, monitoring the brain can tell you something about the burden the software places on the hardware, but relatively little about what the software is doing. However, the picture that is now emerging is that economic behavior, like the brain itself, has layers. Working a spreadsheet to balance a retirement portfolio is indeed a high-level, learned skill. However, economic trading also seems to involve relatively primitive circuits in the limbic system. An evolutionary tale suggests why this may be so.

A few million years ago, the great apes had established family structures that were successful in the essentials, obtaining food, protecting themselves from predators, and reproducing. In common with other animals, they evolved a sense of personal space sufficient to provide some defense against attack, and a system of trust that allowed them to get close to family members. These spatial, interactive activities had a physiological basis – neuromodulators and reward pathways in the brain that facilitated these interactions. Some of these apes discovered that through division of labor, specialization, and trade, they could be more successful in surviving and reproducing. But trade, particularly outside the family, was iffy business. To get close enough to a stranger to trade flints for hides, one had to risk being attacked. The apes who were able to form bonds of trust over larger social groups than the family were the most successful at this. These interactions were facilitated by adapting the brain's visceral reward pathways that already functioned in family units. In addition, these apes developed analytic and communication skills, such as language and empathetic attribution of sentiment, that allowed them to operate in larger social and economic groups. These were cerebral activities, and evolution selected the apes with more cerebral capacity.

Among these apes were our ancestors. They gave us large brains, with the capacity to explore the corners of our universe, and to engage in sophisticated economic activities. They also gave us an emotional reward system that processes economic actions in much the same way that it processes personal interactions: when to trust, when to form personal or professional bonds. Therefore, you should not be surprised to learn that brain hardware, the limbic system and its reward pathways, are associated with economic decisions in a substantial and relatively direct way. In particular, the ventral tegmental dopamine reward pathway in the amygdala qualifies as the brain's primary center for recording pleasure, and appears to be active when we are involved in matters of threat, trust, sex, and economic trade. If you have ever dismayed over convincing students that economics is a sexy subject, you can now tell them that economic activity and sex share the same neurotransmitters and receptors.

Much of the information on the neurological foundations of economic behavior comes from measuring brain activity through levels of cellular energy consumption, using imaging techniques such as functional MRI and PET scans. Used in combination with experimental treatments with electrical probes, neurotransmitters, and neuromodulators, and experimental presentation of economic decision-making tasks in games or markets, one has a powerful tool for detecting the links between choice and sensations of pleasure or pain. Brain-damaged humans and animals allow imaging under conditions under which some brain pathways are blocked. This is not quite Edgeworth's hedinometer. The linkages from psysiological sensation to conscious interpretation and reasoning may be complex, and physiology may give an incomplete picture, just as computer hardware monitoring gives an incomplete picture of what software is doing. Nevertheless, it should be clear than any ability to measure directly in the brain the impact of economic choice tasks on reward pathways is potentially an immensely powerful tool for linking economic activities and consumer well-being. I will outline a scattering of results from human and animal studies that provide an intriguing picture of how sensation is directly influenced by economic tasks.

VI.3.1. How do organisms process sensations of pleasure and pain? The answer goes directly to the question of whether there is a single, absolute physiological scale of well-being, and whether the organism consciously or unconsciously acts out of self-interest to maximize this quantity. First, both behavioral observation and brain studies indicate that organisms seem to be on a hedonic treadmill, quickly habituating to homeostasis, and experiencing pleasure from gains and pain from losses relative to the reference point that homeostasis defines; see Sanfay et al (2003). People quickly grow to accept the city in which they are located, their job, their mate, and their health status. They may recognize and complain about unfavorable absolute states, but their levels of satisfaction by various measures are not nearly as differentiated as they would have to be if their sensation of well-being was experienced on an absolute scale. For example, Inglehart (2004) plots country means of self-rated happiness against income. There are obviously major measurement issues associated with such a study, beginning with the difficulty of rendering comparable semanic scales in different languages, but the study's conclusion that money does not buy proportionate happiness is consistent with both the hedonic treadmill and with the proposition that effects other than market goods enter utility.

Second, the picture that emerges from brain studies is that the ventral tegmental dopamine pathways in the limbic/amygdala region play a central role in experiencing pleasure, and also mitigate, with a lag, the sensation of pain; see Becerra et al (1999). Adaptation to homeostasis and differentiation between the pleasure and pain circuits coincide with the powerful endowment and loss aversion effects, and sensitivity to framing and context, found in behavioral studies, and suggest that these phenomena are tied fundamentally to brain structure. This is good news and bad news for utilitarians: the limbic system reward pathways seem to correspond to a utility pump, but specialized brain circuitry processes experience in ways that are not necessarily consistent with relentless maximization of hedonic experience.

VI.3.2. Ivan Diamond, a neurologist at the University of California, San Francisco who studies ethanol addiction, finds that this and other substance addictions work primarily by stimulating ventral tegmental dopamine pathways, although addiction once established has other physiological effects. His laboratory has engineered neuromodulators that block the D2 dopamine receptors in this reward pathway; these will eventually lead to effective therapies for ethanol addiction. I cite this work because it shows, indirectly, the close relationship between these reward pathways and economic behavior. Diamond and his colleagues operate an experimental bar in which the spending rate is observed for alcoholics treated with various blockers; this rate is a very good predictor for the efficacy of the blocker.

VI.3.3. David Laibson and colleagues have investigated the processing of intertemporal choices. They find that choices involving delayed gratification are primarily processed in the frontal system, and those involving immediate gratification are primarily processed in the limbic system. Thus, eating a candy bar now activates the limbic pleasure center of the brain, deciding to delay gratification requires thought. Unless these systems work together in harmony, time-inconsistent behavior results.

VI.3.4. One of the interesting bits of contemporary biology has been the establishment for a variety of species of simple direct links from particular genes to the production of and receptors for specific neurotransmitters, and from this to specific social behavior. Specific genes control the production and efficacy of the peptide oxytocin in the brain, and this in turn appears to control sexual attraction and behavior in everything from fruit flys to voles to humans. One may ask why these biological findings have any relevance to our discipline. The answer is that sexual reproduction requires close interaction between organisms, and to achieve such interaction requires a suspension of distrust. The oxytocin peptide appears to have the genetic role of promoting trust and bonding between the sexes. This is relevant to economics because trade, and more generally interactions in economic games, also involve elements of trust. Thus, in its fundamentals, the primitives of economic behavior and sexual behavior may be the same neurotransmitters and reward pathways in the brain.

In a study that strikes at the heart of consumer sovereignty, Ernst Fehr and associates (2005) administer oxytocin or a placebo to subjects, and then ask them to play the trust game. In this game, an investor is given 100 MU, and has the option of placing Y MU with an anonmyous trustee, who then receives triple this amount, and then chooses to send Z MU back to the investor. The trustee's game is a dictator game in which norms of fairness and reputation matter, but the rational response in a single-shot anomyous game is to return nothing. By backward induction, the investor should send nothing. In fact, both the investment and the return are usually positive, with the level of investment higher in subjects who are administered the "trust" peptide oxytocin. However, oxytocin has no effect on play of the dictator subgame, where trust does not matter. The conclusion is that economic perceptions and decisions are sensitive to brain chemistry, and succeptible to chemical manipulation.

VII. The Future

What are the challenges and measurement opportunities in the future of research on consumers' economic behavior and well-being? Even from a neoclassical perspective, the role of experience and memory on perceptions and preferences, non-linear budget sets, household production, and hedonics complicate the identification of utility and well-being, but also offer new measurement opportunities, through the added information contained in choice in nonlinear budget sets, and through natural and designed experiments that alter household production possibilities. New results challenge the standard assumption of maximization of individualistic utility, indicating that social networks as information sources, reciprocity, and altruism enter human behavior and cannot be ignored. There are new opportunities to study the sociality of choice through experiments that manipulate the information provided through social networks, the effect of approval, and, through comparative study of isolated societies, the role of cultural and social norms. Finally, the striking ties between brain physiology and behavior in economic decisions, and new methods for measuring and manipulating brain activity, offers the possibility of powerful experiments in which economic, social, and physiological treatments are employed to identify and isolate the causal foundations of economic choice behavior. In particular, the "warm glow" attached to bonding and trust in family and social groups seems to be tied to reward pathways in the limbic system that we experience as pleasure. It may be this chemistry that has worked with selection to promote social cognition and empathy in humans, giving them the mental capacity to function as social animals in large groups, and to organize complex and productive economic systems.

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