# Back to the Ordinalist Revolution: Behavioral Economic Concerns in Early Modern Consumer Choice Theory[1]

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**Abstract:** The paper argues that theoretical work on consumer choice theory during the early twentieth century addressed some of the same issues discussed in recent behavioral economics. This is not generally recognized because the discussion was tied up with the integrability question, the theoretical framework did not involve risky choice or expected utility theory, and the relevant evidence was introspective rather than experimental. The paper makes the case for the similarity and discusses why it is important.

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## 0. Introduction

Recent developments in fields like behavioral economics, experimental economics, and neuroeconomics have begun to revive the long-dormant relationship between economics and psychology. They have also started to have an impact on the way that economists in general (not just those working in these particular subfields) think about and model individual behavior. It is too early to know whether these new approaches will, or will not, ultimately bring about major changes in textbook microeconomics, but regardless of the eventual outcome it is very important to understand the general relationship between the arguments in this recent literature and the standard neoclassical theory of consumer behavior.

Interest in this recent psychologically-informed economics has inspired a number of retrospectives that look for, and find, behavioral ideas in much earlier (late nineteenth century or earlier) economic thought. For example, various behavioral ideas have been found in the work of Adam Smith (Ashrof, Camerer, and Loewenstein 2005), David Hume (Sugden 2006), Jeremy Bentham (Kahneman, Wakker, and Savin 1997), William Stanley Jevons and Francis Edgeworth (Bruni and Sugden 2007), and Alfred Marshall (Bowles and Gintis 2000). There is also a more extensive literature that finds precursors from the middle of the twentieth century such as James Duesenberry, Ward Edwards, George Katona, Brian Loasby, James March, Tibor Scitovsky, Herbert Simon and others (e.g. Camerer and Loewenstein 2004, Earl 1990, Heukelom 2009, Rabin 1998, and Sent 2004). Although this retrospective research has uncovered a rich history of behaviorist and psychologically-inspired ideas in earlier economic theorizing, the one group of economists that is never listed among the precursors to this recent literature are those most responsible for the ordinalist revolution during the 1930s: R. D. G. Allen, John R. Hicks, Paul Samuelson, Eugene Slutsky, Vilfredo Pareto and others. In fact, the ordinalist revolution – the "Paretian turn" (Bruni and Sugden 2007) – is generally considered to be the time when economic theory took the wrong turn that led it away from various psychologically-informed views of individual behavior and toward the more abstract, and for many behavioral economists more sterile, theory that became dominant during the late 1940s and 1950s. The ordinalist revolution initiated the "escape from psychology" (Giocoli 2003) that eventually led to ordinal utility theory and revealed preference theory becoming standard for the analysis of risk-free consumer choice (demand theory)

and von Neumann-Morgenstern expected utility theory becoming the standard framework for the analysis of risky choice.

This paper will argue, contrary to the interpretation in this recent retrospective literature, that theoretical work on consumer choice theory during the early years of the ordinalist revolution in fact addressed some of the same issues discussed in contemporary behavioral economics:[2] particularly endowment effects, reference dependence, irreversibility of preferences, and related anomalies. The main reasons these similarities have not been recognized within the existing literature are: 1) during this period the discussion of these issues was bound up with the so-called integrability problem, 2) the modeling framework of the 1930s did not involve risky choice or expected utility theory, and 3) the source of the insights about economic behavior were common sense, introspection, and thought experiments rather than the laboratory experiments that are common today. The goal of the paper is to demonstrate that even though the early ordinalists focused on the integrability problem in (riskless) consumer choice theory and were relying on very different (and less acceptable) sources of empirical evidence, many were in fact concerned with the same issues, and raised similar concerns about rational choice theory, as contemporary economists.

The point of this alternative reconstruction of the history of consumer choice theory is not to identify precursors and/or assign proper credit, but rather to clarify the historical record and to help us better understand the long-standing and quite complex relationship between consumer choice theory and the endowment effects, path-dependencies, irreversibilities, and other anomalies discussed in recent behavioral economics. The conclusion of the paper discusses why it is important to get the temporal sequence correct and the implications the alternative story might have for certain economists.

## 1. Endowment Effects, Reference Dependence, and the Irreversibility of Preferences

[2] I will use the generic term "behavioral economics" to encompass the recent research in behavioral economics, experimental economics, neuroeconomics, experimental psychology and related fields that uses experimental (and in some cases field) data to challenge the predictive and/or explanatory power of traditional rational choice theory in either its risky (expected utility) or risk-free (consumer choice) form. In a sense I am using the term "behavioral economics" in the generic way that Gul and Pesendorfer (2008) use the term "neuroeconomics." The difference is that I will only be referring to the positive aspects of behavioral economics – theories that predict and/or explain the behavior of individual economic agents – and exclude the more normatively-inclined psychologically-inspired views such as Daniel Kahneman's effort to revive experienced utility as the basis for welfare economics (Kahneman and Thaler 2006, Kahneman, Wakker and Sarin 1997).

Although there has been, and continues to be, much debate about the history of the relationship between economics and psychology and what literature should or should not count as a precursor to contemporary behavioral economics,[3] for many the "defining moment for behavioural economics" (Bruni and Sugden, 2007, p. 161) remains the publication of Daniel Kahneman and Amos Tversky's paper on prospect theory in 1979 (Kahneman and Tversky 1979).

Prospect theory was developed to provide an analytical framework to accommodate the fact that the way in which individuals value changes in their situation depends on the agent's point of reference. The value or utility associated with a particular quantity of a good or level of income ′, depends not simply on ′, but also on other features of the agent's situation at the time: the reference point . Thus the standard, reference-independent utility function (x , should be replaced by a reference-dependent utility function of the form (x . Of course rational choice theory – in either its risky or risk-free instantiation – has not generally taken account of such reference-dependence, and for many sympathetic to behavioral economics this is a serious problem with the standard theory. As Daniel Kahneman explained in his Nobel lecture:

> The proposition that decision makers evaluate outcomes by the utility of final asset positions has been retained in economic analysis for almost 300 years. This is rather remarkable, because the idea is easily shown to be wrong; I call it Bernoulli's error. (Kahneman, 2003, p. 1455)

The particular version of the problem of reference dependence addressed by prospect theory was loss aversion: the fact that people often value the loss associated with a reduction in income much greater than the gain associated with an increase in income by the same amount. This means that the utility or value function will have a kink at the reference point, being concave for increases in income and convex for decreases in income. For a fixed reference point one can thus draw what looks like a traditional, if oddly shaped, utility/value function, but the negative implications for choice theory go beyond merely changing the shape of the utility function. Every time the reference point changes there will be an entirely new function based on the new reference point, and as a result there will be an infinite number of such "functions." Given that the relevant preferences are reconstituted for each reference point, it really means that the traditional stable functional relationship between utility and bundles of commodities (or income, or prospects, or outcomes) simply does not exist.

[3] See for example Bruni and Sugden (2007), Camerer and Loewenstein (2004), DellaVigna (2009), Earl (1990, 2005), Hands (2010), Lewin (1996), Moscati (2007b), Rabin (1998, 2002, 2004), and Sent (2004).

Although Kahneman and Tversky originally presented prospect theory in the context of risky choice and von Neumann-Morgenstern expected utility theory, the basic argument about reference dependence applies just as well to the riskless choice environment of standard consumer choice theory. Again from Kahneman's Nobel lecture:

> Bernoulli's error – the idea that the carriers of utility are final states – is not restricted to decision-making under risk … The error of reference-independence is built into the standard representation of indifference maps. It is puzzling to a psychologist that these maps do not include a representation of the decision maker's current holdings of various goods – the counterpart of the reference point in prospect theory. The parameter is not included, of course, because consumer theory assumes that it does not matter. (Kahneman, 2003, p. 1457)

In the (riskless) consumer choice context the problem of reference dependence is often called the endowment effect (Knetsch 1989, Thaler 1980); things in the endowment are valued more highly than those not in the endowment thus creating an asymmetric valuation with respect to the same increase or decrease in the amount of a commodity (or income). As with the value function in prospect theory, the endowment effect creates a kink in the indifference curve at the particular endowment point (Knetsch 1992, Tversky and Kahneman 1991). Given a particular endowment point, there exists a kinked indifference curve, but since each new endowment generates a new indifference curve, the result is again that the traditional (reference-independent) indifference curves and the underlying utility function simply do not exist. If one starts from the bundle $y_0$ and the associated utility level $u(x_0)$ and moves to the bundle $y_1$ with $x_1 > x_0$ then $u(x_1) > u(x_0)$ as in standard theory. But if the consumer then moves back to the initial endowment $y_0$ the associated utility level will be lower than $u(x_0)$ since the utility lost by giving up $x_1 - x_0$ will be greater than that originally gained by receiving $x_1 - x_0$. Under such conditions there simply is no stable functional relationship between various bundles and the associated level of utility; in other words the utility function isn't – isn't a function that is – it depends on the reference point or endowment and not just the values of the independent variables (commodity bundles or outcomes). In this way the "endowment effect represents an embarrassment for the theory of value, and for the more general assumption that tastes are stable" (Kahneman and Varey, 1991, p. 151).

Of course there is much more to behavioral economics than simply reference-

dependence, endowment effects, and the non-reversibility of indifference curves. There is also a vast and growing literature on a number of related concepts such as mental accounting, preference reversals, constructed preferences and the availability bias. Even though the concerns of the behavioral literature are quite wide-ranging, the implications for standard utility theory seem to be consistently negative.

> All of the above findings suggest that preferences are not the predefined sets of indifference curves represented in microeconomics textbooks. They are often ill-defined, highly malleable, and dependent on the context in which they are elicited. (Camerer and Loewenstein, 2004, p. 14)

With brief review of the anomalies of behavioral economics, it is time to turn to (seemingly quite different) problem of Pareto and integrability.

## 2. The Integrability Problem in Pareto

The authors of contemporary microeconomics textbooks often provide little or no discussion of the integrability problem in demand theory, but those who still mention it define integrability as the problem of finding restrictions on consumer demand functions that are sufficient to guarantee that the function could have been generated by an individual maximizing a well-behaved ordinal utility function subject to the standard linear budget constraint. For example, after discussing the standard implications of consumer choice theory – Walras' Law, the continuity, and zero degree homogeneity of demand functions, and the negative semidefiniteness of the Slutsky substitution matrix – Mas-Colell, Whinston and Green ask the following (reverse) question: "If we observe a demand function $x(p,w)$ that has these properties, can we find preferences that rationalize $x(p,w)$?" (1995, p. 75). The answer is yes, if the Slutsky substitution matrix is symmetric (S). If the Slutsky substitution matrix is symmetric and satisfies the other standard assumptions on demand functions, then it can be rationalized in the sense that it could have been generated by the rational maximizing behavior of a neoclassical consumer.[4] This interpretation of the integrability problem can be traced back to Antonelli (1886); the technical results were worked out (with increasing mathematical sophistication) in the series of

[4] Technically there is a difference between integrability and full rationalizability of demand functions. Given certain smoothness conditions, Slutsky symmetry implies integrability (essentially the existence of a utility function) but an additional restriction on demand functions – the negative semi-definiteness of the Slutsky matrix – is required for the function to have properties that guarantee full rationalization: that the demand function could have been generated by a budget-constrained utility maximizing agent. Hurwicz (1971, p. 177) introduced the useful distinction between mathematical integrability for the former and economic integrability for the latter.

papers Samuelson (1950), Hurwicz and Uzawa (1971), Hurwicz and Richter (1979) and others (see the surveys Chipman 1982 and Hurwicz 1971), and by the middle of the twentieth century this rationalizing definition of integrability had become standard in consumer choice theory. By mid-twentieth century it was no longer a definition of the integrability problem, but was (and continues to be) the definition of the integrability problem.

But rationalizing consumer demand functions was not what the integrability problem was primarily about in the literature of the early twentieth century. The locus classicus for the discussion of integrability during the period was Pareto's reply to Vito Volterra's critical review of the first edition of Pareto's Manual of Political Economy and the associated appendix Pareto added to the 1909 French edition of the Manual (Pareto 1906, 1971; Volterra 1906). In order to avoid "any recourse to psychological concepts such as utility or pleasure" (Bruni and Sugden, 2007, p. 155) Pareto took the indifference curve as the observational basis for his theory of consumer choice and exchange.[5] In the case of only two goods ´ and ², the differential form representing the indifference curve (or indifference line) is given by

. (1)

In his reply to Volterra, Pareto argued that an equation such as (1) could be "arrived at directly by experimentation" (1906, p. 372) and he repeated the claim that it "could be obtained directly from observation" (1971, p. 393) a few years later in the appendix to the Manual. Such differential equations thus constituted the empirical basis for Pareto's theory of consumer choice.

If the functions in (1) satisfy the symmetry condition,

, (2)

then (1) is an exact differential (has an integrating factor of 1) and can be integrated to obtain the unique underlying (potential) function, in this case the

[5] Actually there is some ambiguity about this in the Manual. There are passages where Pareto suggests that entire indifference curves (surfaces) over the entire choice space are potentially observable and passages where it is only the (local) tangents (now marginal rate of substitution) to the indifference surfaces at a finite number of points. Since this latter interpretation is the one taken up by Hicks and Allen (1934) and others during the 1930s and the one most relevant to the integrability problem, it will be the focus of the discussion that follows. See Montesano (2006).

utility index, [illegible].[6] Even if (1) is not exact, there may still exist an integrating factor, a function [illegible] such that the differential form

[illegible]

will be exact. In this case the differential form is integrable and the condition required to guarantee such integrability is called the integrability condition. Integrability guarantees that a solution [illegible] exists, while exactness (having an integrating factor of 1) guarantees, in addition, that the solution is unique and can be found by direct integration.

Volterra's critical point was that while there is no integrability problem in two dimensions – there always exists an integrating factor (although it need not be 1) – in the case of three or more goods an integrating factor need not exist (Volterra, 1906, p. 368). In other words, in consumer choice problems involving three or more goods the utility index and the corresponding indifference surfaces may not exist even if the multi-dimensional analog of equation (1) is well-behaved and given by observation.[7] As Samuelson put it in 1950:

> Vito Volterra in his 1906 review of the Manuale preformed one of the few services professional mathematicians have ever rendered to economic theory: he pointed out that when Pareto treats the case of three or more goods, his discussion of indifference directions is marred by the failure to recognize explicitly the integrability problem. (Samuelson, 1950, p. 355)

Mathematically, the integrability issue is tied up with the question of whether the value of the associated line integral is independent of path. If the equation is exact then the line integral has the same value along any path through the domain (in this case the choice space). In his reply to Volterra and the appendix to the Manual Pareto consistently identified the order of integration with the order of consumption (the order in which the consumer actually consumed the goods in the optimal bundle) and thus identified the question of whether the relevant differential form was integrable with the question of whether the value of the utility index was independent of the order of consumption of the goods. This somewhat dynamic characterization of consumer behavior is generally

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[6] In the appendix to the Manual Pareto was careful to note the ordinal nature of the relevant functions, noting the equivalence of [illegible] and the transformation [illegible] (Pareto, 1971, p. 392).

[7] Bruni and Sugden note that Pareto's first mention of the integrability problem occurred in a letter to Pantaleoni in 1891 (2007, p. 159) and Stigler notes that Pareto recognized the integrability problem for the case of three or more goods as early as 1892, but then "forgot" when writing the Manual (Stigler, 1965, pp. 121-2, notes 156 and 157).

consistent with Pareto's characterization of the consumer as moving about in the choice space along consumption paths and encountering obstacles – particularly in the non-mathematical description of the consumer in chapter three of the Manual (Pareto, 1971, pp. 120-2).

Pareto's identification of the order of integration with the order of consumption has been a frequent target for criticism by later economists. Even those who are generally quite respectful of Pareto's contribution to economic theory often have rather harsh things to say about his treatment of integrability. Samuelson's remarks are a good case in point.

> I don't know whether he drinks his beer before his whisky or his whisky before his beer; I don't know whether it even makes sense to say that he enjoys his shelter before rather than after he enjoys his food. Note too that in going from A to B the guinea-pig does not eat his way along the path, and in going from B to A regurgitate along the same path. (Samuelson, 1950, p. 361)

Of course in many ways this criticism is entirely correct. First of all, the order of integration is a matter for the economic analyst and the order of consumption is a matter for the consumer, and it is simply a category mistake to believe there is any necessary relationship between the two. Second, Pareto often confused the "integrability" of a differential form with it being "exact" (having an integrating factor of 1) and this further confused the relationship between the order of integration (or consumption) and integrability (Chipman, 1976, pp. 80-86; Montesano, 2006, note pp. 83-84). There is no integrability problem in two dimensions – an integrating factor always exists – but a differential form need not be exact even in two dimensions. Thus there is potentially an "order" problem even in two dimensions even though there is no integrability problem; in three or higher dimensions there may be both problems, but they are separate. As John Chipman argued, this "curious gap in his otherwise excellent grasp of mathematics seems to be what is mainly responsible for the unsatisfactory nature of his treatment of the integrability problem" (Chipman, 1976, p. 81). Add to this the point made by Samuelson and others over the years that the order of consumption by the economic agent has nothing to do with the order of integration by the analyst and it becomes clear why Pareto's writings on the integrability problem have "a somewhat dubious reputation in the literature" (Chipman, 1971, p. 324).[8]

[8] It is important to note that Pareto often restricted his argument to the special case of additively separable utility functions – a common restriction in the literature of his day – and in this special case much stronger results are available. The discussion here, of Pareto and throughout the paper, concerns the general, not the additively separable, case. See Moscati (2007a) for a discussion of the additively separable assumption in the history of demand theory.

Despite the fact the critics are correct – the path of integration need not have any relationship to the order of consumption and integrability is not the same as the exactness of the differential form of the indifference surface – Pareto was in fact making an important point about the relationship between rational choice theory (including his own) and the actual behavior of economic agents, and it is a point that has not been sufficiently appreciated in the existing literature on Pareto and integrability. The point is that the consumption bundle $y, \ddot{}^{0}$ is not automatically associated with a particular level of utility $(\bar{x}_0$ because the order of consumption matters. If $'$ is soup and $'$ is dessert, the bundle $y, \ddot{}^{0}$ will give the individual a different level of utility if the soup is consumed before the dessert, than if the dessert is consumed before the soup. Although, in the interest of tractability, Pareto assumed this problem away for much of his analysis, he clearly recognized it as a problem: a problem associated with the descriptive accuracy of rational choice theory. As he says in his discussion of "tastes" in chapter four of the Manual:

> Obviously, one does not experience the same enjoyment if he eats the soup at the beginning of a meal and the dessert at the end, or begins with the dessert and ends with the soup. Hence we ought to take account of the order, but that would increase the difficulties of the theory considerably, and it is not amiss to avoid that problem. (Pareto, 1971, p. 182)

Notice that this issue – the question of the reference-dependency of preferences – is a significant issue whether Pareto properly hooked it up to the question of integrability or not. For example as Chipman notes:

> "Granted Pareto's confusion of concepts, … the question of defining a utility function over consumption paths is nevertheless of some interest in itself. Pareto's article fares somewhat better if judged in terms of its contribution to this subject, rather than as a contribution to the integrability problem; … (Chipman, 1971, p. 325)

Translating Pareto's concern into the language of contemporary experimental psychology and behavioral economics, we have that the value of (1,1) – one unit of soup and one unit of dessert – does not exhibit reference invariance over outcomes; $(\bar{1}$ depends on the particular endowment and is therefore not reference independent as in standard consumer choice theory. $(\bar{1}$ is different whether the path to (1,1) goes through (1,0) – i.e. soup first – or through (0,1) – i.e. dessert first – meaning that utility levels do not depend solely on final consumption bundles, but also the relevant endowment/reference point and/or

the path by which the final consumption bundle was reached. Such reference, or anchoring effects, are a subset of a much broader class of anomalies to traditional choice theory called contextual effects where preferences are constituted (rather than revealed) by the choice context and the process of decision making itself (Lichtenstein and Slovic 2006). This concern may not have anything to do with the order of integration, but it is consistent with contemporary concerns about the reference invariance (and thus the existence) of stable individual preferences.

Later in his discussion of integrability Pareto discusses three cases: the case where the order of consumption does not matter ("is a matter of indifference"), the case where different orders of consumption are possible and the agent chooses the one that is most preferred, and finally the general case where different orders of consumption matter to the level of satisfaction ("is not a matter of indifference") and must all be accounted for (ibid., p. 396). In his reply to Volterra, he considered these last two cases – where "the path is not a matter of indifference" – to be "found in practice" (Pareto, 1906, p. 371). In these cases he argues one can define a path-dependent indifference relation

$$\overset{\gamma}{=} \quad , \tag{3}$$

where ' is a particular consumption path. In this case, by "varying ' we have the various paths of this type, and by following them the differential equation … of the indifference lines may be experimentally determined" (ibid., p. 383).[9] The expression in (3) is essentially a reference-dependent indifference curve. Conceptually this quite similar to the reference-dependent indifference curves and reference-dependent preferences discussed in contemporary theory – and motivated by very similar concerns – as shown by the following two quotations:

> … the important notion of a stable preference order must be abandoned in favor of a preference order that depends on the current reference level. A revised version of preference theory would assign a special role to the status quo, giving up some standard assumptions of stability, symmetry and reversibility which the data have shown to be false. But the task is manageable. The generalization of preference theory to indifference curves that are indexed to reference level is straightforward. (Kahneman, Knetsch and Thaler, 1991, p. 205).

[9] Pareto's use of "path" and order can be rather confusing. The "path" through the choice space is not obviously the same as the "order" of consumption of the goods once the terminus of the path is reached. Although the two are in general different, Pareto often gives examples where order and path end up being the same thing (see Hands 2006, pp. 161-62 for a more detailed discussion).

> … we use the more general concept of a preference structure, defined as a function from $^{n}$ to the set of all preference relations; to each reference point r in $^{n}$, a preference structure assigns a reference-dependent preference relation . The relation describes the individual's preferences over consumption bundles when his reference pint is r (or as we shall sometimes say, his preferences are viewed from r). A preference structure is reference-independent if is identical with for all r, s. This special case corresponds with the treatment of preferences in Hicksian consumer choice theory. (Munro and Sugden, 2003, p. 411)

In this way we can see Pareto's concern over the order of consumption – something he considered to be "found in practice" – as a recognition that, at least ideally, consumer choice theory should be able to accommodate the fact that reference and endowment matters to the level of satisfaction one obtains from a particular commodity bundle and not just the quantities of the goods in the bundle (or in Kahneman's terms the "final states"). In addition to the recognition of a particular kind of reference-dependence Pareto also recognized that integrability determines the existence of an underlying utility function, and since integrability could not generally be guaranteed (at least in dimensions of three or higher), there was a serious question about whether the empirical basis of consumer choice theory – given by (1) – was sufficient to warrant the epistemic leap of faith required for the assumption of stable preferences and a well-behaved ordinal utility function.

This is not to suggest of course that Pareto had an adequate solution to any of these problems, and it also must be admitted that he simply assumed them away for much of his analysis. Nevertheless he did recognize that there were potentially serious problems associated with the assumption of fixed reference-independent preferences (and the associated utility function). There were empirical problems (the order of consumption in fact mattered and choice is reference-dependent) and methodological problems (could the empirical basis of choice theory support such an assumption) and therefore it hardly seems fair to call the move away from such issues a Paretian turn. There was clearly a turn away from such issues during the late 1940s and 1950s, but this move really amounted to turning a blind eye to many of the concerns that Pareto had raised.[10]

[10] Bruni and Sugden discuss Pareto's analysis of the integrability problem (2007, pp. 159-60; also see Bruni 2002, pp. 24-27) and what they say is correct. Where I disagree is with the claim that the "significance of the integrability problem for Pareto's whole project seems to have been missed by the theorists who took up his approach in the 1930s" (p. 160).

3. The Broad Integrability Problem in Early Twentieth Century Consumer Choice Theory

Pareto opened the door to an extensive and wide-ranging discussion of integrability and integrability-related issues during the 1930s. In many cases the economists writing about integrability were concerned with the same general class of reference-dependence and endowment effect issues that are emphasized by contemporary behavioral economists. In other cases their focus was more on the methodological question of whether it was appropriate to go from the finite, local, and potentially observable choices of the individual consumer to the global assumption that the consumer had complete well-ordered preferences over the entire choice space. In either case the integrability question was associated with the appropriateness of assuming the existence of stable well-ordered preferences as the basis for a theory of choice behavior, and that question has again returned to contemporary economic theory.

One consistent critic of the integrability assumption and the associated utility function was Allen. He was very insistent about the observational basis for consumer choice theory – it was the observed actions of consumers and not economic theorists' speculations about the agent's desires or preferences. As he put it:

> Economic actions must be considered objectively, with reference to the observable results and not to the motives which give rise to the actions. Individual economic actions, as manifested in the process of exchange and production of economic goods, form the subject-matter of pure economic theory. (Allen, 1932, p. 199)

Economic action – the observed changes in the consumer's holdings of the various goods – could be observed as a movement within the choice space.

> An individual economic action can be expressed quantitatively as a change from one combination, in which the individual possesses amounts [illegible] of the [illegible] goods, to another combination in which the individual possesses amounts [illegible] of the goods. … The result is an economic action, in fact, may be that the amount possessed of any one good has increased, decreased, or remained constant. The expression of an economic action corresponds to a "movement" from the point [illegible] to the point [illegible]. (ibid., p. 200)

One can, following the mathematical practice in physics, translate the finite differences into infinitesimal differentials; if one selects from among the various differential movements those where the consumer is indifferent (ibid., p. 203) one ends up with an expression like Pareto's differential form (1). Again, if this expression is integrable, then there exists a complete set of indifference surfaces (and associated ordinal utility function) and one can move smoothly from the local observable movements to the underlying preferences that consistently order the entire choice space. Of course, as discussed above, in three or more dimensions such integrability is not automatic and requires additional mathematical restrictions. Allen clearly stated all this in 1932.

> The equation … expresses the relation between the components of an infinitesimal movement, [illegible], about which the individual is indifferent. The equation need not be integrable, so that it is impossible, in general, to pass from infinitesimal "indifferent" movements at a particular point to the indifference loci in bulk. The indifference loci can only be given, in general, in infinitesimal portions by means of the differential equation … If the differential equation is to be integrable, it is necessary to make an additional assumption to this effect. (ibid., p. 222)

In non-mathematical terms it "means, in fact, that the individual can judge his relative preferences for widely separated combinations of goods, and this, in turn, means that the order in which the individual acquires the goods concerned is immaterial to him" (ibid., p. 223). But as Allen makes clear in a footnote to this sentence: "This is obviously not true in general, and illustrates the severity of the assumption of integrability" (ibid., n. 61).

For Allen the great contribution of his theory of consumer choice was precisely that it subsumed both the integrable and the non-integrable cases. He argued that his general theory only required the (observationally reasonable) assumption that the consumer "can make a choice between very small changes (in the limit, infinitesimal changes) from any particular combination" and it does not require "that he can judge his relative preferences for widely separated combinations" (ibid., p. 297). For his theory there is also "no need to assume that a combination has a definite total utility for an individual" (ibid.). In the integrable case more can be said, but integrability is a special and more restrictive case, and it is not, in general, "essential to the theory of exchange equilibrium" (ibid.).

Allen's argument that it is important to develop a non-integrable theory of demand – demand theory without the traditional fixed preferences and/or utility function – and that he had successfully done so was not restricted to his early work on consumer choice theory. This is also how he understood the

important contribution of his collaboration with Hicks (Hicks and Allen 1934),[11] and in particular, how their theory was preferable to Slutsky's (1915). As he explains:

> Our theory was constructed so as to be independent of the existence of an index of utility and it was only in the special case, the so-called "integrability case," that such an index was taken … Slutsky, on the other hand, assumes the special integrability case from the outset and his results are, therefore, unnecessarily limited. (Allen, 1936, p. 127)

Allen retained his general stance against integrability and in favor of a more general approach to choice theory throughout his career. For example, in the 1950 printing of his 1938 mathematical economics text he says:

> In general, therefore, we cannot integrate the set of indifference planes into a complete set of indifference surfaces, and we cannot assume that any utility function exists. The assumption of a scale of preferences for small changes of purchases does <u>not</u> imply that a complete scale of preferences exists. The consumer can discriminate between small changes from his established purchases but need not be able to discriminate between widely different sets of purchases. (Allen, 1950, pp. 440-41)

Of course the skeptical reader might note that even though Allen wanted consumer choice theory to be free of the integrability assumption and the associated reference independent utility function, this does not mean that he was concerned with the same problems that concern contemporary behavioral economists. In a sense of course that is right. If one defines the issue as trying to reconcile the reference-dependency repeatedly observed in laboratory experiments with the behavior implied by expected utility theory, then of course this is not Allen's problem. He had no laboratory experiments and no probabilities were involved. On the other hand, if one characterizes Allen's problem as trying to explain choice behavior in a way that was consistent with the best available facts of experience, and realizing that the assumption that the consumer has reference-independent preferences defined over the entire choice space was difficult to reconcile with those facts (and thus should not be part of the general theory), then yes, Allen is entirely consistent with contemporary concerns. He wanted choice theory to be free of the assumption that the consumer has a traditional utility function and that is also the emphasis of much of the recent research in behavioral economics. Allowing for non-integrability

[11] See Chipman and Lenfant (2002), Fernandez-Grela (2006), Hands (2006) and Samuelson (1950) for a discussion of the differences between Hicks and Allen on this issue.

means allowing for phenomena such as endowment effects and reference-dependency which the integrable case excludes.

Allen is but one example of many economists who attempted to develop a non-integrable theory of demand and consumer choice during the 1930s and 1940s. As Donald Katzner explains:

> An alternative approach suggested by Evans (1930) and later taken up by Allen (1932) and Georgescu-Roegen (1936) was to build a theory of demand which did not rely on integrability conditions. Hence a utility function might not exist and so consumer decisions could not be based on its maximization. In place of utility their analysis focused on properties of nonintegrable marginal rates of substitution and "directions" of preference and antipreference. (Katzner, 1970, p. 10)

Many of these alternative, nonintegrable, theories of choice and demand were directly concerned with issues like reference dependence and endowment effects. For example, Nicholas Georgescu-Roegen's theory (1936, 1950, 1958) was based on the human "psychological threshold" of perception that allowed individuals to assign valuations to bundles relatively close to their current endowment, but not for those much farther away. He developed his own theory of "directed choice" to accommodate this psychological fact.[12] There were also elements of reference-dependence in Ragnar Frisch's 1926 paper on the measurement of marginal utility, W. E. Armstrong's "just perceptible difference" model (Armstrong 1939, Green 1958), and Oskar Morgenstern's "reconstituted" theory of demand (1948). Griffith Evans (1930) was extremely critical of utility theory, arguing that while it is reasonable to talk about a value function for small changes in consumption, the integrability problem means that it "cannot extend it beyond a merely local field unless we are willing to make some transcendental hypothesis about the existence of such a function" (Evans, 1930, p. 122). Harro Bernardelli (1938) considered a version of path-dependent utility, and Frank Knight consistently argued that assuming tastes were unchanged by the act of choice was serious error in economic theory (see Emmett 2006).

It should also be noted that even though by the late 1940s Samuelson did not consider integrability a serious problem (Samuelson 1950) – and in fact was one of those most responsible for translating integrability into the mathematical problem of rationalizing demand functions – his own consumer choice theory of 1938 (what later came to be called revealed preference theory) was in fact a non-integrable theory of consumer behavior. He was concerned with "dropping off the last vestiges of the utility analysis" (Samuelson, 1938, p. 62) and the only one of the standard implications of demand theory that his new theory did not satisfy

[12] Georgescu-Roegen's theory is discussed in detail in Hands (2006, pp. 164-67).

was the symmetry of the Slutsky matrix (S), which is precisely the integrability condition. In 1938 he did not believe that (S) was "subject to refutation under ideal observational conditions" (ibid., p. 68) and since it implied integrability and thus the existence of an underlying utility function, he could not "see that it is really an important problem, particularly if we are willing to dispense with the utility concept and its vestigial remnants" (ibid.). Samuelson's original 1938 theory was behaviorist, and while behavioral economics is not strictly behaviorist, the methodological similarities are much closer than either is to the standard – what many behavioral economists call "normative" – theory of the utility-maximizing economic agent. Although Samuelson eventually played a key role in turning the profession's attention away from the 1930s debates over integrability and reference dependency – thus stabilizing utility-based theory – in 1938 he offered a non-integrable, and thus utility function-free, theory of consumer choice.

In addition to various economic theorists trying to develop alternative, non-integrable, and potentially reference-dependent theories of demand, there was also a widespread belief that the problems of integrability and the order of consumption were significant even among those who were not actively involved in the development of non-integrable theory. For instance, even though Henry Schultz assumed the existence of an ordinal utility function throughout his Theory and Measurement of Demand (1938), he considered the integrability question to be sufficiently important – as he expressed it "whether the individual will eat his dessert at the beginning or at the end of his dinner" (Schultz, 1938, p. 17) – that he was compelled to defend his practice by stressing the "routine" in economic behavior and explicitly assuming "that the order of consumption is known" (ibid., p. 18).[13] Notice that he did not say that the order of consumption did not matter; he simply assumed that it was known to the theorist and thus only a single path was relevant. Schultz's response was similar to Jacob Mosak's in his General Equilibrium Theory in International Trade (1944). Mosak assumes ordinal utility maximization throughout, but explains in detail exactly what that assumption entails:

> The assumption that such a utility function exists implies that the preference ranking of any combination of goods depends not only on the quantities of the goods in the combination and not upon the order in which they are arranged. This means that the rate of change of with respect to is equal to the rate of change of with respect to , namely,
>
> st .

[13] See Hands and Mirowski (1998) and Mirowski and Hands (1998) for a detailed discussion of Schultz's work on demand theory.

> If this were not true, then the individual's preferences could not be integrated into a complete system and they could not, therefore, be described by a utility function. (Mosak, 1944, p. 6)

Although all of these economists offered their own particular solution to (or circumvention of) the integrability problem, all recognized that the issue was ultimately about whether it was empirically reasonable to assume that consumers had stable, non-reversible, endowment-independent, preferences and the associated ordinal utility function. Non-integrable theories of consumer choice were attempts to develop choice theories that did not require or assume such utility functions and thus be able to accommodate reference-dependencies, endowment effects and other anomalies that are discussed so frequently in the contemporary literature. They were also consistent with the general line of inquiry opened by Pareto's discussion of integrability.

> Despite a nostalgic attachment to the nonintegrable case in the 1950s, Allen's original attachment to the nonintegrable case is traceable to a wish to dispense with the concept of utility … The fact that he interpreted $^{2}\bar{U}$ as an expression embodying psychological and palpable content, and $^{2}\tilde{U}$ as psychological hypothesis regarding the order of consumption, is not to be regarded as an isolated fancy: he was acknowledging a Paretian line of interpretation of the integrability problem which was shared by Schultz and not rejected by Slutsky. (Chipman and Lenfant, 2002, p. 580)

Although the various attempts to develop a non-integrable theory of demand – or even just to recognize the issues involved – were motivated by perceived empirical inadequacies in utility-based theory, these empirical difficulties were generally based on introspection or common sense rather than experimental evidence. One exception was the 1931 paper by the psychologist Louis Thurstone on the construction of indifference curves from experimental evidence. As Thurstone explained, the paper was motivated by discussions with Henry Schultz.

> The formulation of this problem is due to numerous conversations about psychophysics with my friend Professor Henry Schultz of the University of Chicago. It was at his suggestion that experimental methods were applied to this problem in economic theory. According to Professor Schultz, it has probably never before been subjected to experimental study. (Thurstone, 1931, p. 139)

Although his paper contains no explicit discussion of integrability, it is important to note that Thurstone's indifference curves were always drawn for a particular reference point and thus could be considered a version of reference-dependent indifference curves rather than the reference-independent curves of standard economic theory. He calls his approach the "constant method" and explains it in the following way:

> The constant method takes the following form. One of the combinations such as eight hats and eight pairs of shoes is chosen as a standard and each of the other combinations is compared directly with it. (Thurstone, 1931, p. 151)

The later experimental literature based on Thurstone's general approach – for example MacCrimmon and Toda (1969) – generally followed his lead in this regard and derived indifference curves relative to a particular reference point – Pareto's $\overset{I}{=}$ . It was thus much more an investigation of endowment-dependent than endowment-independent preferences.[14]

The bottom line is that during the first half of the twentieth century integrability was considered to be a serious problem and its reason for being so was inevitably tied up with the general issues about reference-dependence, endowment effects, and the existence of a stable utility function defined exclusively over outcomes. These issues not only did not disappear from economic theory with the Paretian turn, but were in many ways inspired by it. They did generally disappear from the pure theory of consumer choice theory during the 1950s, but well past the main contributions to the ordinalist revolution.[15] When these issues resurfaced in the experimental and behavioral literature during the last few decades the entire framework of inquiry had changed. Now the focus is risky choice, we have extensive experimental evidence, and the word "integrability" has disappeared entirely from the discussion, but the fact remains that many of the issues of concern are the same as those of the earlier period.

## 4. Conclusion and Implications for Contemporary Theory

This paper has argued that many of the explanations for the anomalous phenomena discussed in the recent literature on behavioral economics were also a concern for economists working on consumer choice theory during the

[14] See Moscati (2007b) for a detailed discussion of this early experimental literature.
[15] One exception is Donald Katzner's work on non-integrable demand theory during the early 1970s (Katzner 1970 pp. 117-31 and 1971). It should also be noted that there have been a few attempts to bring sophisticated new mathematical tools to bear on the problem of nonintegrable demand theory. A recent example is the literature on generalized convexity and nonintegrable demand (Reinhard 2004, 2007).

ordinalist revolution. This fact has not been recognized within the behavioral literature. Surveys of the recent literature note that the problems of reference dependence "have not been fully appreciated" (Rabin, 1998, p. 13; 2004, p. 71) even though they have "a long history" within the economics profession (Rabin, 2002, p. 663), but they never go back to those writing during the first part of the twentieth century. Of course, while it is important to recognize the relationship between the early integrability literature and problems like reference-dependence and endowment effects, it is really not surprising that the relationship has gone unnoticed. It is not immediately obvious that integrability or the symmetry properties of the Slutsky matrix have anything at all to do with well-known experimental results such as the famous coffee mug experiment of Kahneman, Knetsch, and Thaler (1990); but they do. Both suggest that the traditional assumption that preferences are reference-independent and can be represented by a well-behaved utility function defined over outcomes is questionable for a theory of individual choice that is consistent with the best available empirical evidence.

Historians of economic thought have a variety of reasons for being interested in the argument presented here. For one thing, the ordinal and revealed preference revolutions are two of the most important – and to this point, enduring – developments within mainstream economics during the twentieth century and it seems impossible to understand these developments unless one understands how the issues of integrability and path-dependency came to be displaced during the late 1940s (Hands 2006). In order to understand that displacement, it is necessary to recognize the existence of the literature on integrability and related issues during the 1930s, as well as to appreciate how important it was (and why it was so important) to so many economic theorists. Second, contrary to the standard reading of the history – both among behavioral economists and many historians of economic thought – psychology was not simply "driven out" of neoclassical economics during the 1930s (Hands 2010). It did eventually exit, but not until the late 1940s and 1950s with the rise to dominance of Walrasian general equilibrium theory. Finally, the above discussion drives home the point that empiricism – what it means to have economic theories grounded in the best available empirical evidence – is historically contingent and intertemporally unstable. The epistemic preferences of the economics profession, like the preferences of economic agents in general, are highly context dependent; the fact that earlier economic theorists do not define, or treat, the empirical evidence in exactly the way we do today does not imply that they were not interested in whether their theories were consistent with the empirical evidence.

But the literature examined here is not only of interest to historians of economics. It can be argued that it would be useful for behavioral economists to seriously re-examine some of the efforts to formalize non-integrable demand theory in the 1930s. None of these theoretical efforts won acceptance at the time, and by the

1950s they were essentially forgotten, but they may contain some ideas that would be useful to contemporary theorists. Behavioral economists have been quite successful predicting and explaining the empirical facts of individual choice behavior, but they have been less successful developing the type of unified formal framework that constrained utility/preference maximization provides for rational choice theory. Nevertheless, many behavioral economists consider the development of a unified framework – one that would be able to subsume the majority of behavioral insights and also cover rational choice theory as a special case – to be one of the research program's major goals. For instance as Colin Camerer explains:

> Note that the behavioral approach should ideally fully encompass rational-choice approaches as a special case. Keep in mind that behavioral economists do not doubt that incentives matter and do not believe that traditional analysis is useless … Indeed, behavioral economics is meant to be a generalization of rational-choice theory that incorporates limits on rationality, will power, and self-interest in a formal way." (Camerer, 2008, p. 44)

Of course this is very similar to what those who were trying to develop a non-integrable theory of choice and demand were trying to do during the 1930s. They wanted a more general non-integrable theory of demand – one that did not require the individual to have a well-ordered (complete, transitive, irreversible) preference field that assigned values to outcomes regardless of the path by which those outcomes were reached – yet one that would be able to encompass the rational choice approach as a special case. It would be an approach to predicting and explaining individual consumer choice that was more general, more consistent with what we know about real human behavior (albeit from common sense and introspection rather than laboratory experiments), and yet one that did not totally abandon either rational choice or the goal of a formalized general theory. Yes, the anomalies that concerned them did not emerge from controlled experiments, they were working in the context of risk-free choice, and they did think integrability was central to the problem, but they were engaged in a very similar theoretical endeavor and identified many of the same problems.

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