A TEST OF THE THEORY OF REFERENCE-DEPENDENT PREFERENCES*

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Eight alternative methods of eliciting preferences between money and a consumption good are identified two of these are standard willingness-to-accept and willingness-to-pay measures These methods differ with respect to the reference point used and the dimension in which responses are expressed The loss aversion hypothesis of Tversky and Kahneman's theory of reference-dependent preferences predicts systematic differences between the preferences elicited by these methods These predictions are tested by eliciting individuals' preferences for two private consumption goods, the experimental design is incentive-compatible and controls for income and substitution effects The theory's predictions are broadly confirmed

In conventional consumer theory each individual's choices are determined by a preference ordering over consumption bundles, this ordering is independent of the individual's endowment However, a number of recent papers have suggested that preferences may be conditioned on current endowments, and that individuals are typically "loss averse" for example, a person may prefer bundle **x** to bundle **y** if she is endowed with **x**, but prefer **y** to **x** if endowed with **y** The most fully worked-out general theory of this kind is probably Tversky and Kahneman's [1991] theory of *reference-dependent* preferences Tversky and Kahneman present their theory as an explanation of a body of preexisting evidence In this paper we report a systematic experimental test of some of the implications of reference-dependent theory

One interesting feature of reference-dependent theory is that it offers a possible explanation of the frequently observed divergence between willingness-to-accept (*WTA*) and willingness-to-pay (*WTP*) valuations We show that the theory has implications for a range of valuation measures, of which *WTP* and *WTA* are

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just two We test these implications by eliciting individuals' valuations of private goods in an incentive-compatible experimental setting An important aspect of our design is that it controls for all income and substitution effects that are compatible with conventional theory thus, we look for certain patterns of behavior that are predicted by reference-dependent theory but which contravene conventional theory As a consequence of this feature of our design, our tests control for the income and substitution effects that Hanemann [1991] has suggested may explain some of the divergences between *WTA* and *WTP* that have been observed in contingent valuation studies

I Theory

I A *Four Valuation Measures*

Consider an individual who consumes two goods One of the goods is to be interpreted as a particular consumption good while the other is a composite commodity, quantities of which are measured in money units We wish to measure the value to the individual, in units of one of these goods j, of a change in her consumption of the other good i from x_i' to x_i'' or vice versa, given some initial endowment, x_j', of good j

We shall consider four alternative measures These are defined as follows for any x_i', x_i'', x_j' such that $x_i' < x_i''$

(1) *Willingness to Pay* Let the individual be endowed with the quantities x_i', x_j' $WTP_{ji}(x_i', x_i'', x_j')$ is the maximum amount of good j that she would be willing to give up in return for an increase in her consumption of good i from x_i' to x_i''

(2) *Willingness to Accept* Let the individual be endowed with the quantities x_i'', x_j' $WTA_{ji}(x_i', x_i'', x_j')$ is the minimum amount of good j that she would be willing to accept in return for a decrease in her consumption of good i from x_i'' to x_i'

(3) *Equivalent Loss* (*EL*) Let the individual be endowed with the quantities x_i'', x_i' $EL_{ji}(x_i', x_i'', x_j')$ is the maximum amount of good j that she would be willing to give up in place of a reduction in her consumption of good i from x_i'' to x_i'

(4) *Equivalent Gain* (*EG*) Let the individual be endowed with the quantities x_i', x_j' $EG_{ji}(x_i', x_i'', x_j')$ is the minimum amount of good j that she would be willing to accept in place of an increase in her consumption of good i from x_i' to x_i''

These definitions do not depend on any theory of preference the four measures are to be interpreted as independently observable empirical magnitudes We shall now consider some of the implications of conventional consumer theory and of reference-dependent theory for these measures

I B Hicksian Theory

We shall use the term "Hicksian theory" to refer to the conventional neoclassical theory of consumer choice, as refined by Hicks [1943, 1956] In this theory the individual has preferences over all nonnegative bundles of consumption goods these preferences have the properties of transitivity, continuity, increasingness, and convexity, and can be represented by a utility function In our two-good case this utility function may be written as[1] $u(x_i\ x_j)$

For an individual with Hicksian preferences, the four valuation measures considered in subsection I A can be defined implicitly by the following equations

(1) $$u(x_i'', x_j' - WTP_{ji}[x_i', x_i'', x_j']) = u(x_i', x_j')$$

(2) $$u(x_i', x_j' + WTA_{ji}[x_i', x_i'', x_j']) = u(x_i'', x_j')$$

(3) $$u(x_i'', x_j' - EL_{ji}[x_i', x_i'', x_j']) = u(x_i', x_j')$$

(4) $$u(x_i', x_j' + EG_{ji}[x_i', x_i'', x_j']) = u(x_i'', x_j')$$

This Hicksian case is illustrated in Figure I I' and I'' are indifference curves corresponding to the utility levels $u(x_i', x_j')$ and $u(x_i'', x_j')$ Notice that Hicksian theory implies $EL_{ji} = WTP_{ji}$ and $EG_{ji} = WTA_{ji}$ Take the case of WTP_{ji} and EL_{ji} Conceptually, these measures differ with respect to the individual's initial endowment WTP_{ji} is based on the endowment (x_i', x_j') while EL_{ji} is based on (x_i'', x_j') But this difference has no significance within the Hicksian framework, in which preferences over consumption bundles are independent of initial endowments

However, Hicksian theory does not imply equality between WTA_{ji} and WTP_{ji} If good i is normal, it can be shown that

1 Throughout the paper we use the indices i and j to refer to the two goods, without specifying which of i or j is the composite commodity and which is the specific good To simplify the notation, however, we always write the utility function so that its first argument is consumption of good i and its second is consumption of good j Similarly, consumption bundles are written as (x_i, x_j)

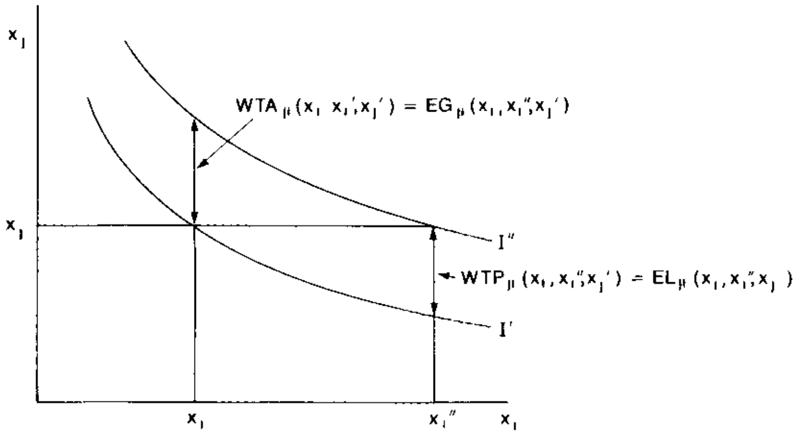

FIGURE I

(5) $$WTP_{ji}(x_i', x_i'', x_j') < WTA_{ji}(x_i'', x_i', x_j')$$

It is natural to ask how large a divergence between these two measures is compatible with Hicksian theory This question has been investigated by Randall and Stoll [1980] and by Hanemann [1991] Randall and Stoll show that the divergence between *WTA* and *WTP* will be no more than a few percentage points, provided that *WTP* is a small proportion of the individual's total income and that the "price flexibility of income" (that is, the elasticity of the marginal valuation of good i with respect to x_j) is "small " Hanemann shows that the price flexibility of income is equal to the income elasticity of demand for good i divided by the elasticity of substitution between the two goods He uses this result to argue that "large empirical divergences between *WTP* and *WTA*" might be expected when good i is a public good for which private consumption goods are imperfect substitutes [p 646]

In the absence of a direct measure of the price flexibility of income, or of the elasticity of substitution, it is difficult to decide whether an observed divergence between *WTA* and *WTP* is too large to be compatible with Hicksian theory Because of this problem, there has been considerable controversy over the interpretation of empirical findings about the relative magnitudes of *WTA* and *WTP* (see Mitchell and Carson [1989, pp 30–38] for a survey of the issues involved)

I C Reference-Dependent Theory

Tversky and Kahneman [1991] propose reference-dependent theory as an alternative to the Hicksian theory of preferences The fundamental idea in reference-dependent theory is that individuals understand the options in decision problems as gains or losses relative to a *reference point* The reference point is normally[2] the "current position" of the individual

Tversky and Kahneman present their model for the case of two goods Preferences are defined over the set of all nonnegative consumption bundles, bundles will be denoted by bold lowercase letters, e g , $\mathbf{x} = (x_i, x_j)$ One such bundle, $\mathbf{r}$, is the individual's reference point The individual has a preference relation over bundles, *conditional on the reference point,* the relation "is at least as preferred as, evaluated in relation to $\mathbf{r}$" is written as $\succcurlyeq_r$ The reference-dependent relations of strict preference and indifference are written as $\succ_{\mathbf{r}}$ and $\sim_{\mathbf{r}}$ Tversky and Kahneman assume that each $\succcurlyeq_{\mathbf{r}}$ is transitive, continuous, and increasing (but not necessarily convex), it can be represented by a reference-dependent utility function[3] $u_r(\;,\;)$

Given this theory, our four measures can be defined implicitly by the equations

(6) $$u_{\mathbf{y}}(x_i'', x_j' - WTP_{ji}[x_i', x_i'', x_j']) = u_{\mathbf{y}}(x_i', x_j')$$

(7) $$u_{\mathbf{z}}(x_i', x_j' + WTA_{ji}[x_i', x_i'', x_j']) = u_{\mathbf{z}}(x_i'', x_j')$$

(8) $$u_{\mathbf{z}}(x_i'', x_j' - EL_{ji}[x_i', x_i'', x_j']) = u_{\mathbf{z}}(x_i', x_j')$$

(9) $$u_{\mathbf{y}}(x_i', x_j' + EG_{ji}[x_i', x_i'', x_j']) = u_{\mathbf{y}}(x_i'', x_j'),$$

where $\mathbf{y} = (x_i', x_j')$ and $\mathbf{z} = (x_i'', x_j')$ Notice that in reference-dependent theory, WTP_{ji} and WTA_{ji} are defined in relation to different utility functions Thus, the methods used by Randall and Stoll and by Hanemann to investigate divergences between *WTA* and *WTP* do not apply when preferences are reference-dependent Notice also that the theory does not imply equality between WTP_{ji} and EL_{ji}, or between WTA_{ji} and EG_{ji}

2 Tversky and Kahneman [1991, pp 1046–47] allow certain exceptions to this rule, but these are not relevant to this paper

3 This function may not be everywhere differentiable Tversky and Kahneman allow indifference curves to be kinked at reference levels (i e , where $x_i = r_i$ or $x_j = r_j$)

The distinctive predictions of reference-dependent theory result from the assumptions that are made about how the preference ranking of a given pair of bundles may change as the reference point changes. It is convenient to use the following definition. Consider preferences over any two bundles **x** and **y** viewed from any two reference points **r** and **s.** We shall say that **s** *favors* **x** if, as the reference point shifts from **r** to **s**, the reference-dependent ranking of **x** and **y** either remains the same or changes in favor of **x.** Formally, **s** favors **x** in relation to **y** and **r** iff (i) $\mathbf{x} \sim_{\mathbf{r}} \mathbf{y}$ implies that $\mathbf{x} \succ_{\mathbf{s}} \mathbf{y}$ and (ii) $\mathbf{x} \succ_{\mathbf{r}} \mathbf{y}$ implies that $\mathbf{x} \succ_{\mathbf{s}} \mathbf{y}$. Now consider preferences over any two bundles **x, y,** such that $x_i > y_i$ and $y_j > x_j$, and any reference points **r, s** such that $r_j = s_j$. After some minor revisions,[4] Tversky and Kahneman's assumptions can be summarized as follows.

(1) *Loss Aversion.* If $y_i = r_i < s_i \leq x_i$, then **s** favors **x** in relation to **y** and **r.**

(2) *Diminishing Sensitivity in Gains.* If $r_i < s_i \leq y_i$, then **s** favors **x** in relation to **y** and **r.**

(3) *Diminishing Sensitivity in Losses.* If $x_i \leq r_i < s_i$, then **s** favors **y** in relation to **x** and **r**.

Tversky and Kahneman [1991, p. 1049] introduce the diminishing sensitivity assumptions to "extend the implications of loss aversion to reference states that do not coincide with [**x** and **y**] on either dimension." In the context of our four valuation measures, this extension is not needed, and so we may focus on the assumption of loss aversion.

The loss aversion assumption is illustrated in Figure II. Here $y_i = r_i < s_i = x_i$. $I_{\mathbf{r}}$ and $I_{\mathbf{s}}$ are indifference curves based on the reference points **r** and **s.** When the reference point is **r, x** and **y** are indifferent, but when the reference point is **s, x** is preferred to **y.** Tversky and Kahneman [1991, p. 1047] see this assumption

4. Tversky and Kahneman's [1991] formal statement of the loss aversion condition is if $y_i = r_i < s_i \leq x_i$, then $\mathbf{x} \sim_{\mathbf{r}} \mathbf{y}$ implies that $\mathbf{x} \succ_{\mathbf{s}} \mathbf{y}$. We have made two revisions to this condition. (1) we have weakened the original condition to '$\mathbf{x} \sim_{\mathbf{r}} \mathbf{y}$ implies that $\mathbf{x} \succeq_{\mathbf{s}} \mathbf{y}$' so as to allow Hicksian theory as a limiting case, and (2) we have added the implication that '$\mathbf{x} \succ_{\mathbf{r}} \mathbf{y}$ implies $\mathbf{x} \succ_{\mathbf{s}} \mathbf{y}$', which we believe to be wholly in the spirit of Tversky and Kahneman's analysis. Where appropriate, we have made corresponding revisions to Tversky and Kahneman's conditions of diminishing sensitivity.

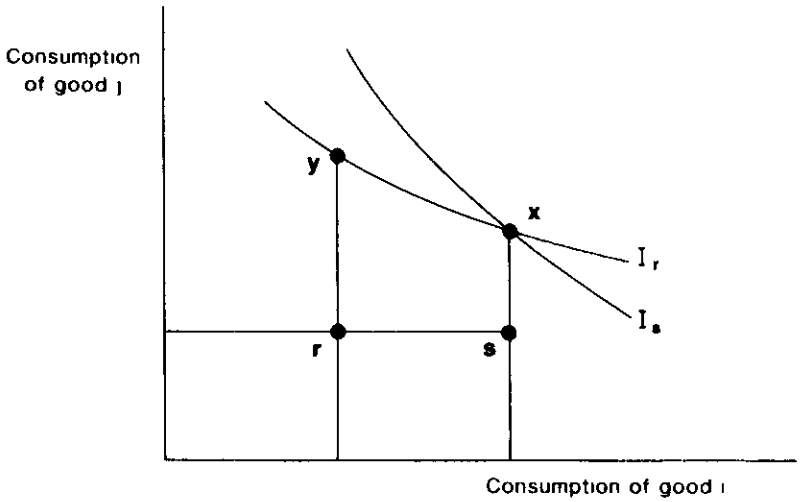

FIGURE II

as representing the psychological intuition that, for each good, "losses loom larger than corresponding gains." When the reference point is **r**, **y** is perceived as offering the reference level of good *i*, while **x** offers a gain of $x_i - y_i$ on the *i*-dimension. When the reference point is **s**, **x** is perceived as offering the reference level of good *i*, while **y** imposes a loss of $x_i - y_i$ on the *i*-dimension. Because losses have more psychological impact than forgone gains, **x**'s superiority over **y** on the *i*-dimension has more weight in the determination of preferences when the reference point is **s** than when it is **r**.

Loss aversion has implications for the relative magnitudes of the four valuation measures. Here we will provide an intuitive account of these implications. A more formal analysis will be given in Section III, when we describe the principles of our experimental design. Recall that each of the measures is a valuation, in units of good *j*, of a given change on the *i*-dimension. WTP_{ji} measures the individual's willingness to incur *losses* on the *j*-dimension to bring about a *gain* on the *i*-dimension. In contrast, WTA_{ji} measures the individual's willingness to accept *gains* on the *j*-dimension in return for incurring *losses* on the *i*-dimension. If losses loom larger than gains, then, in the absence of income effects, we should expect WTA_{ji} to be greater than WTP_{ji}. EG_{ji}, which expresses an equivalence between gains on the two dimensions, and EL_{ji}, which expresses an equivalence between losses, should be expected to take values intermediate between WTP_{ji} and WTA_{ji}.

II. Existing Evidence

Proponents of theories of reference-dependent preferences are able to point to supporting evidence from a wide range of laboratory experiments and "real" economic decisions. For example, evidence of endowment effects has been found in a double-auction experimental market for insurance [Myagkov and Plott 1995], in a public goods experiment [Andreoni 1995], and in the decisions of Harvard University employees in relation to health plans [Samuelson and Zeckhauser 1988]. It has been argued that the discrepancy between the long-run returns on stocks and on bonds may be explained by loss aversion [Benartzi and Thaler 1995].

However, the most significant source of relevant evidence concerns observed disparities between *WTA* and *WTP*. When contingent valuation surveys elicit both *WTP* and *WTA* valuations of the same good, it is quite common for the mean and median values of *WTA* to be several times higher than the corresponding *WTP* values (e.g., Bishop and Heberlein [1979], Rowe, d'Arge, and Brookshire [1980], Jones-Lee, Hammerton, and Philips [1985], and Viscusi, Magat, and Huber [1987]). Significant *WTA-WTP* divergences have also been found in many laboratory experiments. These experiments have typically used incentive-compatible designs, in which subjects report *WTP* and *WTA* for low-value private goods (e.g., Knetsch and Sinden [1984] and Kahneman, Knetsch, and Thaler [1990]).

Some commentators have interpreted this evidence as showing that, contrary to the implications of Hicksian theory, individuals are subject to loss aversion [Kahneman, Knetsch, and Thaler 1990]. Others have argued that large *WTA-WTP* divergences may be the result of low elasticities of substitution between income and the goods being valued [Hanemann 1991]. Relatively few tests for *WTA-WTP* divergences have controlled for income and substitution effects. Shogren et al. [1994] test for the impact of substitution effects by eliciting *WTP* and *WTA* valuations for two kinds of good, "market" (represented by candy bars) and "nonmarket" (stringent screening of food for various pathogens). They find that, after subjects have gained experience of the experiment's incentive mechanism, there are significant *WTA-WTP* divergences for nonmarket goods, but not for the market good. Hypothesizing that the relevant elasticities of substitution are smaller for nonmarket than for market goods, Shogren et al. interpret their results as evidence that large *WTA-WTP* divergences can be caused by substitution effects. However, in the absence of any direct measure of elasticities of substitution, this interpretation can only be speculative. Countervailing evidence has come from experiments that have found significant *WTA-WTP* divergences after controlling for income and substitution effects [Knetsch and Sinden 1984, p. 512; Knetsch 1989].

Reference-dependent theory offers one explanation of the observed tendency for *WTA* to exceed *WTP*. However, since the discovery of *WTA-WTP* divergences predates the development of reference-dependent theory, this evidence cannot be regarded as a powerful test of that theory. Our strategy is to derive a range of new predictions from the theory and to test these.

III. Experimental Design: Basic Principles

Our experimental design is built around the following setup. As in Section I, consider an individual who consumes a specific good (good 1) and a composite commodity (good 2). Let x_1', x_1'' be two levels of consumption of good 1, such that $x_1' < x_1''$. Similarly, let x_2', x_2'' be two levels of consumption of good 2, such that $x_2' < x_2''$. Consider four bundles **a, b, c, d** defined by $a_1 = c_1 = x_1'$, $b_1 = d_1 = x_1''$, $a_2 = b_2 = x_2''$, $c_2 = d_2 = x_2'$. Now consider the following ways of posing the question, "Is **a** preferred to **d?**"

(1) Is $WTP_{21}(x_1', x_1'', x_2'')$ less than $x_2'' - x_2'$? If preferences are Hicksian, and if the answer to this question is yes, we may infer that **a** $>$ **d.** To see why, look at Figure III, in which I' and I'' are Hicksian indifference curves. If preferences are reference-dependent, it becomes relevant that $WTP_{21}(x_1', x_1'', x_2'')$ is based on an initial endowment of **a.** Thus, if the answer to the question is yes, we may infer that **a** $>_{\mathbf{a}}$ **d.** Preferences inferred from valuations in this way will be called *implicit preferences*.

(2) Is $WTA_{21}(x_1', x_1'', x_2')$ less than $x_2'' - x_2'$? If the answer is yes, the implicit Hicksian preference is **a** $>$ **d,** and the implicit reference-dependent preference is **a** $>_{\mathbf{d}}$ **d**.

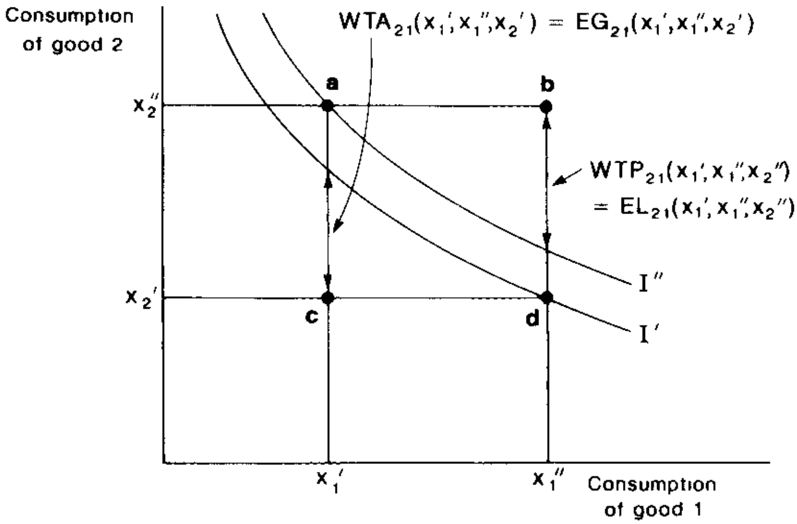

FIGURE III

(3) Is $EL_{21}(x_1', x_1'', x_2'')$ less than $x_2'' - x_2'$? If the answer is yes, the implicit Hicksian preference is **a** $>$ **d,** and the implicit reference-dependent preference is **a** $>_{\mathbf{b}}$ **d.**

(4) Is $EG_{21}(x_1', x_1'', x_2')$ less than $x_2'' - x_2'$? If the answer is yes, the implicit Hicksian preference is **a** $>$ **d,** and the implicit reference-dependent preference is **a** $>_{\mathbf{c}}$ **d.**

Hicksian theory implies that the implicit preference between **a** and **d** should be the same, irrespective of whether it is derived from answers to the questions (1), (2), (3), or (4) In contrast, reference-dependent theory allows the four implicit preferences to differ, because each is based on a different reference point The loss aversion assumption implies the following propositions about changes in the ranking of **a** and **d** as the reference point shifts

(1) Comparing reference points **a, b: b** favors **d.**
(2) Comparing reference points **a, c: c** favors **d.**
(3) Comparing reference points **b, d: d** favors **d.**
(4) Comparing reference points **c, d: d** favors **d.**

Thus, reference-dependent theory makes specific predictions about the directions of any differences between the implicit rankings of **a** and **d** derived from (1), (2), (3), and (4) So by eliciting the four measures, $WTP_{21}(x_1', x_1'', x_2'')$, $WTA_{21}(x_1', x_1'', x_2')$, $EL_{21}(x_1', x_1'', x_2'')$, and $EG_{21}(x_1', x_1'', x_2')$, we can test whether implicit rankings vary with reference points as reference-dependent theory predicts Notice that all four implicit rankings are of *the same* bundles **a** and **d:** thus, this test controls for all Hicksian income and substitution effects

So far in this section, we have considered valuations of good 1 (the specific good) in units of good 2 (the composite commodity) But it is also possible to test reference-dependent theory by eliciting valuations of good 2 in units of good 1 This gives us four more ways of asking whether **a** is preferred to **d** (see Figure IV, which is drawn on the same principles as Figure III)

(5) Is $WTA_{12}(x_2', x_2'', x_1')$ greater than $x_1'' - x_1'$? If the answer is yes, the implicit Hicksian preference is **a** > **d,** and the implicit reference-dependent preference is **a** $>_a$ **d.**

(6) Is $WTP_{12}(x_2', x_2'', x_1'')$ greater than $x_1'' - x_1'$? If the answer is yes, the implicit Hicksian preference is **a** > **d,** and the implicit reference-dependent preference is **a** $>_d$ **d.**

(7) Is $EL_{12}(x_2', x_2'', x_1'')$ greater than $x_1'' - x_1'$? If the answer is yes, the implicit Hicksian preference is **a** > **d,** and the implicit reference-dependent preference is **a** $>_b$ **d.**

(8) Is $EG_{12}(x_2', x_2'', x_1')$ greater than $x_1'' - x_1'$? If the answer is

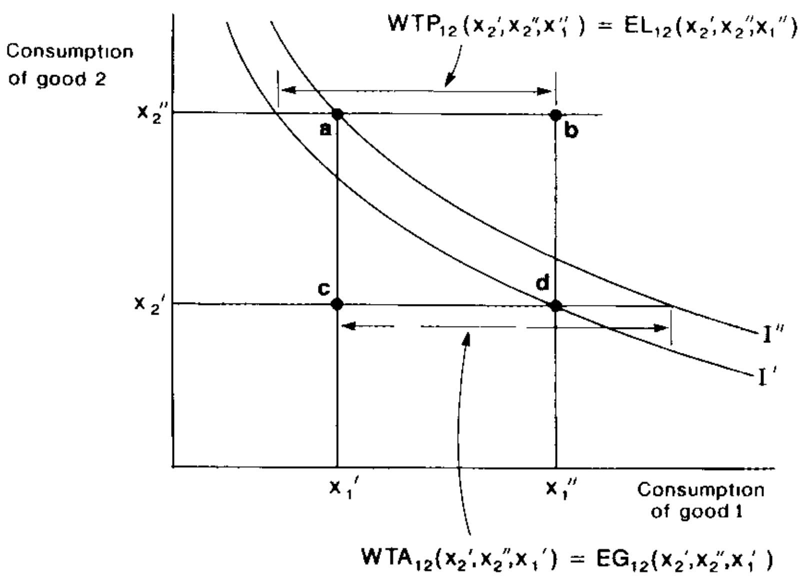

FIGURE IV

yes, the implicit Hicksian preference is **a** > **d**, and the implicit reference-dependent preference is **a** $>_c$ **d**.

By comparing the implicit rankings generated by (5)–(8), we can make further tests of whether preferences vary with reference points in the directions predicted by reference-dependent theory

Comparisons between the implicit rankings generated by these elicitation methods can also be used to investigate the effect of changes in the *response mode* (i e , the units in which valuations are expressed) For example, compare $WTP_{21}(x_1', x_1'', x_2'')$ and $WTA_{12}(x_2', x_2'', x_1')$ Each of these measures generates an implicit ranking of **a** and **d**, conditional on the same reference point **a**. Hicksian theory and reference-dependent theory both imply that these two implicit rankings should be the same However, there are theories (some of which have been developed by Kahneman and Tversky themselves) which suggest that implicit preferences may differ according to the response mode The guiding idea behind these theories is that each response mode makes certain information, certain concepts, or certain decision-making heuristics particularly salient to the individual [Tversky and Kahneman 1974, Tversky, Sattath, and Slovic 1988] For example, observations of preference reversal have been explained by the hypothesis that different decision-making heuristics are used, according to whether tasks require responses in the form of binary choices or in the form of money valuations [Slovic and Lichtenstein 1983, Tversky, Slovic, and Kahneman 1990]

The *contingent weighting* theory of Tversky, Sattath, and Slovic [1988] has the closest application to the decision problems considered in this paper This theory is designed to apply to "matching tasks" in which subjects compare two options, each of which can be described in two dimensions of desirability (e g , two candidates for a job are each described by two test scores, one for literacy and one for numeracy) One option is fully described, while the other has one missing piece of information (e g , the numeracy score for one of the candidates) Subjects are instructed to fill in this missing information so as to make the two options equally desirable Here, the response mode is the dimension of the missing information (e g , numeracy) Contingent weighting theory predicts that subjects will give greater implicit weight to any given dimension if it is the response mode than if it is not

The valuation measures considered in this paper might be interpreted as the products of matching tasks For example, suppose that an individual is endowed with $\mathbf{a} = (x_1', x_2'')$ and is asked to state the value x_2^* at which she would be indifferent about exchanging **a** for (x_1'', x_2^*) This is a matching task in which the response mode is good 2 But it can also be understood as a method of eliciting *WTP*, since $x_2'' - x_2^* = WTP_{21}(x_1', x_1'', x_2'')$ see Figure III If the decision tasks of our experiment are treated as equivalent to matching tasks, contingent weighting theory implies that changing the response mode from good 2 to good 1 should tend to shift implicit preferences between **a** and **d** in favor of **d** (the option that is better on the dimension of good 1)

IV Experimental Design Details

The experiment was designed to elicit preferences between two bundles **a** and **d,** using each of the eight methods described in Section III, for each of two specifications of the bundles **a, b, c, d.** In one specification the two goods were cans of Coke (good 1) and money (good 2), with $x_1' = 2$ cans, $x_1'' = 6$ cans, $x_2' = £2\ 20$, $x_2'' = £3\ 00$ In the other specification the goods were vouchers for chocolates (good 1) and money (good 2), with $x_1' = 2$ chocolates, $x_1'' = 12$ chocolates, $x_2' = £1\ 50$, x_2'' £3 50 The vouchers were redeemable at a local specialist chocolate shop for given numbers of a premium range of Belgian chocolates These chocolates sell at approximately £0 40 each (they are normally sold by weight)

In choosing these particular values of x_1', x_1'', x_2', x_2'', we recognized that our design would fail as a test of reference-dependent theory if **a** was so attractive relative to **d** that, for all elicitation methods, almost all subjects reported an implicit preference for **a.** Equally, it would fail if **d** was too attractive relative to **a.** We used a pilot study to identify specifications of **a** and **d** such that, aggregating over all eight elicitation methods, we could expect significant proportions of subjects to report each of the implicit preferences $\mathbf{a} > \mathbf{d}$ and $\mathbf{d} > \mathbf{a}$.

We chose Coke and luxury chocolates to represent two very different types of good We expected that many of our subjects would buy Coke fairly regularly, while few would have much experience in buying this type of chocolate There are a number of reasons for thinking that *WTA-WTP* disparities might be less in the case of the regularly consumed good First, subjects might be expected to be surer of their own preferences in the case of Coke, and thus their valuations might be less liable to stochastic variation and error Second, subjects who know the market price of a good might use this as an "anchor" when thinking about their own valuations, with the result that valuations for Coke might tend to cluster around its price Third, if a subject is a regular Coke buyer, she might think of any cans of Coke received in an experiment as representing money savings (she needs to buy fewer cans) rather than extra consumption If she does, loss aversion might be expected to have less psychological impact

The experiment involved 156 subjects, mostly undergraduate and postgraduate students, recruited on the campus of the University of East Anglia After inspecting samples of the goods, receiving pre-scripted instructions, and carrying out some practice exercises (described later), each subject was given a series of eighteen decision tasks Each subject knew that one of these tasks, to be picked at random at the end of the experiment, would be for real Of the eighteen tasks, eight were designed to test the implications of reference-dependent theory, we shall focus on these [5]

Each such task was described by a display on a VDU screen At the top of the screen were the words "If this question is selected, you will be given ," followed by a specification of an endowment of money and of Coke or chocolates (e g , " £3 50 and 12 chocolates") The next text on the screen was "In addition to this, you will be required to accept either *K* or *L*" (or some other pair of letters) The letters denoted alternative options, which were then described in terms of transfers of money or the other good or both from the subject to the experimenters ("you give us") or from the experimenters to the subject ("we give you") The second option was fully described For the first option one quantity (of money or of the other good) was unspecified In place of this quantity there was an empty box If the unspecified quantity was a transfer from the subject to the experimenters, we effectively asked the subject to state the highest value of this quantity at which she would still prefer the first option If the unspecified quantity was a transfer from the experimenters to the subject, we effectively asked the subject to state the lowest value at which

5 The other ten tasks involved two other goods (bottles of sparkling wine and boxes of teabags) and were of two types One type of task had the same format as those described in this paper, and elicited *WTP* or *WTA* valuations for the relevant good The other type of task required a choice between two fully described options This part of the experiment, which we plan to report in another paper, was designed to test whether implicit preferences elicited by valuation tasks are systematically different from preferences revealed in binary choices

she would still prefer the first option The precise mechanism used to elicit responses will be described later

This general format can be used to elicit answers to any of the questions (1)–(8) considered in Section III For example, one task, based on an endowment of £3 50 and 12 chocolates, involved the options "You give us   in cash" and "You give us 10 chocolates " This elicits EL_{21}(2 chocolates, 12 chocolates, £3 50) Another task, based on an endowment of £3 00 and 2 cans of Coke, involved the options "We give you   cans of Coke and you give us £0 80 in cash" and "Nothing" (i e , no change from the initial endowment) This elicits WTA_{12}(£2 20, £3 00, 2 cans)

In using this design to test reference-dependent theory, we treat the endowment for each task as the relevant reference point Notice that, for a subject facing a given task, the relevant endowment is merely conditional she will be given it only if that task is later picked to be the one that is for real This conditionality may weaken the tendency for a subject to integrate her endowment into her mental conception of her "current position " Some relevant evidence is provided by Loewenstein and Adler [1995], who compare *WTA* valuations reported by subjects who have actually been endowed with a good with corresponding valuations reported by subjects whose endowments are conditional on random events The former valuations tend to be significantly greater than the latter This suggests that our design may fail to pick up the full effects of shifts in reference points In this respect, we are subjecting reference-dependent theory to a particularly severe test

To ensure incentive compatibility, we used a Becker-DeGroot-Marschak [1964] mechanism We believe that this mechanism is preferable to the repeated auctions used in some recent investigations of *WTA-WTP* divergences (e g , Coursey, Hovis and Schulze [1987], Kahneman, Knetsch, and Thaler [1990], and Shogren et al [1994]) It is well-known that an individual's reported valuation of a good can be influenced by cues which carry suggestions about the good's real value [Mitchell and Carson 1989, pp 240–46] or which can work as anchors in an anchor-and-adjustment heuristic [Tversky and Kahneman 1974] If subjects bid against one another in repeated auctions for the same good, and if the market price determined in each auction is then reported to the subjects, later bids may be influenced by earlier prices A Becker-DeGroot-Marschak mechanism is equivalent to an auction in which the only bidders are the subject herself and a random device This ensures that subjects' responses cannot contaminate one another

The incentive mechanism worked in the following way Recall that the description of the first option in each task included an empty box in place of a quantity Subjects were told "The computer will pick an amount at random to write in the box Please complete the following statement " If the amount in the box referred to a transfer from the subject to the experimenters, the statement had the following form "If this question is selected, I (i e , the subject) will take K if the amount in the box is   or less Otherwise, I will take L " If the amount in the box referred to a transfer from the experimenters to the subject, "or more" was substituted for "or less " The subject's task was to fill in the blank in the statement This was done by using the up and down arrow keys on the keyboard, which increased or decreased the amount in the statement in steps of five pence (for money) or one unit (for cans of Coke or chocolates) from an initial value of zero When the blank referred to a transfer from the subject to the experimenters, the subject was not allowed to give a response greater than her endowment of the relevant good It was explained that the maximum permitted response would guarantee that the subject received the second option

At the end of the experiment, one decision problem was selected at random and displayed on the screen The specified endowments of money and the other good were then handed to the subject A random device, represented by a display of a ball spinning around a roulette wheel, picked an amount to write in the box for the first option This, combined with the statement that the subject had completed, determined which of the two options the subject had to accept, and any necessary exchanges were then carried out

Clearly, it is essential for this design that subjects understand the incentive compatibility of the Becker-DeGroot-Marschak mechanism In each session about 30 minutes were spent on instructing subjects by means of four practice exercises These exercises used the same screen displays as were used in the main experiment, but with a well-known brand of individually packaged biscuits as the nonmoney good in place of Coke or chocolates The exercises elicited in turn WTP_{21}, EG_{12}, WTA_{12}, and EL_{21} In each exercise, after the subject had completed the relevant statement, the "roulette wheel" was used, just as it would be at the end of the experiment, to determine the (in this practice case, hypothetical) outcome for the subject Subjects were guided through the first two exercises by the experimenters reading from a script The oral instructions explained in simple terms the incentive compatibility of the Becker-DeGroot-Marschak mechanism Subjects did the remaining two exercises on their own

To allow us to check subjects' understanding of the design, each subject had to answer two multiple-choice questions—one as part of the second exercise, the other as part of the fourth exercise These questions were presented after the subject had completed the statement, but before the roulette wheel was displayed For example, the two options for the second exercise were "We give you biscuits" and "We give you £2 00" Suppose that the subject's response had been 10 Then the multiple-choice question might be [6] "If the computer wrote 11 in the box, which of these options would you be required to accept? a We give you 11 biscuits b We give you 10 biscuits c We give you £2 00" The other multiple-choice question had the same format Subjects were not allowed to ask for advice while answering these questions, but if a subject gave the wrong answer, an experimenter provided further explanation to that subject In most cases, incorrect answers seemed to be the result of carelessness or error rather than of misunderstandings of the principles of the incentive system Of the 156 subjects, 123 gave correct answers to both test questions, 15 gave the correct answer to the second question but not to the first, 16 gave the correct answer to the first but not to the second, and 2 answered both questions incorrectly The overall success rate of 89 percent correct answers suggests that most subjects had a clear understanding of the incentive system

Recall that the experiment was designed to elicit eight distinct valuation measures for each of two specifications of the set {**a**,**b**,**c**,**d**} Ideally, we would have liked to use a completely between-subjects design, so as to exclude any possibility that subjects' responses to one task might be influenced by their responses to another, but this would have required a prohibitively large sample size As a compromise solution, we divided subjects at random into two subgroups (here labeled I and II), and each sub-

6 There were two alternative forms of the question, of which one was picked at random One question was based on the hypothesis that the amount picked by the computer was slightly larger than the subject's response, the other on the hypothesis that it was slightly smaller

group faced four of the eight decision tasks for each of the "Coke" and "chocolate" specifications [7] By spacing out these four related tasks among the eighteen tasks for the whole experiment, we hoped to reduce cross-task contamination as much as possible In addition, we randomized the order of related tasks, independently for each subject Thus, if any contamination were to occur, it would not have any systematic effect on our results

Our statistical tests use the null hypothesis that each subject acts on Hicksian preferences, but with some random variation We represent this random variation by a *random preference* model [Becker, DeGroot, and Marschak 1963, Loomes and Sugden 1995] For each individual in such a model, there is a probability distribution over a set of alternative preference orderings, each of which satisfies the restrictions imposed by the relevant theory (in the present case, Hicksian consumer theory) In each decision task the individual acts on one of these orderings, drawn independently and at random from the set

On the assumption that the null hypothesis is true, we can infer a *strict* implicit preference between **a** and **d** from each response Recall that in each task, each subject chose one of a set of *discrete* alternative responses (amounts of money in multiples of five pence, numbers of chocolates, or cans of Coke) For example, consider the task that elicits WTP_{21} for Coke The subject is endowed with **a** (i e , 2 cans of Coke and £3 00) She is asked to state the highest multiple of five pence that she is willing to pay for four extra cans of Coke If her response is £x, she is reporting that she is willing to pay £x but not willing to pay £x + 0 05, so the true value of WTP_{21}, expressed on a continuous scale, is in the range $x \leq WTP_{21} < x +$ 0 05 Thus, a response of £0 80 or more reveals the implicit preference **d** $>$ **a** (where **d** is 6 cans of Coke and £2 20), a response of less than £0 80 reveals the implicit preference **a** $>$ **d.** A similar analysis applies to every other task

Our null hypothesis of stochastic Hicksian preferences implies that, for any given individual in the experiment and for given **a, d,** the probability that she will reveal the implicit preference **a** $>$ **d** is constant across decision tasks Since the two subgroups are random samples from the same population, this

7 In assigning tasks to subgroups, we tried to ensure that the tasks faced by any given subject were as different from one another as possible Thus, whenever two valuations (e g , WTP_{21} and EL_{21}) were equivalent to one another according to Hicksian theory, one was elicited from one subgroup and one from the other

implication can be extended to comparisons across subgroups the probability that a randomly selected individual will reveal the implicit preference **a** > **d** is constant across both decision tasks and subgroups

V Results

The results are summarized in Tables I and II Table I refers to the eight tasks that involved Coke Each row refers to a distinct task The first column shows which subgroup faced this task, the next three columns identify the task by response mode, valuation measure, and reference point The last two columns report the distribution of implicit preferences between **a** and **d** (reported values are percentages, and sample sizes are given below the tables) Table II is constructed in a similar way, but the data refer to the eight tasks that involved chocolates

VA Reference Point Effects

We begin by examining the effect of changing the reference point, holding the response mode constant If reference-dependent theory is correct, then the proportion of subjects with an implicit preference for **a** over **d** should be less when the reference point is **b** or **c** than when it is **a,** and less when it is **d** than when it is **b** or **c.**

Inspecting the first four rows of Table I (the data for Coke when the response mode is money), notice that, as the reference point shifts from **a** (row 1) to **d** (row 4), there is a marked decrease

TABLE I
Implicit Preferences in Tasks Involving Coke

Subgroup	Response mode	Measure	Reference point	**a** > **d**	**d** > **a**
I	money	WTP_{21}	**a**	60 0	40 0
II	money	EL_{21}	**b**	50 0	50 0
I	money	EG_{21}	**c**	26 3	73 7
II	money	WTA_{21}	**d**	15 8	84 2
I	Coke	WTA_{12}	**a**	43 7	56 3
I	Coke	EL_{12}	**b**	43 7	56 3
II	Coke	EG_{12}	**c**	35 5	64 5
II	Coke	WTP_{12}	**d**	15 8	84 2

n – 80 for subgroup I n – 76 for subgroup II

TABLE II
IMPLICIT PREFERENCES IN TASKS INVOLVING CHOCOLATES

Subgroup	Response mode	Measure	Reference point	**a** > **d**	**d** > **a**
I	money	WTP_{21}	**a**	92 5	7 5
II	money	EL_{21}	**b**	92 1	7 9
I	money	EG_{21}	**c**	70 0	30 0
II	money	WTA_{21}	**d**	64 5	35 5
I	chocolate	WTA_{12}	**a**	92 5	7 5
I	chocolate	EL_{12}	**b**	75 0	25 0
II	chocolate	EG_{12}	**c**	81 6	18 4
II	chocolate	WTP_{12}	**d**	56 6	43 4

n = 80 for subgroup I, n – 76 for subgroup II

in the proportion of subjects with the implicit preference **a** ≻ **d** (from 60 percent to 16 percent) Notice also that the proportions revealing an implicit preference for **a** when the reference point is **b** or **c** (50 percent and 26 percent, respectively) are intermediate between the proportions observed for reference points **a** and **d.** A similar pattern is observed in the data for Coke when the response mode is Coke, and for chocolates for both response modes (Table II)[8] Thus, the data appear to follow the pattern implied by reference-dependent theory

Could these data also be explained in terms of random variation within a stochastic Hicksian preference model? Table III reports a set of tests of association between the distribution of implicit preferences between **a** and **d** and the reference points used to elicit them The extreme left-hand column indicates the reference points being compared The remaining columns contain chi-square statistics, one column for each combination of good (Coke or chocolates) and response mode These statistics are based on different combinations of rows from Tables I and II, though using raw data rather than percentages One value is recorded for each pairwise comparison between reference points except for that between **b** and **c,** where reference-dependent theory makes no definite prediction In addition, the final row of the

8 With one exception in the data for Coke when the response mode is Coke, the proportion of subjects with the implicit preference **a** > **d** when the reference point is **b** is equal to the corresponding proportion when the reference point is **a** Reference-dependent theory would lead us to expect this proportion to be lower when the reference point is **b**

table provides an overall test of association combining data for all four reference points

The general null hypothesis tested is that of no association between implicit preferences and reference points, as predicted by Hicksian theory These tests indicate significant violation of that theory the null is rejected in fourteen out of the twenty pairwise comparisons and hence, unsurprisingly, in the four aggregate tests too

Two of the pairwise comparisons in which the null is rejected are instances of the well-known divergence between *WTA* and *WTP* (comparisons between the reference points **a** and **d** when the response mode is money) These results add to the existing body of evidence of *WTA-WTP* disparities Since our design has controlled for income and substitution effects, these disparities are clearly contrary to Hicksian theory, and they are in the direction predicted by reference-dependent theory

The two comparisons between **a** and **d** when the response mode is the consumption good provide a new type of test for a divergence between *WTA* and *WTP* Here, too, the differences between implicit preferences are highly significant, contrary to Hicksian theory, and in the direction predicted by reference-dependent theory

Clearly, any theory that predicts a change in implicit preferences as the reference point shifts from **a** to **d** must also predict such a change for at least one of the reference point pairs (**a**,**b**) and (**b**,**d**), and similarly for at least one of the pairs (**a**,**c**) and (**c**,**d**) Thus, we need to be careful before claiming that the evidence from (**a**,**b**), (**b**,**d**), (**a**,**c**) and (**c**,**d**) comparisons provides *additional* support for reference-dependent theory But if we were to find significant (and correctly signed) changes in implicit preference for both (**a**,**b**) and (**b**,**d**), this *would* be new evidence in favor of reference-dependent theory, and not merely a predictable consequence of *WTA–WTP* disparities Similarly, significant changes in implicit preferences for both (**a**,**c**) and (**c**,**d**) would be new evidence for that theory There are eight cases in which such evidence can be looked for (two in each column of chi-square statistics in Table III) It can be found in two of those cases the combination of (**a**,**c**) and (**c**,**d**) for chocolates with chocolate as the response mode, and the combination of (**a**,**b**) and (**b**,**d**) for chocolates with chocolate as the response mode

On the basis of pairwise comparisons, then, we cannot draw firm conclusions about the effects of having **b** or **c**, rather than **a**

TABLE III
TESTS FOR REFERENCE POINT EFFECTS

	Good Coke Response mode		Good chocolates Response mode	
Comparison	Money	Coke	Money	Coke
a, b	1 58	0 0	0 09	9 00**
a, c	18 58**	1 10	13 29**	4 16*
a, d	32 19**	14 47**	18 35**	26 82**
b, d	20 15**	14 47**	17 07**	5 90*
c, d	2 56	7 76**	0 54	11 12**
a, b, c, d	1 62**	17 74**	30 99**	29 45**

*indicates significance at the 5 percent level
**indicates significance at the 1 percent level

or **d**, as reference points [9] One way to pursue this question further would be to analyze the data at a more aggregated level In subsection VC below we shall present such an analysis

VB Response Mode Effects

Table IV reports a set of eight tests for response mode effects These are chi-square tests of association between the distribution of implicit preferences over **a**,**d** and the response mode used to elicit them, in each test the reference point is held constant Recall that contingent weighting theory implies that shifting the response mode from money to the consumption good should tend to reduce the proportion of subjects with the implicit preference **a** > **d** (see Section III) To aid interpretation, we have placed a (−) in cells where switching the response mode from money to the consumption good has reduced the proportion of subjects with the implicit preference **a** > **d** and a (+) where there has been the opposite effect There are significant differences in two cases, and both have changes in the direction predicted by contingent weighting theory But while this suggests that changes in the response mode can matter, there is no obvious pattern in the data

9 One hypothesis that goes some way toward organizing the data is that there are no systematic differences between *WTP* and *EL* responses, or between *WTA* and *EG* responses This hypothesis would lead us to expect no significant differences in implicit preferences over the reference point pairs (**a**,**b**) or (**c**,**d**) when the response mode is money, and no significant differences over (**a**,**c**) or (**b**,**d**) when the response mode is the consumption good Five out of the six insignificant chi-square statistics fit this pattern, but there are three significant statistics that do not fit it

TABLE IV
TESTS FOR RESPONSE MODE EFFECTS

Reference point	Good Coke	Good chocolates
a	4 23* (−)	0 0
b	0 61 (−)	8 21** (−)
c	1 58 (+)	2 84 (+)
d	0 0	0 99 (−)

*indicates significance at the 5 percent level
**indicates significance at the 1 percent level

as a whole Again, it seems that a more aggregated analysis is needed if we are to draw firm conclusions

V C Econometric Analysis

Table V presents a summary of an econometric analysis of the aggregated data Two models, one for each of the goods, were estimated using the Probit routine in LIMDEP The dependent variable was the implicit preference ranking of **a** and **d** (coded 0 if **a** < **d**; 1 if **a** > **d**) Three dummy variables, *BREF, CREF, DREF,* were introduced to model the impact of changes in the reference point, using reference point **a** as the benchmark *BREF* was coded with a value of 1 when the reference point was **b,** 0 otherwise, *CREF* and *DREF* were constructed in a similar way for reference points **c** and **d,** respectively Finally, a dummy variable *RMODE* was introduced, with a value of one when the response mode was the consumption good, zero otherwise The final row of the table reports likelihood ratio statistics for the two models

A priori expectations based on the Hicksian model suggest *BREF* = *CREF* = *DREF* = *RMODE* = 0 Alternatively, reference-dependent theory suggests that 0 > *BREF, CREF* > *DREF,* and contingent weighting theory implies *RMODE* < 0

The estimation results may be summarized as follows The restriction that all slope coefficients are zero (the Hicksian model) is confidently rejected for both goods on the basis of the likelihood ratio test (1 percent) There is little support for a response mode effect although *RMODE* is correctly signed in each case, it is never significantly different from zero The results, however, are largely consistent with the implications of reference-dependent theory all six reference point dummies are correctly signed, they

TABLE V
AGGREGATE PROBIT ANALYSIS

	Good Coke	Good chocolates
Constant	0.073 (0.652)	1.504 (9.425)
Regression coefficient with respect to		
BREF	−0.111 (−0.785)	−0.466 (−2.455)
CREF	−0.534 (−3.699)	−0.749 (−4.084)
DREF	−1.035 (−6.561)	−1.174 (−6.531)
RMODE	−0.084 (−0.793)	−0.125 (−1.070)
log-likelihood	−380.936	−300.909
log-*L* (slopes = 0)	−409.072	−327.163
$X^2(4)$	56.271	52.507

t-ratios are in parentheses.
Dependent variable = (0 if **d** > **a**; 1 if **a** > **d**).

are strongly significant (1 percent) in all but one case (*BREF* is not significant in the model for Coke), and *DREF* has the largest quantitative effect in each case. In both models, each of the hypotheses *BREF* = *DREF* and *CREF* = *DREF* can be rejected at the 1 percent level in favor of the alternative hypotheses that *BREF* > *DREF* and *CREF* > *DREF*.

V.D. Comparing Coke with Chocolates

As explained in Section IV, when designing the experiment, we thought of Coke and chocolates as representatives of different types of good: we could be fairly confident that many subjects would have experience in buying and consuming Coke, while few would have such experience for the premium brand of chocolates that we used. Our prior hunch was that reference point effects, if they occurred at all, would be stronger for chocolates than for Coke.

In fact, our results show considerable similarity between responses for the two goods. In particular, for each good (and for either response mode), moving the reference point from **a** to **d** is associated with a large and statistically significant reduction in the proportion of subjects with an implicit preference for **a** over **d**. However, the data for chocolates are marginally more supportive of reference-dependent theory than are the data for Coke.[10]

10. The number of significant pairwise comparisons in Table III is greater when the good is chocolate than when it is Coke; all three of the reference point dummies are significant in the chocolate equation while only two are in the Coke equation.

Since our experiment was not designed to be a formal test of the hypothesis that the day-to-day experience of buying a good tends to reduce reference point effects, we cannot draw firm conclusions on this issue.

VI. Conclusions

The principal objective of the research reported in this paper was to test a set of predictions derived from the loss aversion hypothesis of the theory of reference-dependent preferences. We have identified eight alternative methods of eliciting an individual's preferences between money and a consumption good; most previous investigations of disparities between valuation measures have focused on just two of these. Hicksian consumer theory implies that these methods will elicit a common system of preferences, while reference-dependent theory predicts systematic divergences between them. Our main result is that significant divergences do occur, and that these divergences are in the directions predicted by reference-dependent theory.

Our experiment elicited valuations for two private consumption goods, one of which is sold in almost every supermarket and would have been extremely familiar to most subjects. The experiment was incentive-compatible and controlled for income and substitution effects. In respect of divergences between willingness-to-accept (*WTA*) and willingness-to-pay (*WTP*) valuations, our results are consistent with those of a large number of other experiments and field surveys. In the light of this evidence, it seems that the influence of loss aversion is a robust effect.

If loss aversion is a fundamental property of many people's preferences, then observed divergences between different valuation measures must be attributed, not to biases in elicitation methods, but to the limitations of Hicksian consumer theory. The challenge for economics is then to design measures of welfare change that are compatible with reference-dependent preferences.

However, our results are open to an alternative interpretation. It might be suggested that loss aversion, although resulting from predictable psychological mechanisms of the kind modeled by reference-dependent theory, is a relatively superficial phenomenon which would quickly be eroded by the experience of buying and selling the relevant good. On this view, experienced economic agents in real-world markets might behave according to Hicksian theory, even though laboratory subjects and survey respondents do not. This is an issue that clearly needs to be investigated We suggest that a precondition for such an investigation is that defenders of Hicksian theory propose testable hypotheses about the precise mechanisms by which market experience induces Hicksian behavior

If such a hypothesis were to be proposed and to be confirmed by empirical tests, then preferences revealed in market behavior might be interpreted as "true" preferences However, economists would still be left with the problem of discovering an unbiased method of eliciting individuals' preferences for nontraded goods, and so it would still be important to understand the way loss aversion impacts on survey responses

There seems to be a consensus in the contingent valuation literature that *WTP* measures should be preferred to *WTA* ones (e g , Arrow et al [1993]), but the merits and demerits of other measures are rarely discussed Those economists who argue that divergences between *WTA* and *WTP* would disappear with market experience have usually predicted that market-induced convergence would be toward initial *WTP* valuations (e g , Coursey, Hovis, and Schulze [1987]) But if reference-dependent theory is accepted as the explanation of those divergences, it is not obvious that *WTP* is the natural point of convergence For example, suppose that the difference between individuals with and without market experience is that the latter tend to overweight losses Then we might expect equivalent gain measures, which establish equivalences between gains of the relevant good and gains of money, to be less biased than *WTP* measures, in which losses of money compensate for gains of the good We hope that our work will lead to further investigation of the possibility of eliciting preferences using welfare measures other than *WTP* and *WTA*

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