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IMPROVING THE SENSITIVITY OF THE TIME TRADE-OFF METHOD: RESULTS OF AN EXPERIMENT USING CHAINED TTO QUESTIONS

by

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Abstract

We present a new approach to estimating health gains from treatments by asking respondents to directly compare the 'before' and 'after' treatment health states in the time trade-off (TTO) framework. We found that responses to these direct comparisons were much more likely to capture a perceived change in health status than the usual approach to TTO estimation. This is an important finding because the TTO method is preferred by practitioners to many other generic methods of health status valuation on empirical grounds and yet still revolves around the notion of opportunity cost, which is central to consumer theory, by requiring respondents to express their preferences by foregoing some of one good in exchange for more of another (unlike a rating scale).

Acknowledgments

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I. Introduction

A problem facing both privately and publicly funded health care systems is that there are more treatments and services needed than can be afforded. This problem is not unique to health care, it pervades everyday life, which is why much of microeconomics is devoted to the allocation of scarce resources. Health economists have used various means of evaluating health and health care: disease specific methods (e.g., Kurtzkes Extended Disability Status Scale), 'activities of daily living' measures (e.g., Functional Independence Measure), pro-forma approaches (e.g., SF-36, Euroqol), and generally applicable methods of evaluation such as those provided by mainstream economics (e.g., willingness to pay, standard gamble), and those designed for the evaluation of health (e.g., time trade-off, healthy-years-equivalent). A shortcoming shared by many methods used to elicit health related quality of life values is that, typically, the more versatile the method the less sensitive it is to small (but important) changes in quality of life. These methods can identify the treatments that give the biggest health improvements and this in itself is informative, but a simple measure of health gain is insufficient information for allocating health care resources. It is necessary to know the value of health gains relative to their cost. Provision of a treatment that brings about only a small health improvement but at a very low cost may be considered preferable to one that brings about large health improvement at a disproportionately higher cost. Therefore it is important that treatments giving small health improvements not be neglected due to the inability of some methods to detect those changes. In assessing health gains from surgical and orthotic interventions, this study uses SF-36 and, in case a *pro forma* method is not sufficiently sensitive to register relatively small changes in quality of life, a general method of health status valuation, time trade-off (TTO), is also employed.

The main purpose of the study is to investigate the feasibility and sensitivity of SF-36 and TTO in assessing the impact of surgical and orthotic interventions on the health related quality of life of severely disabled patients and their carers. Most patients have both profound intellectual and multiple physical disabilities (e.g., Cerebral Palsy) and any interventions employed can only be expected to bring about small improvements in motor skill. Given this context, the sensitivity of the outcomes measurement methods used is a primary concern. This sensitivity is the subject of this paper.

II. Sample and Method

A sample size of between 20 and 30 subjects was considered adequate for the main study as data collection on each individual was detailed, and processed as case-reports. Furthermore, there are few patients with complex physical disabilities within a geographical region for whom surgical or orthotic intervention could be expected to be of significant benefit. Twenty seven patients with profound and multiple disabilities referred to the Orthopaedic and Orthotic Departments at Dundee Royal Infirmary and the Dundee Limb Fitting Centre in Scotland were recruited for the study. The patients were all scheduled to receive surgical intervention, orthotic devices, customised seating or powered wheelchairs.

Some valuation methods, though theoretically sound, are simply not appropriate in some contexts. In this study the objective was to assess the benefits of surgical or orthotic interventions on patients with complex physical disabilities and the indirect effect of these interventions on the patients' carers (usually a parent). To do this, quality of life improvements are estimated both for the patient and their primary carer. The latter is important since the nature of the disorder means that any improvements in motor skill could have important benefits for the carer as well as the patient. It is prudent to evaluate benefits to both carers and patients using the same methods since it is the carer that will be assessing their

own as well as the patient's quality of life improvements. Using too many methods, each of which must be explained to the respondent, could lead to information overload and hence respondent fatigue. Also, inconsistencies between methods of evaluation are well documented (eg, Read *et al* 1984; Hornberger *et al* 1992; Jones-Lee *et al* 1995; Morrison 1996; Krabbe et al 1997), so in order to compare benefits to the patients and those accruing to their carer it is necessary that the same method be used for both. Having decided that patients' and carers' quality of life should be evaluated using the same methods, methods that are sensible for both must be chosen. Of the available general methods of health status evaluation, TTO (Torrance *et al* 1972 & 1986) is used because it seems the most suitable in this context.[1] For example, asking carers (who are usually the patient's parent) what they are willing to pay to cure their child, when there is in fact no cure, is in bad taste to say the least. In any case, asking their willingness to pay for the treatment their child receives is fraught with problems in a country with public health insurance since there is a tendency for people to give a 'protest' response because they feel it is wrong to be charged when the health service is funded through general taxation. Alternatively, asking carers how much of a risk of death they would be willing to accept to avoid being a carer, as in a standard gamble question, is just a silly question. The choice of TTO is also in agreement with others who have found TTO preferable to standard gambles (SG) on empirical or theoretical grounds (e.g., Torrance 1976; Richardson 1994).

Each patient's principal carer (usually a parent) completed health related quality of life questionnaires both on the patient's behalf, and with respect to themselves. The questionnaires were completed in a face-to-face interview in a home visit. Quality of life was assessed both before and after the scheduled intervention took place. In the population of interest, it is difficult to predict when the intervention will actually reach some end-point, since there is no standardised intervention or process--interventions need to be customised to the

[1] The TTO questions used in the survey are reproduced in appendix A.

individual patients more than they do for most treatments or services. Therefore, some patients may experience no problems, complications, or need for modifications relating to their intervention, while others may remain in the 'intervention process' for some period of time. Consequently, as a general rule, we decided to administer the post-intervention SF-36 questionnaire 3-6 months after completion of the initial intervention, and again between 6 months and one year. The TTO post-intervention questionnaires were administered 3-6 months after intervention for nine cases, but for the 15 surgical patients they were completed 9-12 months after surgery because of the longer period of rehabilitation. There are 24 patients that completed both pre- and post-intervention questionnaires.

III. The Alternative TTO Approach

Methods of forming health status indices can be insensitive to small changes in quality of life. The main purpose of this study was to investigate the quality of life improvements resulting from surgical or orthotic intervention on patients with complex physical disabilities. Given the nature of these disabilities (most patients were children with Cerebral Palsy) only small improvements can be expected for the patients and, especially, for their carers. In case the usual approach to chronic health state TTO estimation was not sensitive enough to pick up changes in quality of life, we incorporated a modified TTO method whereby respondents were asked to directly compare the two health states of interest—that is, the pre- and post-intervention states. The alternative TTO approach involves two stages. First a scaled value for the pre-intervention health states (of the patient and the carer) are obtained using the usual TTO approach. Then, respondents are asked to compare the pre-intervention and post-intervention states directly by stating how many years of life they would be willing to give up in order to be in the post-intervention state of health rather than the pre-intervention state. The TTO estimation for temporary health states offers people a worse state of health for a

shorter duration than that of their current ill state—they are asked how much shorter the duration would have to be in order to make them indifferent between their current state and the worse state. The variation we employed is more similar, in rationale, to the usual and 'chained' gamble approaches of the standard gamble (SG) method whereby two SG questions can be combined to arrive at a scaled utility between death, 0, and normal health, 1.[2]

The reasoning is as follows. Figures 1a and 1b show for the pre- and post-intervention health states, respectively, the usual TTO approach to valuing chronic health states. That is, "full" or "normal" health is taken to have a scaling of 1, death a scaling of 0, and the health states of interest are scaled relative to those two anchors. However, although respondents could state their responses to the nearest day, it seems likely that they would round to the nearest month or year. Moreover, in constructing the questionnaires we considered the possibility that even if a surgical or orthotic intervention did bring about a perceived improvement in a patient's health state, both the pre- and post-intervention states would be a long way from what could be considered normal health. This could exacerbate the rounding of responses. Such rounding could lead to the usual TTO approach failing to register a change in health state before and after intervention, even if one were perceived to have occurred. But, if there is a perceived change, then that should be picked up by asking respondents to explicitly compare the 'pre' and 'post' intervention health states. This is what our measurement approach is intended to do. As in figure 1c, the pre-intervention health state is scaled relative to the post-intervention state and death. The scaling obtained in the usual way for the post-intervention state (fig 1b) is then used to assign a value to that state when calculating the pre-intervention health state scale from the approach used in figure 1c.

[2] This is mentioned simply because the same rationale applies. The independence axiom of von Neumann-Morgenstern's Expected Utility Theory dictates that the same expected utility should be obtained when this two stage approach is used as when the one stage is used. This theory does not apply to the TTO method, but given that TTO assumes no time preference (or that HS values are linear with respect to time), by extension it should

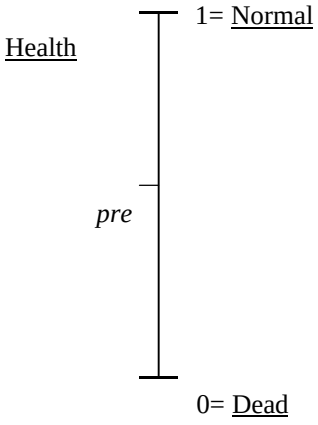

Fig. 1a.

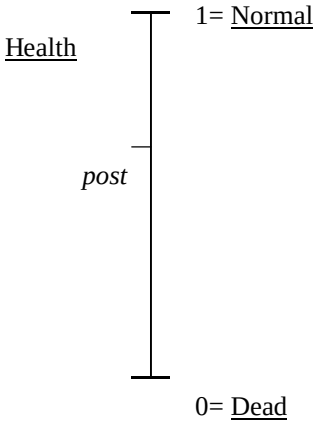

Fig. 1b.

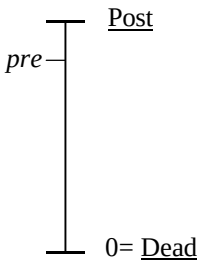

Fig. 1c.

Scales of reference. Figures 1a & 1b relate to the usual TTO valuation of pre- and post-intervention health states, respectively, whereby respondents are asked to value the pre/post intervention state relative to normal health and immediate death (N.B., trading off all available time is accepting immediate death). Figure 1c depicts the alternative approach to TTO valuation, where the respondent is asked to value the pre-intervention state relative to the post-intervention state and immediate death.

The calculation of health status scalings using the usual approach to TTO are as follows. First, to evaluate the severity of the pre-intervention health state, respondents are asked how many years (*x1*) in "normal health" would be equivalent to spending *T* more years in their current state of health. The scaling for the pre-intervention state is calculated as,

$$pre = x1/T. \quad (1)$$

So, if the respondent considers their pre-intervention health state to be as good as normal health, then *x1* will be equal to *T*. Similarly, the scaling for post-intervention state is calculated using the number of years in normal health (*x2*) that the respondent feels would be equivalent to spending *T* years in their post intervention state—that is,

$$post = x2/T\,. \quad (2)$$

Using our approach of allowing respondents to directly compare their pre- and post-intervention health states, the health status scaling for the pre-intervention state is calculated

not matter whether health state 'X' is valued relative to normal health or any other health state better than 'X.'

using the post-intervention scaling (*post*) just described. The respondent states how many years (*x3*) in the post-intervention health state would be equivalent to *T* years in their pre-intervention health state. This direct comparison of the pre- and post-intervention states gives an alternative scaling for the pre-intervention state: $pre^{\text{alt}} = (x3/T) \times post$, or

$$pre^{\text{alt}} = (x3/T) \times (x2/T). \tag{3}$$

Figure 2 illustrates the two approaches to obtaining TTO estimates of health status values. In both approaches to TTO scaling, the respondent is asked to trade-off some time in exchange for a better health state. The amount of time traded-off is measured on the horizontal axis and the health status value on the vertical axis. The usual TTO approach to valuing health states is represented by the measurable value function stretching from T on the horizontal axis to normal health on the vertical axis (because the better health state offered in the question is normal health). The alternative approach is represented by the value function extending from, again, T on the horizontal axis to the "better" health state offered in the question. This could be any health state considered worse than "normal health" and better than the state being valued. For our purposes it is the post-intervention state. In both TTO approaches, the more time is traded-off the lower the associated health status value. If an individual were willing to trade-off all time available to them (i.e., they choose the point where the value function intercepts the horizontal axis), then that individual considers the health state being valued to be equal to death. Conversely if they were unwilling to give up any time at all, then this indicates that they consider that state to be at least as good as the "better" health state (normal health in the case of the usual TTO or the post-intervention health state in the alternative TTO approach).

If the source of the insensitivity in the usual TTO method *is* the rounding of responses, the alternative TTO approach described above might facilitate the collection of more precise

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If there is no time preference, then the same health status scaling should emerge.

responses. The TTO method assumes that there is a constant trade-off between health and time—that is, it assumes that there is no discounting. If this is the case (and it was

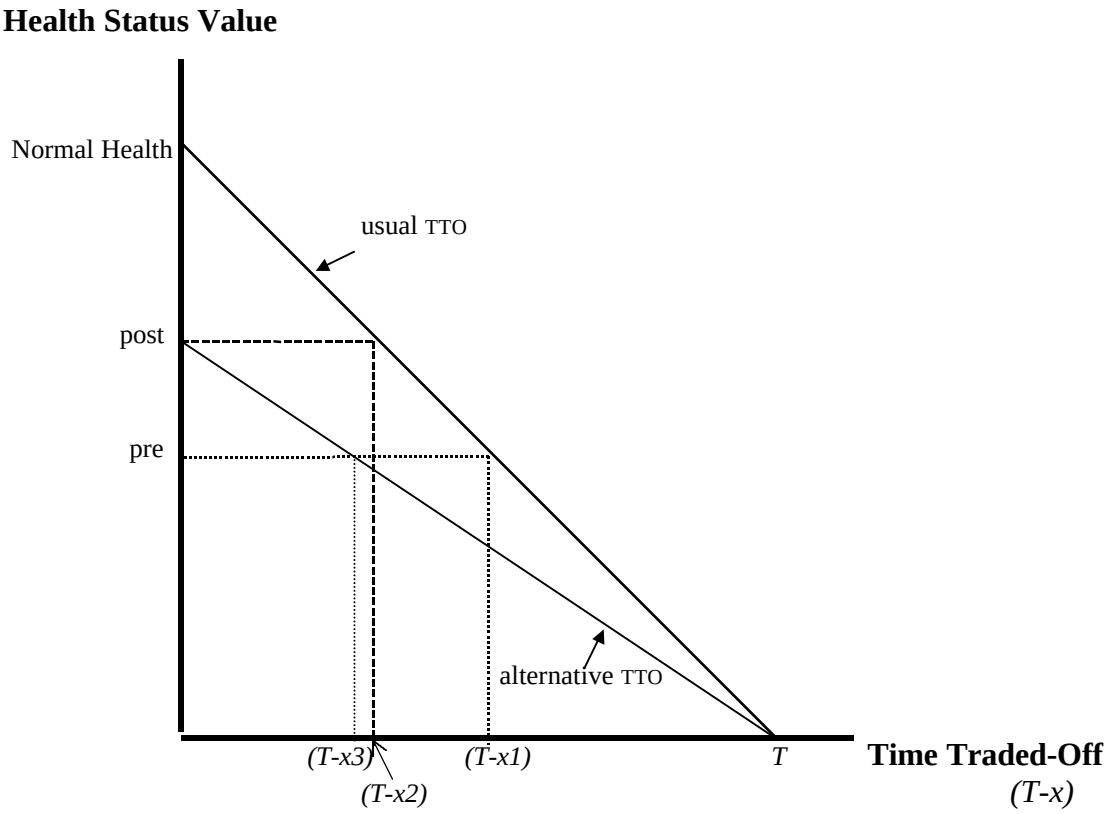


Figure 2. Usual and alternative TTO values: chronic health states
The amount of time traded-off is measured on the horizontal axis, while the associated health status values are measured on the vertical axis. For the usual TTO questions, the best attainable health state is 'normal health.' For the alternative TTO approach, the question presents respondents with a best attainable health state that is better than the reference state but worse than 'normal health.' In this experiment, the reference state was the pre-intervention health state while the best attainable state in the alternative TTO question was the post-intervention health state. For patients, T=50 and for carers, T=75. Holding the best health state constant (eg, normal health), more time traded-off indicates a more serious disability/illness. If the standard TTO assumption of constant trade-off between time and health holds, then regardless of whether the usual or alternative TTO approach is used, the same value estimate should be obtained.

found to be so by Dolan *et al* 1995), then the alternative TTO should obtain the same health status scalings as the usual TTO. If the respondents do not round their responses, then the scaling estimates for the pre-intervention state obtained from equations (1) and (3) will be

equal (apart from error). The focus of this paper is the sensitivity of and consistency between these two approaches to TTO scaling estimation.

IV. Results

4.1 Usual and alternative TTO scalings

The usual and alternative TTO scaling calculations are summarised in table 1. Table 2 presents the TTO responses and the resulting health status scalings while table 3 shows the ratios of the pre- and post-intervention health states. Considering the results from the 'usual' TTO approach, the treatment appears to bring about some improvement in the patients' quality of life, but none for the carers. The amount of health gained inferred from the usual TTO health scaling estimates are 0.07 and 0.00 for the patients and carers, respectively. The near one to one relationship between the pre- and post-intervention quality of life of the carers, shown in table 3, supports this suggestion that the intervention yields no health gain to the carers. Wilcoxon matched-pairs signed-ranks tests[3] were used to ascertain if there is a statistically significant difference between the pre- and post-intervention health status values. The results in table 4 confirm that there is no significant change for the carers, but also reveals that (at α=.01) there is no statistically significant improvement for the patient. That is, at the 1% level of significance (the preferred significance level given the necessarily small sample used in the experiment), the null hypothesis that the usual TTO scaling estimates for the pre-intervention and post-intervention states are equal could not be rejected for either the carer or the patient. This suggests that the intervention is not worth performing and, yet, when the

[3] Scaled responses often do not follow a normal distribution. Since the measures of skewness and kurtosis support this expectation, non-parametric statistics are used.

carers were asked more generally about their views on the intervention, they said that there was a change. Although, for the patients, the null of no change *can* be rejected at α=.05, the 'usual' TTO approach to health status scaling is not as sensitive as it might be to perceived changes in quality of life.

Table 1. Scale Calculations from TTO Responses:
years in normal health considered equivalent to T years in the state being valued

	Usual TTO Approach		**Alternative TTO**
	Pre-intervention	Post-intervention	Pre-intervention
TTO response	*x1*	*x2*	*x3*
HS scale calculation	*x1/T*	*x2/T*	*(x3/T)×(x2/T)*

Table 2. TTO Responses and Health Status Scalings

	Usual TTO Approach		**Alternative TTO**
	Pre-intervention (*x1*)	Post-intervention (*x2*)	Pre-intervention (*x3*)
Patient			
TTO response (*T*=50)	36.65 (38.00) [12.86]	40.22 (40.00) [10.25]	38.39 (40.00) [11.67]
HS scaling	.7330 (.7600) [.2572]	.8044 (.8000) [.2049]	.6351 (.6400) [.2839]
Carer			
TTO response (*T*=75)	70.39 (75.00) [8.22]	70.74 (75.00) [8.82]	68.83 (75.00) [9.50]
HS scaling	.9386 (1.0000) [.1096]	.9432 (1.0000) [.1176]	.8759 (.9735) [.1861]

cells display mean, (median), and [standard deviation]. The scale ranges from 0 for death, to 1 for normal health.

Table 3. Ratio of Pre- and Post-Intervention Health States (pre:post)

	Usual TTO	**Alternative TTO**
Patient	0.902:1 (1:1) [0.205]	0.768:1 (0.8:1) [0.233]
Carer	0.998:1 (1:1) [0.044]	0.918:1 (1:1) [0.127]

Table 4. Comparing the Pre-Intervention, Post-Intervention, and Alternative-TTO Scalings: Wilcoxon matched-pairs signed-ranks tests

	Pre- versus Post-Intervention Scaling *(one-tailed tests)*		**Usual vs Alternative scaling** *(two-tailed tests)*
	Usual TTO	Alternative TTO	Internal Consistency
Patient	p=.0105 (z=-2.3102)	p=.0005 (z=-3.2958)	p=.0132 (z=-2.4797)
Carer	p=.2965 (z=-0.5345)	p=.0026 (z=-2.8031)	p=.0069 (z=-2.7011)

As previously noted, while designing the questionnaire it was considered that the usual TTO approach to health status scaling might be insensitive to quality of life changes in the patients in this study. Specifically, it was thought that people might round their TTO responses to the nearest year or month rather than the nearest week or day. Thus the usual TTO approach might obtain the same scaling for the pre- and post-intervention states even if there were a perceived change—indeed, as just discussed, this is what happened. Herein lies the advantage of the alternative TTO approach to health status measurement. In asking respondents to directly compare pre- and post-intervention quality of life, individual responses are more likely to pick up on perceived changes. From table 2 we see that on average the respondents consider that a patient spending about 38 years in the post-intervention state is equivalent to 50 years in their pre-intervention state. With respect to the carer, the mean response was that about 69 years of caring for the patient in the post-intervention state is equivalent to 75 years in the pre-intervention state. So when asked to directly compare the two health states of interest, individuals do indicate an improvement.

This is useful in assessing whether or not a treatment brought about an improvement. But how can we use these results to assess the quality of life benefits of this treatment relative to another? Just as the standard gamble (SG) method can be used to directly compare two intermediate health states and then, through a second stage question, adjust that response to put it on a scale relative to normal health and death. The same general approach of

transforming the scaling from the direct comparison is used here. That is, the pre-intervention health state is valued relative to the post-intervention state and death, and then the value for the post-intervention state obtained in the usual way is used to place the pre-intervention state on a scale between normal health and death.

Both the scaled values in table 2 and ratios in table 3 suggest that the interventions brought about an improvement in the quality of life of the patient, and of the carer. More specifically, from table 2 we see that the alternative TTO scalings indicate a health gain of 0.17 and 0.07 for the patients and carers, respectively. So, not only do the carers say that there is an improvement, the TTO method picks up that significant change when respondents are allowed to compare the pre- and post-intervention states directly—the alternative TTO approach appears to be more sensitive than the usual approach. Furthermore, the results of the Wilcoxon matched-pairs signed-ranks tests presented in table 4 support this finding. That is, at α=.01 the null hypothesis that the pre- and post-intervention health state values are equal must be rejected in favour of the alternative hypothesis that the pre-intervention state as measured using the alternative TTO approach has a lower health status value than the post-intervention health state. This is the case both for the patient and the carer, whereas using the usual TTO approach the null hypothesis of no significant improvement could only be rejected with respect to the patient. So, the alternative TTO approach is more sensitive to quality of life improvements than the usual approach.

4.2 Internal consistency

Given that the alternative TTO approach detects an improvement between the pre- and post-intervention health states when the usual approach does not, it is natural to question the internal consistency of the method. In particular, are the usual and alternative estimates of the pre-intervention health state value equal? If there is a constant trade-off between health and

time, and if respondents do not round their responses, then they should be equal. Indeed, we cannot reject the hypothesis that they are equal at α=.01 for the patients' quality of life; but we must reject it with respect to that of the carer. Since the alternative TTO approach was devised *because* we expected that the usual approach would be too insensitive to detect a change between the before and after treatment health states, this is not worrying. In fact it is what the alternative approach is intended to do.

Having considered the within subject statistical consistency between the usual and alternative approaches to eliciting TTO values, we must consider the logical consistency of individual subjects' responses. First, consider what constitutes a consistent response. Let T be the maximum remaining years of life that the TTO questions allow an individual to have. Using the notation introduced in section 3, $x1$ and $x2$ are the responses to the usual TTO approach of asking what number of years in normal health are equivalent to T years in the pre- and post-intervention states, respectively. The response to the alternative TTO approach relating to the number of years in the post-intervention state that are considered equivalent to T years in the pre-intervention state is denoted by $x3$. An individual is said to be strictly consistent if their responses to the three questions fit the following pattern: $x1 = x2 \leq T$ *and* $x3 = T$. That is, if they are willing to trade-off the same number of years when valuing the post- as the pre-intervention states in the usual TTO method, then they should consider the two state to be equal (i.e., trade-off no time) when they compare them directly in the alternative TTO approach. Similarly, a respondent can be considered broadly consistent if they answer that $x1 \prec x2$ *and* $x3 \prec T$, even if the calculated value for the pre-intervention state from the usual and alternative approaches are not equal. This is because such a response does not indicate a preference reversal.

However, responses that do suggest a partial or complete preference reversal are considered to be logically inconsistent. Respondents are labelled strictly inconsistent if they

answer in either of the following ways: $x1 \neq x2 \ \ and \ \ x3 = T$, or $x1 \succ x2 \ \ and \ \ x3 \prec T$. In the first case, the individual indicates that there is a difference between the pre- and post-intervention state when asked about each separately (usual TTO), but then state that there is no difference when asked to directly compare the two. This is a partial preference reversal. In the latter case the respondent prefers the pre-intervention state when asked to assess the two separately, and then reverses that preference when asked to compare the two directly. A respondent that states $x1 = x2 \leq T \ \ and \ \ x3 \prec T$ is weakly inconsistent, since if they are willing to trade-off the same number of years when valuing the two states separately in the usual TTO method, then they should not be willing to trade-off any time when they compare them directly. This last form of inconsistency is seen as only weakly inconsistent because such answers would only be inconsistent if we did not anticipate the rounding of responses. But this is precisely the sort of insensitivity that the alternative TTO approach is intended to overcome.

Table 5 lists the number of people whose responses are consistent or inconsistent following these definitions. This is done both for answers concerning the patient and the carer. The majority of the 23 subjects responded in a consistent manner both with respect to the patient and the carer, and in each case only 1 responded in a strictly inconsistent manner (a different person did so with respect to the patient than with respect to the carer). There are 5 responses regarding patients and 7 regarding carers which are weakly inconsistent—that is their inconsistency is of a form suggesting that they rounded their responses to the usual TTO form of question. For these individuals, the alternative TTO approach is sensitive enough to detect a change between the before and after treatment states, whereas the usual TTO method was unable to distinguish between the two.

Table 5. Logical Consistency of Responses

	Patients	**Carers**

Strictly Consistent		
$x1 = x2 \prec T \quad \& \quad x3 = T$	3	2
$x1 = x2 = x3 = T$	6	11
Consistent		
$x1 \prec x2 \quad \& \quad x3 \prec T$	8	2
Strictly Inconsistent		
$x1 \neq x2 \quad \& \quad x3 = T$	0	0
$x1 \succ x2 \quad \& \quad x3 \prec T$	1	1
Weakly Inconsistent		
$x1 = x2 = T \quad \& \quad x3 \prec T$	2	2
$x1 = x2 \prec T \quad \& \quad x3 \prec T$	3	5

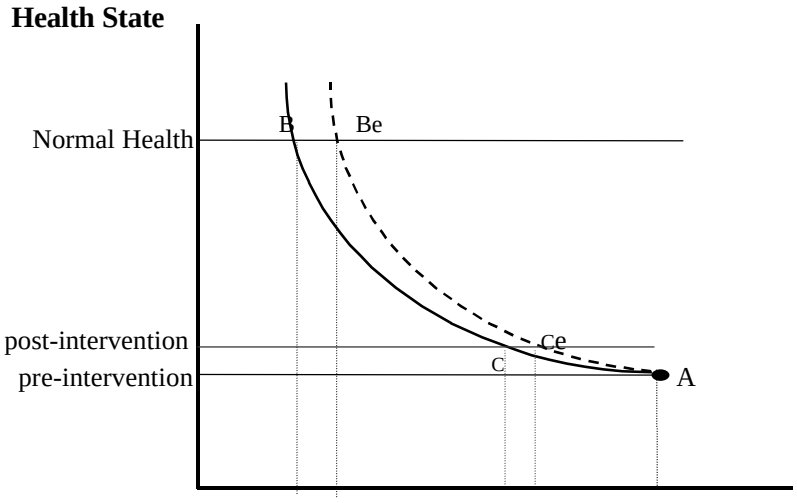
4.3 Sources of inconsistency: error, imprecise preferences, discounting, endowment effect

Rather than simply assuming that any inconsistencies between the usual and alternative TTO health status value estimates for the pre-intervention state are entirely due to the usual approach's insensitivity stemming from rounding, it is necessary to examine other possible sources. Respondent error is always a possibility, but given that only one response indicated a preference reversal regarding the patient and one regarding the carer, the respondents do not appear to have been confused by the questions. So there is no reason to assume that the weakly inconsistent responses were driven by confusion. However, they could be the result of imprecise preferences.

In a study using willingness to pay to value road safety, individuals showed considerable imprecision in their responses (Dubourg *et al* 1994 & 1997). Since people are used to trading-off money for goods in everyday purchases, it is reasonable to assume that they would show at least the same degree of imprecision when asked to express their value in an unfamiliar medium of exchange. It seems likely then that respondents are imprecise when asked to trade-off some of their life expectancy in exchange for a better state of health. Indeed, rounding could in part be caused by imprecise preferences. This seems particularly likely when respondents are asked to compare two health states as disparate as the pre- (or

post-) intervention health state and normal health. It is easy to see that a little imprecision in such responses could lead to identical answers for the pre- and post-intervention states. An advantage of the alternative TTO approach is that it allows the direct comparison of the two relevant states (here both states involve severe disability), but adjusts the frame of comparison such that even imprecise responses can reflect a perceived difference. If this is the source of the difference between the alternative and usual TTO values for the pre-intervention state, then we would argue that this is a good thing. It is this sort of insensitivity of the TTO method that we were trying to overcome in introducing the alternative approach.

Discounting is another possible source of inconsistency. The TTO method assumes no time preference, and a constant trade-off between health status and time, hence the straight lines in the illustration of the TTO health status values in figure 2. However, this does not mean that the indifference curves depicting the TTO decision in figure 3 must be straight lines. A value function is simply an ordinal utility function, so the fact that the TTO method requires the health status values to be linear with respect to time does not imply that the associated utility function must be linear. That is, even given the assumptions of the TTO value calculations, an individual's utility function can exhibit diminishing marginal utility. Consequently the decision involved in the TTO method can be illustrated with a utility curve that is convex to the origin as in Mehrez and Gafni (1990).



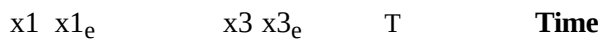


Figure 3. The Endowment Effect and the TTO Method

The TTO method for valuing the pre-intervention state is depicted here both with and without an endowment effect. Whether using the usual or alternative TTO approach, point *A* is the point of endowment when valuing the pre-intervention health state. The solid indifference curve relates to a TTO response where there is no endowment effect. The usual TTO method asks people to state how many years of life they would give up in order to improve their health state from the pre-intervention state to normal health. This can be illustrated as the movement from point *A* (where they will be in the pre-intervention state for their remaining years of life, *T*) to point *B* (where they will be in a state of normal (full) health for *x1* years). That is, the individual is willing to trade-off $(T - x1)$ years in order to have a state of normal health instead of remaining in the pre-intervention state. If an endowment effect is present, then it will manifest itself through respondents being less willing to give up any of the time that they have left. In this case the usual TTO decision can be illustrated by the movement from point *A* to point *Be* along the dashed utility curve (i.e., they will give up $(T - x1_e) \prec (T - x1)$ years of life in exchange for a normal state of health. So, if there is an endowment effect, then the respondent will be willing to give up fewer years of life and the resulting health status value will be higher than if there were no endowment effect. The alternative TTO approach involves a movement from *A* to *C* on the solid utility curve if there is no endowment effect, or a movement from *A* to *Ce* if an endowment effect is present. Again, fewer years are traded-off if there is an endowment effect $(T - x3_e)$ than if there is not $(T - x3)$, and the health status scaling is higher where there is an endowment effect.

There is some evidence in the literature that people do discount future health and that their discount rate is not even constant over future years (e.g., Olsen 1993; Cairns 1994; Cairns et al 1997). Since duration of illness is an integral part of any health state description, the incorporation of time preference in responses is not a problem in itself. Indeed, discounting could be considered a good thing with respect to health status valuation. Although Broome (1993) argues that individuals that discount their good over time are not maximising their total good, it can equally be argued that discounting with respect to health accounts not only for simple time preference, but also for the fact that as people age, their state of health diminishes. For example, a hip replacement might get a person out of a wheel chair for this year, but, weakness brought on by the ageing process might have them back in a wheel chair in ten years—how much benefit do they get from a working hip in that tenth year? Individual's exhibiting time preference in their responses may be consciously incorporating this into their response.

Dolan and Jones-Lee (1997) discuss the effects of discounting and of a lifetime reallocation of consumption (i.e., people consume more of their accumulated wealth each year

if they live for fewer years) on TTO scores. They showed that the former would impose a downward bias on TTO scores, that bias being greater the more severe the illness under consideration, while the latter would not be expected to have much of an effect. Such a downward bias in the TTO health status values is intuitive. That is, if year *T* is discounted such that it is only worth 0.95 of a year to the individual, then they are that much more willing to give up that year. The results of this experiment could fit into this discounting scenario. The disparity observed here is that the TTO values for the pre-intervention state obtained using the usual TTO method exceed those obtained from the alternative approach (see table 2). The alternative approach involves two steps. The pre-intervention state is valued relative to the post-intervention state (and death), and the post-intervention state is valued relative to normal health (and death). In each case the full life expectancy of *T* is used when asking how much time individuals would trade-off. If people are indeed discounting future years, then they will do this in each of these two steps. Consequently, any discounting would be compounded across the two stages when the alternative TTO approach to health status valuation is used. However, a study examining discounting in the TTO method found a constant trade-off between health and time (Dolan *et al*, 1995)—that is, they found no evidence of discounting. Distinguishing between discounting and imprecise preferences is beyond the scope of this experiment. But given the evidence of no discounting in the TTO method, the disparity between the usual and alternative TTO estimates seem more likely due to the insensitivity of the former stemming from imprecise preferences (and rounding).

The endowment effect (Knetsch 1989) offers an explanation of the disparity frequently observed between willingness to pay and willingness to accept measures of value (e.g., Knetsch *et al* 1984) and of the asymmetry observed in a barter experiment (Kahneman *et al* 1990). The endowment effect refers to the situation where an individual places a higher value on a bundle once they own it than they did before. That is, they require a higher price to sell

the bundle than they would pay to get it in the first place. Say, for example, an individual is indifferent between two bundles, A and B, when given the choice between them. Once they are endowed with bundle A, their indifference curve effectively pivots from that point of endowment thereby placing B on a lower indifference curve as in figure 3.[4] Tversky and Kahneman (1991) suggest that such disparities arise because of loss aversion, whereby alternatives are viewed in terms of gains or losses relative to the current endowment as in Kahneman and Tversky's (1979) Prospect Theory. If the point of endowment alters people's preferences such as illustrated in Morrison (1997a), and as the results of many contingent valuation experiments suggest (e.g., Kahneman *et al* 1990; Morrison 1998), then there is no reason to believe that this is peculiar to one method of value elicitation. Indeed a similar phenomenon has been observed in the standard gamble (SG) method between the Probability Equivalent (often referred to as SG) and Certainty Equivalent (CE) approaches. For example, Hershey *et al* (1985) found in experiments that respondents are more risk averse with respect to Probability Equivalent questions than CE questions—this would be expected if an endowment effect were present. These results and their implications for the healthy-years-equivalent technique are illustrated by Morrison (1997b). The significance is that, if responses to other value elicitation methods incorporate an endowment effect, then (as noted by Dolan 1996a) there is no reason to believe that it is absent in TTO.

If an endowment effect were present in TTO responses, then respondents would be willing to trade-off less time than they would in the absence of such an effect. This would (1) reduce the estimated severity of illnesses/injuries (i.e., increase health status values) and, therefore, (2) decrease the estimated difference between different illnesses/injuries, because the maximum health status scaling is 1. This compounded with imprecise preferences—since respondents are likely to round answers to the nearest year or at best the nearest month—can

[4] See Morrison 1997a for a more thorough explanation.

lead researchers to incorrectly conclude that a treatment does not improve health even where respondents perceive a significant improvement. The possibility of such inferences could have serious implications for health care evaluation. If TTO responses are influenced by an endowment effect, then that influence would be present in both stages of the alternative approach—in each step less time would be traded-off than if there were no endowment effect. Thus, if there is an endowment effect, then *ceteris paribus* the value obtained from the alternative TTO approach should exceed that from the usual TTO method. This experiment obtained the opposite result. So, we can conclude that either an endowment effect is not present, or that it is outweighed by the effects of imprecise preferences and/or discounting.

The results of this experiment are consistent with imprecise preferences and with discounting. It is beyond the scope of this experiment to test whether one or both of these are present, or to test for an endowment effect. However, given that Dolan *et al* (1995) observed no discounting in their TTO study, and that our results conflict with an endowment effect, we conclude that imprecise preferences are the more likely cause of the disparity between the usual and alternative TTO values. This, together with the information that respondents do perceive a change in health status after intervention, indicates that the alternative TTO approach is more sensitive to perceived differences between health states than the usual TTO method. Thus, the evidence obtained from this experiment leads us to conclude that the alternative TTO approach improves the sensitivity of the TTO method.

V. Conclusion

This paper has two main purposes. Firstly, to introduce a means by which the TTO method can be modified so as to improve its sensitivity, and secondly, to present the results of an experiment in which this alternative approach was employed. A problem common to most (or all) generic forms of health status valuation, is that they are too insensitive to quantify mild

illnesses or to assess health gained from treatments that provide only a modest improvement. Given that a large proportion of current health care interventions do not bring about giant leaps in the patients' health, this is not a trivial issue. We must be able to detect perceived differences in health states otherwise the results of economic evaluations will lead to incorrect policy recommendations.

The alternative TTO approach presented here is not another method of valuing health, rather it is offered as a way of improving the sensitivity of the existing TTO method. Within subject tests showed a high degree of consistency in respondents with only 4% of respondents indicating a preference reversal. So, respondents do not appear to have had difficulty with the questions. The anticipated sources of bias discussed in the last section are by no means specific to TTO estimation, but can be expected and in some cases have been observed in other methods of valuation. The disparity between the usual and alternative TTO estimates are not a reason to dismiss the alternative approach. Rather, these results are encouraging—the alternative approach appears to have overcome the insensitivity of the TTO method.

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Appendix A

Time trade-off questions used to assess the patients' and carers' quality of life, before and after intervention.

I. Patient's quality of life

Before Intervention --

Without intervention, the patient can be expected to live in their current state of health for 50 years (i.e., the rest of their life).
How many years in a state of normal health would you consider to be equivalent to this prognosis?

Post-Intervention --

(i) usual TTO approach

The patient can be expected to live in their current *(post- intervention)* state of health for 50 years (i.e., the rest of their life).
How many years in a state of normal health would you consider to be equivalent to this prognosis?

(ii) alternative TTO approach

How many years in the patient's current *(post-intervention)* state of health would you consider to be equivalent to their spending the rest of their life in their previous *(pre-intervention)* state of health?

II. Carer's quality of life

Before Intervention --

Without intervention, the patient can be expected to live in their current state of health for the rest of their life. Assume that you would take care of the patient to the same extent that you do now. Alternatively, say that someone were available to care for the patient to give you the freedom to do what you wish.
Given the option of spending the rest of your life taking care of the patient as you do now, or of having this freedom in your everyday life, how many years of
normal life (i.e., freedom) would you consider to be equivalent to 75 years of taking care of the patient?

Post-Intervention --

(i) usual TTO approach

The patient can be expected to live in their current *(post- intervention)* state of health for the rest of their life. Assume that you would take care of the patient to the same extent that you do now (after they have received surgical/orthotic intervention). Alternatively, say that someone were available to care for the patient to give you the freedom to do what you wish.
Given the option of spending the rest of your life taking care of the patient as you do now, or of having this freedom in your everyday life, how many years of life with normal freedom would you consider to be equivalent to 75 years of taking care of the patient?

(ii) alternative TTO approach

How many years of taking care of the patient in their current *(post-intervention)* state of health would you consider to be equivalent to spending the rest of your life (75 years) taking care of them in their previous *(pre-intervention)* state of health?