Time trade-off or time gain?: It all depends on your point of reference.

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Abstract: Traditionally, attempts to measure utilities for health states under certainty have involved the time trade-off method in which respondents are asked to consider what length of life they are willing to give up to improve their health. Underlying this approach is the notion that the amount of time traded off is varied until the subject is indifferent between remaining in a health state that is less than 'full health' for a defined period of time *t* and shorter period of time *x* in 'full health'. Implicitly this assumes a person's reference position is to have an initial endowment of time *t* and to be in 'less than full health'. However, this is not the only reference position since a person can also start in full health with an initial endowment of time *x* and accept a *gain in time* in order to compensate them for a reduction in health status. The purpose of this paper is to examine the importance of the reference position by conducting an experiment in which we compare estimates of utility based on time trade-off and *time gain* formats for two different health states from the EQ-5D in a pilot survey of University students (n=53). In particular we examine whether these choices are subject to *loss aversion* in which people value gains less than losses that is known to influence other aspects of economic behaviour. The final section of the paper considers which reference point should be used in future applied studies that attempt to value utilities for health states under certainty.

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Introduction

There are a number of different techniques for assessing the utility of health states. Two of the most widely used methods of direct assessment are the standard gamble and the time trade off methods (Torrance, 1986). The methods differ in a number of respects, for example, they have a different *numeraire* (the standard gamble uses risk and the time trade off uses time) and make different assumptions regarding the certainty of the health states presented (the standard gamble is concerned with health states under uncertainty and the time trade off is concerned with health states under certainty). A further difference is that the time trade off method has no theoretical foundation whilst the standard gamble method is a direct application of one of the axioms of expected utility theory. However, in recent years, the time trade off method has increasingly been used in empirical work and was the method chosen to estimate general population tariffs for EQ-5D health states (Dolan et al. 1995). A number of studies have explored potential issues affecting the validity of the time trade off method such as framing effects, duration and the assumption of constant proportionality (Blumenschein and Johannesson, 1998; Buckingham et al. 1996; Kirsch and McGuire, 2000; Stiggelbout et al. 1995). A methodological issue that has not been investigated to date is the reference point, or starting point, used in time trade off experiments. Yet the reference point is likely to be important if, as has been shown in the literature, people value losses and gains differently (Tversky and Kahneman, 1991). The aim of this paper is to apply the concept of loss aversion to the design of time trade off experiments.

Theoretical background

Traditionally, attempts to measure utilities for health states under certainty have involved the time trade-off method (Torrance 1986) in which respondents are asked to consider what length of life they are willing trade-off to improve their health. Mehrez and Gafni (1990) demonstrate that it is possible to represent such a choice within a standard economic framework through the use of indifference curves. To illustrate, consider the evaluation space represented in figure 1 in which levels of health status are represented on the vertical axis and the individual's remaining life time on the horizontal axis. An individual is given a reference bundle X=(t, h_i) consisting of health status level *i* (denoted as h_i) and time *t* , which is typically interpreted as the individual living in a chronic health state h_i for *t* years. They are then asked to consider whether they prefer alternative bundles such as Y=(x, h_f) that return them to full health (h_f) for a reduced period of time *x* (where *x*<*t*) until a point on the same indifference curve is reached (point Y in figure 1). In the following we denote bundles that are strictly preferred by $\succ$ (i.e. $X \succ Y$ denotes that *X* is strictly preferred to *Y*) and we denote indifference between bundles by $\sim$. Hence, the time trade-off method involves finding $X \sim Y$. Within this framework the amount of time given up *(t-x)* can be regarded as a compensating variation in that it represents the amount of time that must be taken from the individual to leave him or her just as well off before the improvement in health (Johansson, 1995).

However, the selection of bundle X as the reference point is arbitrary since it is also possible for a person to start with bundle Y (i.e. be in full health with life expectancy of time *x*) and accept a *gain in time* in order to compensate them for a reduction in health status to h_i (figure 1). The standard formulation of consumer choice assumes the individual's entitlement to time and quality of life should not shift this indifference curve. Hence, if an individual is entitled to bundle X and trades off time to be restored to h_f and their preference for the bundles can be represented as $X \sim Y$ then they should also be indifferent between the same bundles when they are entitled to Y and gain time *t-x* to compensate them for a reduction in their health status to h_i . Since this gain in time returns them to the initial level of utility it can also be regarded as a compensating variation.

However, real world behaviour is rarely this simple as choices are often affected by the individual's initial entitlements and this been shown empirically with everyday consumer goods (Kahneman, Knetsch and Thaler ,1990). The valuation of non-market goods has also shown wide divergences when questions are phrased in terms of willingness to pay (WTP), or willingness to accept (WTA) (Mitchell and Carson 1989). Tversky and Kahneman (1991) attempt to explain this phenomenon by extending their concept of *loss aversion* to decisions under certainty. Under this framework a decision maker evaluates choices relative to a reference point as either a gain or a loss. This reference point can be the *status quo*, or an expected level of entitlement. Any point in the evaluation space is measured as a gain or a loss relative to this point. Under this formulation we denote $\succ_R$ as 'preferred to'[1] and $\sim_R$ as 'indifferent between' when evaluated from the reference bundle *R*. Tversky and Kahneman (1991) argue that the reference point can have two effects on decisions. Firstly, individuals often display *loss aversion* which arises when losses are valued more highly than gains. The second effect is *diminishing sensitivity* which occurs when the marginal value decreases with the distance from the reference point. Diminishing sensitivity will alter the shape of the indifference curve around the reference point. In particular, when considering gains diminishing sensitivity will act in a similar fashion to the traditional assumption of diminishing marginal utility and produce an indifference curve which is convex to the origin. However, when considering losses, diminishing sensitivity will act in the opposite direction and the indifference curve may be non-convex. Loss aversion and diminishing sensitivity represent two distinct behavioural characteristics. While it is possible to examine how both affect choices involving health status and length of life we will for the sake of brevity focus on examining only loss aversion for the time dimension in this study.

What implications does loss aversion have for experiments involving time trade-off or time gain? To answer this question we must first establish the reference point and then postulate how it influences behaviour. To avoid undue complexity we will only consider the case of chronic health states that are preferred to death so that utility is an increasing function of both time and health state. While the reference point is not explicitly defined in most time trade-off experiments, the framing of question is consistent with a reference bundle such as X in figure 1. For example, Dolan et. al. (1996a) in the self complete booklet version of TTO ask respondents to indicate "the number of years of life that (s)he would be prepared to *sacrifice* in order to be in full health" (emphasis added). The use of the term *sacrifice* is likely to convey to the subject they should consider different levels of loss in the time dimension from a bundle such as *X*. To define loss aversion in regard to time, consider an individual

[1] Note Tversky and Kahneman (1991) define the relation $\succ_R$ as being 'strictly preferred to', while Sugden (1999) defines it 'at least as preferred as' (pp. 164-5).

with a choice between two bundles (X and Y) relative to two alternative reference bundles such as X=(t, h_i) and W=(x, h_i) where the individual has the same health status, but different entitlements regarding their length of remaining life. If the reference bundle is W then the difference between X and Y=(x, h_f) is that Y has the same level of time as the reference bundle W (with a greater level of health status), while X represents a gain of *t-x* above the reference bundle W (with the same level of health status). If instead the reference bundle is X then Y represents a loss of *t-x* with greater level of health status. Loss aversion means that Y $\sim_W$ X implies Y $\succ_X$ X. As Sugden (1999) has shown loss aversion can also be defined for the dimension represented on the vertical axis i.e. health status. Consider alternative reference bundles W and *Y*, both have the same quantity of time, but Y is superior in the level of health status. Loss aversion means that $Y \sim_W X$ implies $Y \succ_Y X$.

How would loss aversion affect responses to surveys involving health status and time that are phrased in terms of either time trade-off or time gain? Consider an individual who is asked questions regarding preferences for *Y* and *X* using the standard time trade-off format. The evaluation space in figure 2 represents their preferences. Assume their reference point is X (which is consistent with a loss or sacrifice in the time dimension) and we are trying to determine a bundle Y to which they are indifferent (i.e. Y $\sim_X$ X). Alternatively, if they are asked the same question in the *time gain* format we assume their reference point is Y. Loss aversion in the time dimension means that Y $\sim_X$ X implies Y $\succ_W$ X. Similarly, it follows that Y $\succ_W$ X implies Y $\succ_Y$ X and hence Y $\sim_X$ X implies Y $\succ_Y$ X (Sugden 1999). This means that if an individual is indifferent between X and Y from X then if we change the reference point to Y by framing the question in terms of gains in time instead of losses the individual would not be willing to exchange X for Y, but instead would be indifferent to bundle with a greater amount of time such as Z=(t', h_i), that is Y $\sim_Y$ Z. So in figure 2, an individual's preferences from reference point X can be represented by I_X, while I_Y is the indifference curve representing preferences from reference point Y. If standard procedures for estimating the utility (U) associated with h_i are applied, then using the time trade-off method $U_{TTO} = x/t$ and the time gain method its $U_{TG} = x/t'$. Hence if an individual is loss averse then the time gain method should produce lower estimates of the utility value for any given health state h_i (i.e. $U_{TTO} > U_{TG}$). Such a result is analogous to the divergence between WTP and WTA that is often observed when these monetary measures of welfare are measured empirically.

An overview of the EQ-5D

In this experiment we defined health states using the EQ-5D health state descriptors because population norm data (Kind et al. 1999) and general population data (Dolan et al. 1996a) can be used both to inform the design and in the analysis of the results. The EQ-5D covers five dimensions of health related quality of life: mobility; self-care; usual activity; pain/discomfort; and anxiety/depression. Each dimension has three response categories: level 1 “no problems”, level 2 “some problems” and level 3 “inability or extreme problems”. The responses to the levels for each of the five dimensions combine to give a five-digit health state description.

It is also important to select the duration of the health state in any time trade off or time gain experiment. The EQ-5D time trade off social tariffs are based on experiments involving a ten year duration. Dolan et al. (1996b) state that the reason for the choice was:

> "…..because it was considered long enough for respondents to be able to make meaningful sacrifices and to be able to distinguish between states but not too long so as to be unrealistic for older respondents. It is recognised that this time horizon would have been unrealistically short for many younger respondents but it was felt that other alternatives (such a variable time horizons based on a person's own expected life expectancy) would have created even greater problems of measurement and interpretation". page 144.

In order to be consistent with the EQ-5D social tariffs, a 10 year duration was used in the time trade off and time gain methods in this experiment.

Experimental design

Previous time trade-off studies (for example, Dolan et al. 1996a) have commonly used a form of bargaining game involving a *ping-pong* format to elicit time trade-off values. This involves asking the first trade off question as a choice between t number of years and a health state such as h_i and q years in h_f. The value of q is then varied from low to high values over a series of trades until a point of indifference denoted as x years is reached. However, such a format is generally used in interviewer administered surveys and is more difficult to administer in questionnaire based surveys as it requires respondents to answer an initial trade off question and a large number of follow up questions (the number depending on when the indifference point is reached). Further bidding games in other contexts have been shown to produce biases in responses (Mitchell and Carson 1989). An alternative approach is to offer respondents a single choice between 10 years in health state A or B versus a randomly chosen amount of years in full health. Unlike the ping-pong format the amount b_j (*j=1..n*) is a randomly chosen *bid* from a set of values and offered to the subject on a take-it-or-leave-it basis. This approach which is similar to *closed-ended* format developed to elicit monetary willingness to pay (Hanemann and Kanninen 1999) provides qualitative information in the form of a bound on the amount a respondent would be willing to trade-off or gain. The choices of respondents when offered different b_j can then be used to estimate x and hence U_{TTO} or U_{TG}. While a standard gamble postal survey employed this method (Bosch et al. 1998) we are unaware of this format previously being used in a time trade-off survey and so we will explain the closed ended approach in some detail.

To outline the main hypothesis for the experiment consider an individual whose preferences for health status and time are not affected by their reference point (see figure 3). As before X=(10years, h_i) ~ Y=(x, h_f). In the closed-end time trade-off or time gain survey they would be offered the choice between X and bundles containing randomly chosen amounts of b_j. For example if they were offered the choice between X and B$_2$ =(b_2, h_f) using either time trade off or time gain, then they would be willing to sacrifice (or gain) *at least* 10-b_2 years as $B_2 \succ X$ (since it is located on a higher indifference curve I'). If instead they had been offered bundle B1=(b_1, h_f) they would choose X (as it is located on I'' which is higher than I''') indicating that 10-b_1 is greater than the amount they are willing to sacrifice (or gain).

Now, consider loss aversion in the time dimension that is represented by the preference structure in figure 4, where the subscripts on the indifference curves denote the points of reference. Now when the closed ended time trade-off method is employed the bundle B_2 lies above (and B_1 below) I''_X and so $B_2 \succ_X X$ and $X \succ_X B_1$. However, when the time gain method is used loss aversion leads to a flattening of the indifference curves associated with reference bundles B_1 and B_2 and so again $B_2 \succ_{B_2} X$, but now $B_1 \succ_{B_1} X$. We therefore conclude that loss aversion concerning time implies that for any given b_j the proportion of subjects willing to sacrifice 10-b_j years in a time trade-off survey (from reference point X) should be less than or equal to one minus the proportion of subjects who would accept 10-b_j (from reference point B*j*) to compensate them for a reduction to h_i. Due to the small sample size in the pilot survey no formal statistical analysis was undertaken, but proportions were compared to provide an indication of the pattern of responses.

Subjects, setting and an overview of the survey instrument

A pilot experiment was conducted involving 53 third year undergraduate students who were taking the health economics module at Nottingham University, but who were not familiar with the time trade-off technique. The questionnaires which were randomly sorted were handed out at the beginning of one lecture and students were given as much time as they needed to complete the questionnaires.

The questionnaire asked all respondents some background information that was similar to that collected in previous UK studies involving the EQ-5D (Kind et al. 1999). The first four questions from the EQ-5D background information were included: experience of serious illness (in self, family, caring for others); age; sex; and smoking status (non-smoker, smoker of less than 20 cigarettes a day, smoker of more than 20 cigarettes a day). Given that the sample was comprised of students, the remaining EQ-5D background questions were excluded since they were either not relevant (such as whether the respondent had ever worked in health services) or already known (such as main activity and educational status). An additional question on whether the respondent had children or other dependents was also included since they may affect responses to time trade off and time gain questions. The questionnaire also asked respondents to complete the EQ-5D (self rated health status) and the time trade off based social tariffs (Dolan et al. 1995) were applied to give a weighted health state index from EQ-5D.

To test loss aversion subjects were randomly assigned to different surveys with the valuation questions phrased in terms of time trade-off or time gain (see appendix 1). Two health states were valued by all subjects. The first *health state A* which has been classified as a "mild" health state in Dolan et al. (1996b) is defined as 11122 using the EQ-5D descriptors. The second *health state B* defined as 22222 has been classified as "moderate" in Dolan et al. (1996b). These health states were two of the forty-three health states valued directly by the general population in the study reported by Dolan et al. (1996b). The reason for including a "mild "and "moderate" state was to test whether there was any difference between the valuations of health states from the time trade off and time gain methods according to severity of health state. The two EQ-5D health states (11122 and 22222) were chosen because each has at least three dimensions that are the same and this limits any potential problems that may arise if respondents have difficulty comparing and trading different levels of attributes simultaneously. A second reason for choosing these states is the median social tariff value is 0.83[2] for state A and 0.63 for state B and so the majority of respondents are likely to considered both states to be preferable to death.

In accordance with the principles of optimal design we used a bid vector with three values: 9, 6, 3 years (Hanemann and Kanninen 1999). These values were chosen to encompass the median values for the two health states (0.83 and 0.63 respectively, Doaln et al. 1996b). However, since the values of respondents may differ from the population values all respondents were asked whether they considered the health state to better or worse than death. Only those respondents that preferred the health state to

[2] Direct estimate from interview based survey as reported in Dolan et. al. (1996b).

death undertook the valuation exercise for that health state. The health states were then valued relative to full health. It has been argued that for consistency of measurement full health should be defined (Smith and Dobson, 1993) and consequently full health was therefore defined as the EQ-5D health state "11111" and was presented to respondents when they valued each health state.

Results

Out of the 53 questionnaires returned one had to be excluded due to non-completion. The responses were divided between the time-trade-off (48%) and time gain technique (52%), and between each bid (see table 1). Table 2 lists the summary statistics for the samples by questionnaire format and shows that the sample characteristics are similar with respect to age, gender, number of dependents, smoking habit, direct experience of illness or with family members and self rated health status from the EQ-5D and social tariffs. The overall sample mean weighted health state index from EQ-5D was 0.96. Table 3 reports the sample's mean weighted health state index from EQ-5D compared to the population norms weighted health state index from EQ-5D by age and smoking status.

All 52 respondents stated that they thought health state A was better than death. Therefore all 52 responses were included in the analysis. However for health state B, 6 (3 from the TTO, 3 from the TG) of the 52 respondents thought that health state B was worse than death, and one had a missing response on time gain for health state B and these were excluded from any further analysis.

The responses from the questionnaires are displayed graphically in Figures 5 and 6 for health states A and B respectively. Figure 5 shows health state A in the evaluation space at 10 years and at a health state value of 0.83 (the median value from Dolan et al. 1996b for state 11122). The figure shows, for each of the bids (9 years, 6 years and 3 years), the number of individuals prepared to remain in the initial health state and the numbers prepared to give up time in full health (TTO) or gain time in health state A (time gain). For the TTO exercise: one individual chose to remain in health state A while 7 opted to trade off 1 year of life to return to full health; 2 individuals chose to remain in health state A while 7 opted to trade off 4 years of life; and 6 individuals chose to remain in health state A while 2 opted to trade off 7 years of life.

For the TG exercise: 5 individuals opted to remain in full health for 9 years with 6 opting to gain 1 extra year in health state A; 3 opted to remain in full health for 6 years with 4 opting to gain 4 extra year in health state A; and none opted to remain in full health for 3 years with 9 opting to gain 7 extra year in health state A.

Figure 6 shows health state B in the evaluation space at 10 years and at a health state value of 0.83 (the median value from Dolan et al. 1996b for state 22222). The figure shows, for each of the bids (9 years, 6 years and 3 years), the number of individuals prepared to remain in the initial health state and the numbers prepared to give up time in full health (TTO) or gain time in health state B (time gain). For the TTO exercise: none of the respondents chose to remain in health state B while 7 opted to trade off 1 year of life to return to full health; none of the individuals chose to remain in health state B while 8 opted to trade off 4 years of life; and 6 individuals chose to remain in health state B while 1 opted to trade off 7 years of life. For the TG exercise: 3 individuals opted to remain in full health for 9 years with 5 opting to gain 1 extra year in health state B; 4 opted to remain in full health for 6 years with 2 opting to gain 4 extra year in health state B; and 3 opted to remain in full health for 3 years with 6 opting to gain 7 extra year in health state B.

Figures 7 and 8 compare the proportions accepting losses and gains by severity of health state. For those responding to the TTO questionnaire a greater proportion are willing to accept a loss for the worse health state B compared to A. Whereas for those responding to the TG questionnaire a greater proportion are willing to accept a gain for the worse health state B compared to A.

While we emphasize that number of subjects in each group is relatively small, the results suggest that responses to some bid values may not be consistent with behaviour characterised by either the standard model of decision making or loss aversion in the time dimension. For example, in the time trade-off question for a bid of 9 years, 7 of the 8 subjects (88%) opted to sacrifice one year to be resorted to full health rather than live for ten years in health state A. If loss aversion in the time dimension characterises responses one would expect the overwhelming majority of subjects answering the time gain survey to opt to remain in full health 9 years (i.e. not accept the gain of one year). Surprisingly, 6 of the 11 subjects (55%) preferred to change to health state A for 10 years. This pattern of responses was also present in subjects offered the bid of 6 years. It was also present when the same subjects responded to the "moderate" health state for both these bids.

Discussion

It has long been recognised that economic welfare can be quantified using measures that are based on sacrifice (i.e. WTP) or compensation (i.e. WTA). When these measures are used to value both market and non market goods empirical studies have shown a wide divergence between WTP and WTA and *loss aversion* has been proposed as one means of explaining this divergence. While WTP is most often used in practice it is important to emphasize that both WTP and WTA represent valid measures of welfare. Indeed some environmental economists (Knetsch 1990; Schulze 1993) have argued that WTA should be used in preference to WTP when valuing damages to natural resources. In contrast health economists when valuing health states under certainty have been primarily been interested in the time trade-off method that is based on the notion of sacrificing time to return to full health. However, this is not the only measure as it is also possible to measure the increase in length of life span that would compensate them for a reduction in health status. While this measure may be less familiar, many real world health care choices involve this type of decision. For example, a terminally ill patient may be offered a treatment that will extend their life, but due to side-effects reduce the quality of their remaining life. The patient's choice as to whether to opt for the treatment would provide a *revealed preference* for quantity vs quality of life.

In this study we conducted a pilot experiment to compare responses to time gain and time trade-off valuations of health status. While the experiment involved a relatively small number of subjects the results indicate that responses *may not* be consistent with either of traditional decision theory or loss aversion for the time dimension for some of the bid levels. We therefore intend to conduct a larger experiment in the near future. This will facilitate: i) the application of formal statistical testing; ii) testing of loss aversion in the health status dimension; iii) testing for diminishing sensitivity in the loss and gain domains. Hopefully this will lead to a greater understanding of how reference points affect choices involving quality and length of life.

Table 1: Number of responses by question type and bid

	Time Gain	Time Trade-Off
10 years in health state X versus 9 years in full health	11 (41%)	8 (32%)
10 years in health state X versus 6 years in full health	7 (26%)	9 (36%)
10 years in health state X versus 3 years in full health	9 (33%)	8 (33%)

Table 2: Sample characteristics

	Time Gain (n=27)	Time Trade-Off (n=25)
Female	9 (33%)	13 (52%)
Age (years) mean	20	20
SD	0.83	0.78
Number of dependents	0	0
% Non smoker	24 (89%)	22 (88%)
% <20 per day	2 (7%)	3 (12%)
% >20 per day	1 (4%)	0
Number with experience of serious illness - self	0	2 (8%)
Number with experience of serious illness - family	11 (41%)	12 (48%)
Number caring for others with serious illness	1 (4%)	2 (8%)
EQ-5D - Weighted health state index	0.98	0.94

Table 3 Comparison of sample means compared with population means for the EQ-5D weighted health index

	Sample N	Sample mean	Population N*	Population mean*
<25 years & non smoker	45	0.959	166	0.97
<25 years & <20 cigarettes pd	5	0.969	105	0.91
<25 years & 20+ cigarettes pd	1	1.0	33	0.89

* Source: Kind et al. 1999

Figure 1

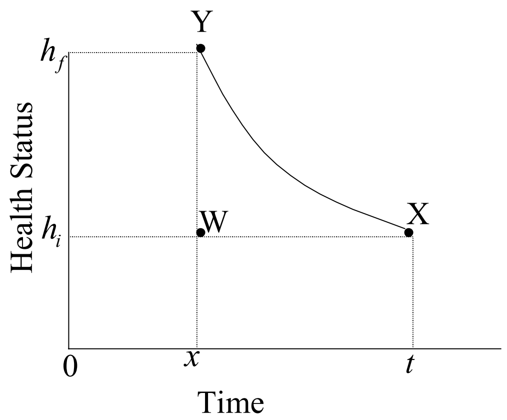


Figure 2

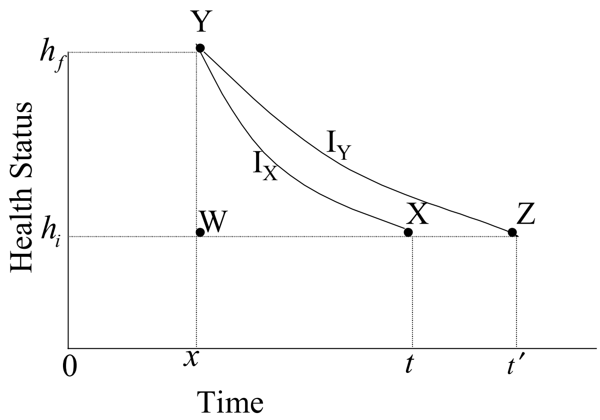


Figure 3

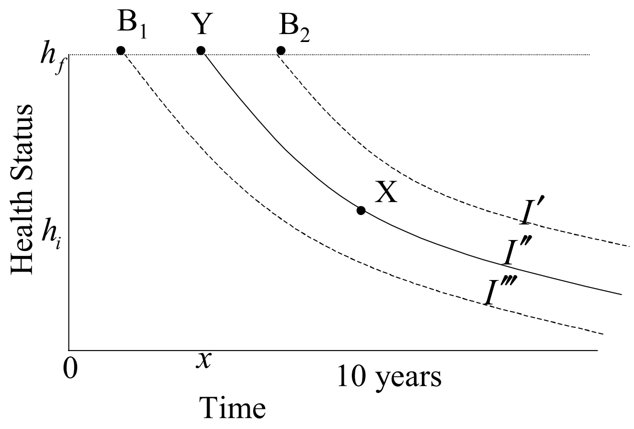


Figure 4

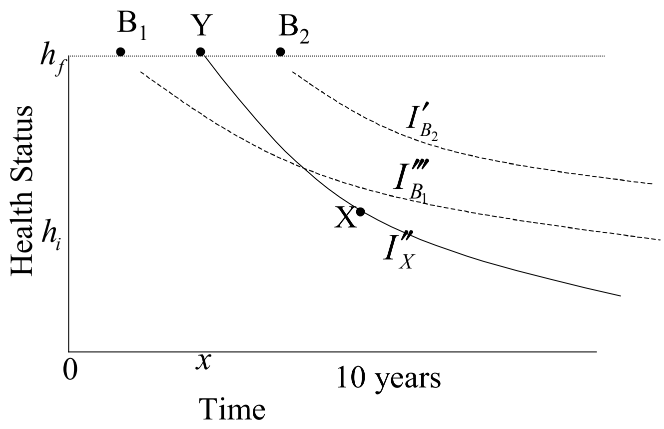


Figure 5
Graphical representation of time gain and time trade-off results for health state A

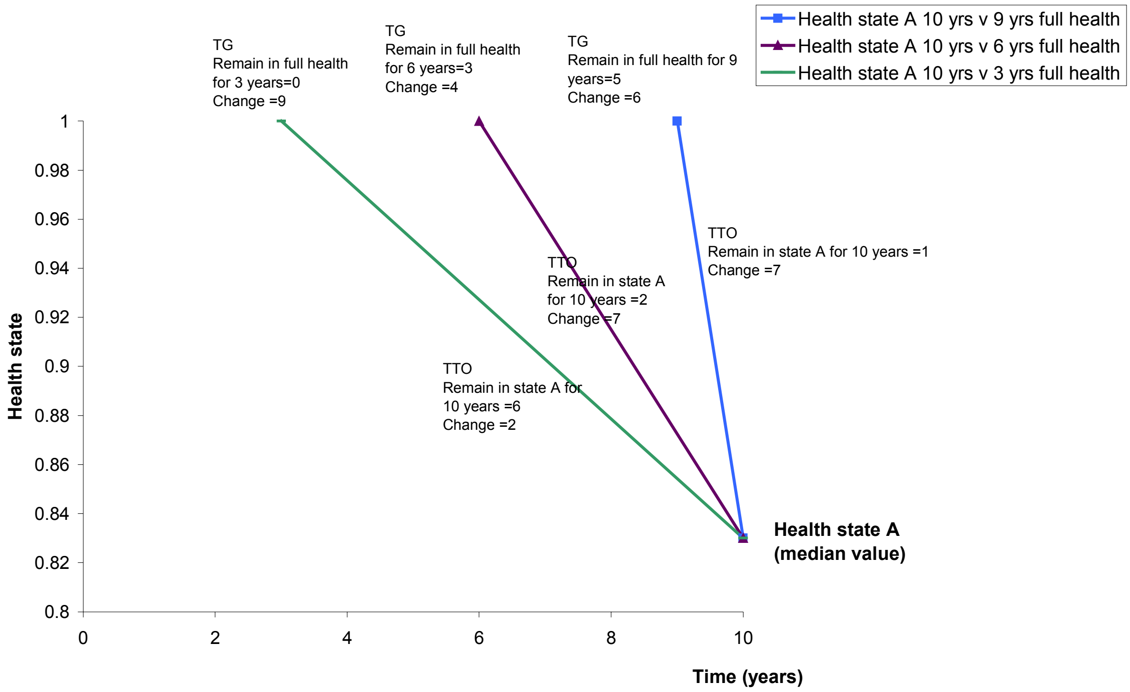


Figure 6
Graphical representation of time gain and time trade-off results for health state B

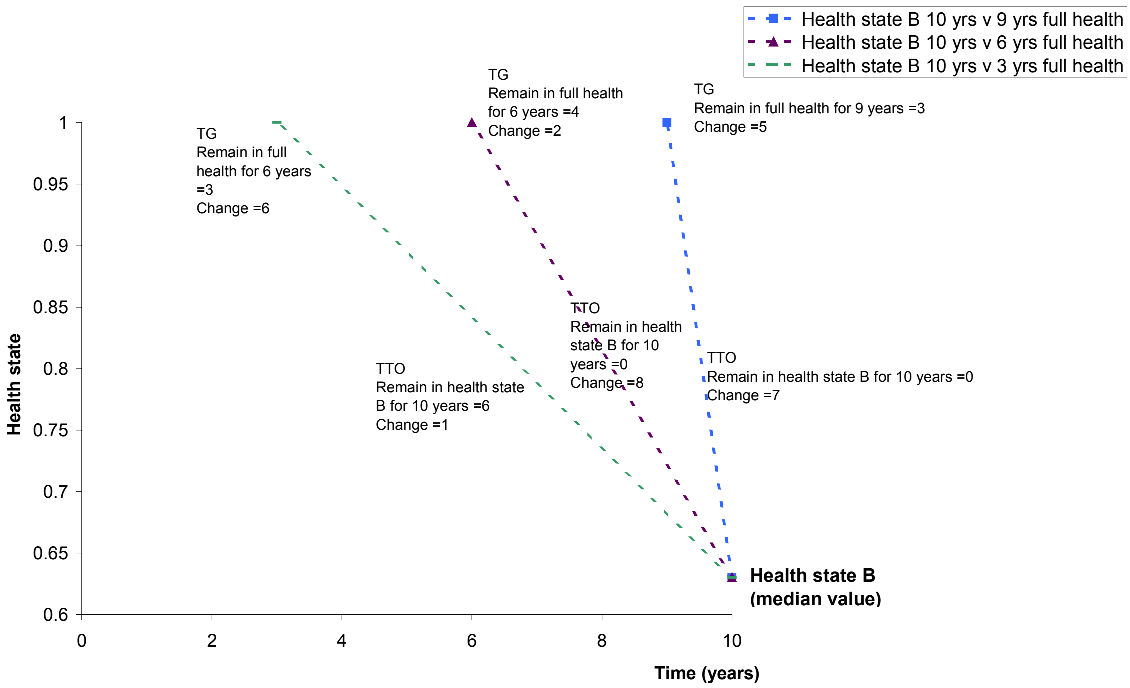


Figure 7
For time trade off, the proportion accepting a loss in years for health states A and B

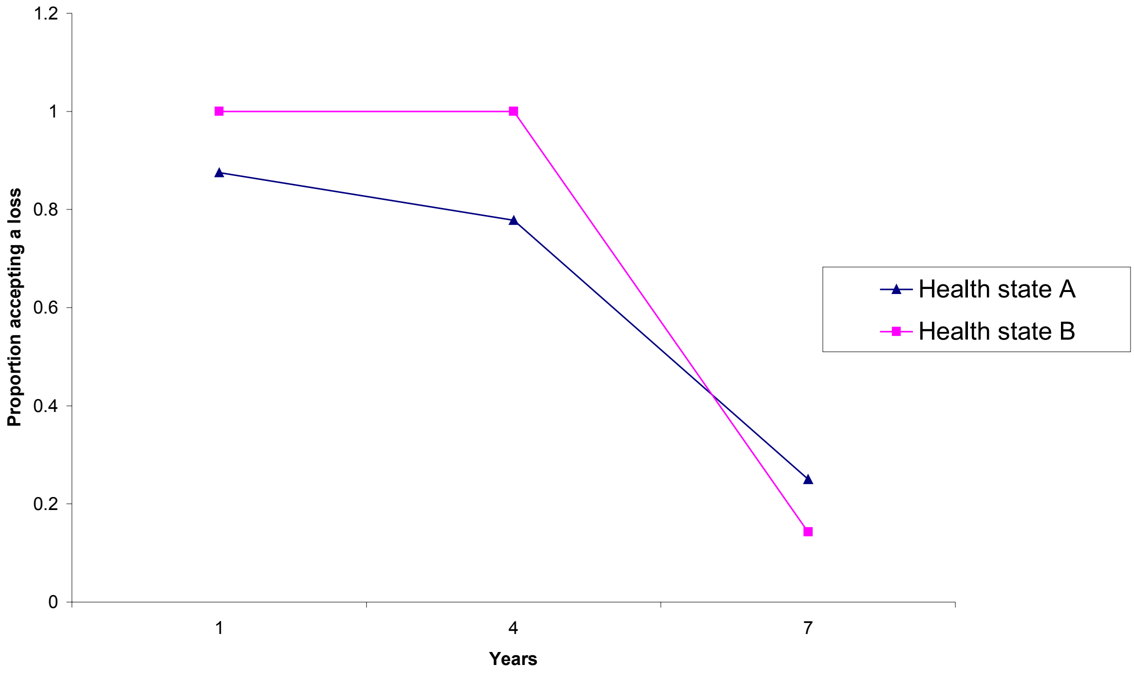
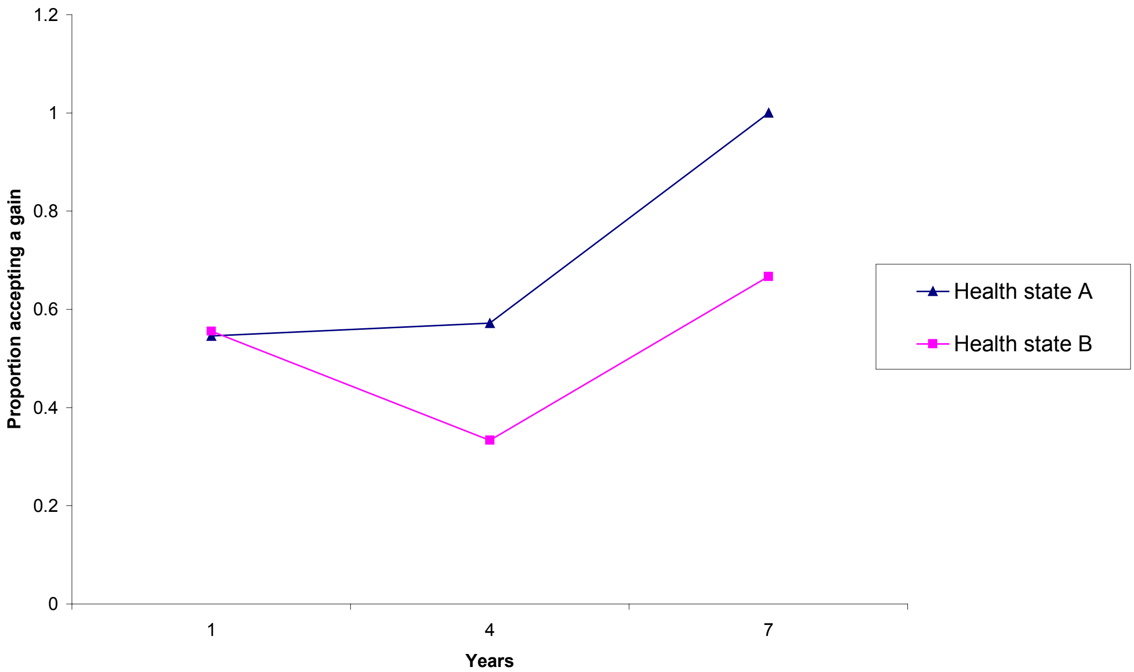


Figure 8
For time gain, the proportion accepting a gain in years for health states A and B.



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Appendix 1: Survey questions

Time trade-off version

Imagine that you are in health state A for 10 years, followed by death. Imagine that a treatment could improve your quality of life to full health but it would be for β years. Which option would you choose?

Please tick one box

Remain in health state A for 10 years followed by death	☐
OR	
Improve your quality of life to full health for β years followed by death i.e. reduce the length of your life by 10-β year	☐

Time gain version

Imagine that you are in full health for 9 years, followed by death. Imagine that a treatment could increase the length of your life but it would reduce your quality of life to health state A. Which option would you choose?

Please tick one box

Remain in full health for β years followed by death	☐
OR	
Reduce your quality of life to health state A for 10 years followed by death i.e. increase the length of your life by 10-β year	☐

Where β is a randomly chosen amount from the following: 3, 6, 9 years.