Department of Economics

The Implications of Linking Questions
within the SG and TTO Methods

Anne Spencer

Queen Mary
University of London

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Anne Spencer[*]

Department of Economics,

Queen Mary, University of London

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Abstract

We consider the impact of introducing intermediate stages, chained together, into the Standard Gamble (SG) and Time Trade-Off (TTO) methods. We broadly replicate the patterns of responses observed in other SG studies. Less is known about the impact of intermediate stages, chained together, in the TTO method. We find that the TTO responses do not replicate the patterns found in the SG responses. We discuss additional issues that are brought to bear in the TTO responses compared to the SG responses and consider whether these can account for the different results.

JEL classification: I31

Key words: Standard Gamble, Time Trade-Off, Chaining

1 Introduction

Quality adjusted life years (QALYs) have been developed to incorporate people's preferences towards treatment outcomes that differ in terms of quality of life and life expectancy. We consider two methods that are frequently used to elicit people's preferences: the Standard Gamble (SG) and Time Trade-Off (TTO) methods (Torrance, 1971; Drummond, O'Brien, Stoddart, Torrance, 1997). To assist respondents in expressing their preferences for minor or more intermediate health states, the methods are often decomposed into two or more intermediate questions. It is concerning that in SG methods that adopt such procedures the preferences are found to systematically vary with procedures used. The paper reports on a study that tries to replicate these systematic differences for the SG method. It also considers the implication of decomposing the TTO method into two questions. In so doing, we consider the impact of the additional issues that are brought to bear in the TTO responses compared to the SG questions.

In the SG and TTO methods, it is sometimes difficult to assess people's preferences towards minor and temporary health states on a scale that includes death. It has been shown that whilst minor states may be rated lower than normal health (using the Visual Analogue Scale), respondents may be unwilling to trade longevity or chances of survival for improvements in health status (Robinson, Dolan, Williams, 1997; Jones-Lee, Loomes, Philips, 1995). One explanation is that respondents may feel that such valuations are inappropriate or insufficiently sensitive to capture their attitudes towards minor states. In principle, this problem can be overcome by linking minor and temporary health states *indirectly* to death. A simple, two-stage procedure would involve firstly comparing the health state with normal health and a more-severe state and secondly, comparing the more-severe health state with normal health and death (Torrance 1986; Jones-Lee, Loomes, O'Reilly, Philips, 1993). This process is called chaining. Questions that chain to normal health are less common, mainly because the rationale to avoid

comparisons with normal health that this would imply is less compelling. A simple, two-stage procedure would involve firstly comparing the health state with a less-severe state (but not normal health) and death and secondly, comparing the less-severe health state with normal health and death. Chaining to normal health, therefore, would involve treatments that do not lead to full recovery. Given the trend to make the questions more realistic to the decisions involved, it is easy to imagine that these questions will become more popular as many treatments do not lead to full recovery.

Both the SG and TTO methods are viewed as a valid measure of preference under expected utility theory (Pliskin, Shepard, Weinstein, 1980; von Neumann, Morgenstern, 1944). Expected utility theory predicts consistency of preferences elicited under the same method. In theory, therefore, the values should be unaffected by the choice of health state used to chain them (McCord, DeNeufville, 1986).

Most of the work on chaining has concentrated upon the SG method (Llewellyn-Thomas, Sutherland, Tibshirani, Ciampi, Till, Boyd 1982; Rutten-van Mölken, Bakker, van Doorslaer, van der Linden, 1995; Morrison, 1996), with fewer investigations for the TTO method (Spencer, 1998; Jansen, Stiggelbout, Wakker, Vlieland, Leer, Nooy, Kievit, 1998; Torrance 1986). Carthy and Spencer (2001) distinguish between SG questions that chain to normal health and those that chain to death. Their paper shows how Prospect Theory (PT) can explain the systematic patterns observed in the SG responses. States chained to death have values that are higher than those derived from direct comparisons. States chained to normal health, on the other hand, have values that are less than or equal to the direct comparisons. The study here investigates whether we can replicate this pattern for the SG questions and considers whether a similar pattern arises in the TTO questions.

We are aware of only one study that compares chained TTO and SG methods. Jansen et al. (1998) chained temporary states to death in the TTO and SG methods for breast cancer treatments. They found that the chained TTO and chained SG values were not statistically different, suggesting equivalence between the patterns observed in the two methods for temporary states. Of interest to us, is whether this results holds for chronic states. Jansen et al. (1998) give reasons to doubt if this result would apply to chronic states chained to death, since they argue that some of the upward biases arising from PT in the chained SG questions no longer arises in temporary states.

2 Method

2.1 Overview of the questionnaire

The study used the EuroQol classification system, which describe states of health along five dimensions: mobility, self-care, usual activities, pain and anxiety (Dolan, Gudex, Kind and Williams, 1996). Each dimension has three levels of severity: no problems, some problems and more-severe problems, denoted by 1, 2 and 3 respectively and colour-coded black, blue and red in our study. Respondents were asked to tick one statement from each dimension that best described their current state of health. This helped to familiarise respondents with the EuroQol dimensions. Respondents were then presented with 6 cards: 5 EuroQol states (11111, 12221, 21211, 21222 and 22232) and immediate death. Other studies had shown that these states gave distinct mean and medians and were chosen to ensure that respondents could easily discriminate between the different states (Dolan, 1996). Each state was colour-coded but are simply referred to here by letters: 11111 is referred to as N, 12221 as W, 21211 as X, 21222 as Y, 22232 as Z and death as D.

The respondents were asked to imagine that each state lasted for ten years without change, to be followed immediately by death. They were asked to rank the cards from the best state to the worst and then to place the cards on a visual analogue scale, putting the best state at 100 and the worst state at 0. This was followed by 12 TTO questions and 7 SG questions. To elicit the preferences we used the TTO boards and interview protocol developed by the measurement and valuation of health study (Gudex, Dolan, Kind and Williams, 1997). These boards and interview protocols were modified slightly to include the colours depicting each health state. The respondents were asked 4 basic reference TTO questions that valued health states with normal health and death (questions 1 to 4). They were then asked 8 more TTO questions that varied the comparison health states, 4 of which we discuss in detail here (questions 5 to 8) and the remainder are reported elsewhere.

Table 1 summarises the questions: column 1 shows the health states that were valued; column 2 the health states that were used for comparison and column 3 the abbreviations used for the value assigned to the health state. In what follows we make a distinction between *direct values* that are based on comparisons with normal health and death, and *indirect values* that are based on questions that chain to normal health or to death.

Table 1. An overview of the questionnaire

The TTO questions fall into 3 broad categories:

Questions 1 to 4.   Basic reference TTO questions: comparing a health state with normal health and death.

Questions 5 and 6.   States chained to normal health: comparing a health state with another health state (but not normal health) and death.

5

Questions 7 and 8.   States chained to death: comparing a health state with normal health and another health state (but not death).

In all the TTO questions respondents were asked to imagine living in a given health state for 10 years or a treatment which offered them a combination of time in a better state and time in a worse state.

The SG section also fall into three broad categories:

Questions 1 to 4.   Basic reference gambles: comparing a health state with normal health and death.

Question 5.   States chained to normal health: comparing a health state with another health state (but not normal health) and death.

Questions 6 and 7.   States chained to death: comparing a health state with normal health and another health state (but not death).

In all the SG questions respondents were asked to imagine living in a given health state for 10 years or a risky treatment that resulted in a better or a worse state.

2.2 TTO questions

The respondents were asked 4 basic reference TTO questions that valued health states using normal health and death (questions 1-4). These questions were used to assign a value for each health state based on a direct comparison with normal health and death and were used to check the consistency of later responses. To distinguish the TTO values from the SG values we use the notation V(.) to represent the TTO value assigned to the health state. The basic reference

questions are illustrated using question 3 in figure 1. A respondent was asked to imagine living in health state Y for 10 years or undergoing a combination of t_3 years in normal health (N) but dying (D) 10-t_3 years earlier (where the subscript on time t indicates the question number). The choice in question 3 is summarised in row 3 of table 1, where 10 years in health state Y (column 1, table 1) is compared with Normal Health and Death (column 2, table 1). In effect, they were asked to consider a shorter period in a higher quality of life.

Figure 1. TTO question 3

The time t_3 was varied until the respondent was indifferent between the two alternatives. The majority of applied work using the TTO method then assumes that respondents gives equal weight to all time periods (or a zero rate of time preference) Dolan (2000). It is therefore possible to express this equivalence by the following equality to calculate the direct value for Y, denoted by direct V(Y) (column 3, table 1):

To calculate the direct V(Y):

$$10 \ V(Y) = t_3 \ V(N) + (10 - t_3) \ V(D)$$

If the value for V(N) = 1 and V(D) = 0 this expression can be rearranged to give

$$V(Y) = t_3/10 \tag{1}$$

The concept of chaining states to normal health is illustrated by considering question 5. In question 5 a respondent was asked to imagine living in health state Y for 10 years or a combination of t_5 years in health state X but dying (D) 10-t_5 years earlier. Question 5 is summarised in row 5 in table 1, where 10 years in health state Y (column 2) is compared with health state X (column 3). Time t_5 was varied until the respondent felt indifferent to either alternative.

Figure 2. TTO question 5

Question 5 is used to derive an indirect value for Y (column 4), denoted by indirect^N V(Y) (where the superscript, N, indicates that the value is chained to normal health). Equivalence between the two alternatives in question 5 results in the following equality:

To calculate the indirect^N V(Y):

$$10 \quad V(Y) = t_5 \quad V(X) + (10 - t_5) \quad V(D)$$

If the value for V(D) = 0 and V(X) = t_2/10 from question 2, this expression can be

rearranged to give $V(Y) = \dfrac{t_5 t_2}{10^2}$ (2)

The concept of chaining states to death is illustrated by question 7. In question 7 a respondent was asked to imagine living in health state Y for 10 years or a combination of t_7 years in health state Z and (10-t_7) years in normal health (N). Question 7 is summarised in row 7 in table 1, where 10 years in health state Y (column 2) is compared with health state Z followed by normal health (column 3). The treatment, therefore, was characterised by a bout of ill-health followed by complete recovery. Time t_7 was varied until the respondent felt indifferent to either alternative.

Figure 3. TTO question 7

It is possible to link the question back to a comparison with normal health if a value is assigned to health state Z that is based on a comparison with normal health and death. The basic reference TTO questions set the values for all states using normal health and death and so could

provide this link. TTO values calculated in this way are denoted by indirect^D V(.) (where the superscript, D, indicates that the value is chained to normal death).

These links can be shown more formally using algebra. Equivalence between the two alternatives in question 7 results in the following equality:

To calculate the indirect^D V(Y):

$$10 \ V(Y) = t_7 \ V(Z) + (10 - t_7) \ V(N)$$

If the value for V(N) = 1, V(D) = 0 and V(Z) = t_4/10 from question 4, this expression can

be rearranged to give $V(Y) = \dfrac{t_7 t_4 + (10 - t_7)10}{10^2}$ (3)

A version of these types of questions have already been used by Torrance (1986) to link minor states indirectly to death, the only difference being that in his application both alternatives involved a temporary state.

The TTO questions test the null hypothesis that a respondent's direct value is equal to their indirect value (chained to normal health or to death) for a health state. The null hypotheses (H$_0$) and alternative hypotheses (H$_1$) considered in this study are:

H$_0$: direct V(Y) = indirect^N V(Y) and H$_1$: direct V(Y) $\neq$ indirect^N V(Y).

H$_0$: direct V(Z) = indirect^N V(Z) and H$_1$: direct V(Z) $\neq$ indirect^N V(Z).

H$_0$: direct V(Y) = indirect^D V(Y) and H$_1$: direct V(Y) $\neq$ indirect^D V(Y).

H$_0$: direct V(X) = indirect^D V(X) and H$_1$: direct V(X) $\neq$ indirect^D V(X).

2.3 SG questions

The respondents were asked 4 basic reference SG questions that valued health states using normal health and death (questions 1-4). These questions were used to assign a value for each health state based on a direct comparison with normal health and death and were used to check the consistency of later responses. To distinguish the SG values from the TTO values questions we use the notation U(.) to represent the SG value assigned to the health state.

Figure 4. SG question 3

The SG question is illustrated using the SG question 3 in figure 4 and the choice between remaining in health state Y or a risky treatment. In the SG method, the choice was between remaining in a health state or undergoing a risky treatment. This treatment had probability p_3 of succeeding, resulting in a better health state (say normal health, N), or $(1-p_3)$ of failing, resulting in a worse health state (say death, D). The subscript on probability here denotes the question number. Probability p was varied until the respondent was indifferent between the two alternatives. The point at which respondents are indifferent can be expressed by the following equality using the continuity assumption of expected utility

To calculate the direct U(Y):

$U(Y) = p_3\ U(N) + (1-p_3)\ U(D)$.

If the U(N)=1 and U(D) = 0 this expression becomes

$U(Y)=p_3$ (4)

The concept of chaining states to death using the SG question will be used here as illustration, but a similar procedure is used to chain states to normal health. In question 6, the choice is

between remaining in health state Y or a risky treatment. The treatment offers the probability p_6 that it will succeed, resulting in normal health (N), or $1-p_6$ that it would fail, resulting in the worse health state, Z. This choice is summarised in row 15 in table 1, where 10 years in health state Y (column 1) is compared with a risky treatment involving normal health or health state Z (column 2). Probability p_6 is varied until the respondent is indifferent between the alternatives. The indirect value assigned to Y is denoted by indirect^D U(Y) in this case (where the superscript, D, indicates that the value is chained to death) and linked back to normal health and death by substituting in the value for Z from the basic reference SG questions.

Figure 5. SG question 6

The links can be shown more formally using algebra. The point at which the two alternatives in question 6 appear equivalent can be expressed by the following equality:

To calculate the indirect^D U(Y):

$U(Y)=p_6 U(N)+(1-p_6)U(Z)$.

If the $U(N)=1$, $U(D) = 0$ and $U(Z)=p_4$ from question 4 then this expression becomes

$U(Y)=p_6+(1-p_6) p_4$ (5)

The concept of chaining states to normal health using the SG question follows a similar procedure, although this time, the two-stage procedure would involve firstly comparing the health state with a less-severe state (but not normal health) and death and secondly, comparing the less-severe health state with normal health and death. Question 5 values health state Y using this procedure. An indirect value assigned to Y in this case is denoted by indirect^N U(Y) (where

the superscript, N, indicates that the value is chained to normal health) and linked back to normal health and death by substituting in the value for X from the basic reference SG questions.

The SG questions test the null hypothesis that a respondent's direct value is equal to their indirect value (chained to normal health or to death) for a health state. The null (H_0) and alternative hypotheses (H_1) considered in this study are:

H_0: direct $U(Y)$ = indirect^N $U(Y)$ and H_1: direct $U(Y) \neq$ indirect^N $U(Y)$.

H_0: direct $U(Y)$ = indirect^D $U(Y)$ and H_1: direct $U(Y) \neq$ indirect^D $U(Y)$.

H_0: direct $U(X)$ = indirect^D $U(X)$ and H_1: direct $U(X) \neq$ indirect^D $V(X)$.

3 Data

Respondents were recruited from members of the general public and from mature students beginning a course in the Department of Health Sciences at the University of York. Respondents were invited to take part in a 90-minute interview in the Department of Economics at York University for a payment of £15. In total, 30 respondents were interviewed, 12 males and 18 females.

Table 2. The sample

Respondents were recruited from people who were aged between 21 and 59. The study did not recruit people who were 60 years old or over as it was felt that they might imagine dying before the end of the 10 year period.

4 Results

In the TTO questions, the median direct values for health states X, Y and Z are 0.9, 0.65 and 0.45 (see table 3) and the Wilcoxon signed ranks test showed that respondents found the states statistically different (P = 0.0002 or less in all cases, Howell, 1987). In TTO questions that chained states to normal health (questions 5 and 6), the median indirect values for health states Y and Z are 0.68 and 0.45 compared to the direct values of 0.65 and 0.45 (table 3). The Wilcoxon signed ranks test showed that respondents' direct and indirect values were not statistically different in either question (row 7, columns 3 and 4 table 4). In questions that chained states to death (questions 7 and 8), the median indirect values for health states Y and X are 0.68 and 0.83 compared to the direct values of 0.65 and 0.90 (table 3). The Wilcoxon signed ranks test showed that respondents' indirect and direct values were not statistically different (row 7, columns 2 and 3 table 4).

Table 3. The summary statistics

Table 4. The Wilcoxon signed ranks test for the TTO method

In the SG questions, the median direct values for health states X, Y and Z are 0.9, 0.65 and 0.5 (see table 3) and the Wilcoxon signed ranks test showed that respondents found the states statistically different (P = 0.0222 or less in all cases). In SG questions that chained states to normal health (questions 5), the median indirect values for health state Y is 0.63 compared to the direct value of 0.65 (table 3). The Wilcoxon signed ranks test showed that respondents' direct and indirect values were not statistically different in the SG question chained to normal health (row 6, column 3 table 5). In questions that chained states to death (questions 6 and 7), the median indirect values for health states Y and X are 0.83 and 0.90 compared to the direct values of 0.65 and 0.90 (table 3). The indirect values were in a majority of cases higher than the direct

for both questions (table 5), the difference was statistically significant for health state Y but statistically insignificant for health state X. Both these questions support the notion that health states chained to death gave a higher values that the direct comparisons with normal health and death but these differences were statistically significant for health state Y only.

Table 5. The Wilcoxon signed ranks test for the SG method

5 Discussion

The direct and indirect SG values are not statistically different for states chained to normal health. This result is in line with previous work (Llewellyn-Thomas et al., 1982;Rutten-van Mölken et al., 1995; Morrison, 1996; Spencer, 1998). Also, in the majority of cases the indirect values are higher than the direct values for states chained to death, but the differences are statistically significant for only one of the two questions. This is broadly in keeping with other work which reports higher values for states chained to death. It is possible that we failed to find statistically significant differences for one of the two questions, since the statistically insignificant question was the last one in the questionnaire and fatigue may have set into the interview at this point.

The results show that direct and indirect TTO values are not statistically different for states chained to normal health or to death. Our predictions for the TTO method were that there would be no difference between the direct and indirect value for states chained to normal health, but a higher indirect value for states chained to death. This prediction was based upon Prospect Theory (PT) proposed in 1982 to explain differences in direct and indirect SG methods (Llewellyn-Thomas, et al., 1982). The explanation offered by PT will be expanded here to the

TTO method to embrace the predicted differences between direct and indirect values in this method.

The explanation offered by PT does not rely on the existence of uncertainty and is equally likely, therefore, to be present in the TTO and SG methods. PT incorporates a value function which predicts respondents reformulate treatments in terms of gains and losses relative to a reference point (Kahneman, Tversky, 1979; Tversky, Kahneman, 1992). The shape of the value function $v(.)$ is shown in figure 6 where x takes on different outcomes, in this case health states. The point $x = 0$, is the reference point, and is assumed to be the health state that respondents are asked to consider. Under PT respondents think in terms of gains and losses in health relative to this reference point. There is diminishing sensitivity to gains or losses as these increase from the reference point. In particular the curve is concave for gains ($v''(x) \leq 0$) and convex for losses ($v''(x) \geq 0$). Hence the preference function is quasi-concave under PT and respondents give relatively greater emphasis to small-to-medium gains and losses than they do to larger gains and losses. In addition, there is a pronounced asymmetry between gains and losses, termed *loss aversion*. For an equivalent change in health status, respondents experience a greater feeling of displeasure from losses than they do of pleasure from gains of the same magnitude, i.e. $v'(x) < v'(-x)$.

Figure 6. Prospect Theory

The combination of diminished sensitivity and loss aversion of the value function can account for systematic differences between the direct and indirect values as already discussed for the SG method by Carthy and Spencer (2001).

Consider states chained to death, and question 7, which values health state Y using health state Z and normal health (N). If health state Y is the reference point, then health state Z represents a loss in health whilst normal health N represents a gain. In chaining states to death, therefore, the questions can be thought of in terms of linking through the loss outcome, health state Z. Let t_7^p denote the time in Z under PT. Since Z is better than death, ceteris paribus this should make treatment involving Z (rather than death) appear more attractive. Therefore, at the point of indifference under EUT a respondent should reduce the time in normal health $(T-t_7^e)$ and increase the time in health state Z. But the insensitivity to losses under PT leads to $t_7^p < t_7^e$. In terms of equation (3) the indirect value for Y would increase relative to the direct value for Y (given that in equation $t_4<10$ and so $(t_7 t_4)-(t_7 10)<0$).

In chaining states to normal health, the questions link through the gain outcome. To see this, consider question 5 that values health state Y using health state X and death. If health state Y is again the reference point, then health state X represents a gain in health whilst death represents a loss. Hence, the question can be thought of in terms of linking through the gain outcome. Let t_5^p denote the time in health state X under PT in question 5. In question 5, since the respondent spends time in health state X, rather than normal health, ceteris paribus this should make the treatment appear less attractive. Under EUT, a respondent should require to spend more time in X but the insensitivity of responses to gains under PT suggests that $t_5^p < t_5^e$. This insensitivity has the potential to decrease the indirect value for Y below that of the direct, as in equation (2). However, since losses loom greater than gains, the opportunity for this insensitivity to be transmitted into the responses is much less in the case of gains. This would suggest that responses to the indirect methods are less than or equal to the direct methods.

Loewenstein's 1987 paper suggests that different decisions could involve different reference points. This gave Chapman (1996) the idea that expected profiles may act as a reference point, as

well as represent current consumption. In our study, respondents know for certain the order in which health states will occur and may think in terms of moving from one health state to another in a logical progression (Loewenstein, Prelec, 1993), thereby changing their point of reference. For instance, in questions that chain states to death, respondents may think in terms of moving from the state under consideration, say Y in question 7, to a treatment which offers a period in Z, then a period in normal health (N). At each point, the respondent would then think in terms of gains and losses relative to the preceding state: for instance, a movement from Y to Z along the value function and then a movement from Z to normal health along the value curve. The improvement in health status from Z to N is greater than the improvement from Y to N but the weight given to the losses is likely to still dominate. So the conclusion already drawn for states chained to death is unaffected; similarly the conclusion of states chained to normal health is unaffected. Given that we did not find these effects, it is possible that that other issues affected the TTO questions and served to counteract these tendencies. We discuss some of these other explanations below.

One theory that would offset the impact of PT on states chained to death is Robinson et al.'s (1997) idea of a *threshold of tolerance* below which states must fall before respondents would consider sacrificing time. They predicted that respondents may be unwilling to choose premature death in direct comparisons with normal health and death. This would generate a value for Y that was close to or, in the extreme, equal to 1. However, when considering states that are chained to death, the same respondents may be willing to go through a bout of a much worse state, say Z, in the knowledge that they will improve later. Consider again question 7 and let t_7^t denote the time under the threshold of tolerance. If respondents are more willing to spend time in Z, given it is followed by normal health, then $t_7^t > t_7^e$. This would result in the indirect values for Y becoming lower than the values based on normal health and death. The threshold of tolerance is unlikely to affect states that are chained to normal health since, like the direct questions, they

involve comparisons with death. For instance, in question 5 which values health state Y, if respondents were unwilling to choose premature death in direct comparisons with normal health and death, they would be equally unwilling to choose premature death in comparisons with health state X and death. The value for Y is set equal to 1 in both cases.

A person's concern over the timing of ill-health could also potentially have an impact. Like most TTO studies we have assumed here that a respondent gives equal weight to all time periods. If, instead, a respondent prefers to consume health in the short-term more than in the long-term, they will assign a higher weight to the short-term. A value that correctly adjusts for the higher short-term weight and subsequently discounts the long-term periods is hereafter termed a *discounted value*. If these time preferences had been systematically incorporated into the calculations from the beginning, the values should have been unaffected. However, since these time preferences were not, assuming an equal weight for all time periods is equivalent to over-weighting the importance of health states in the long-term

In chaining states to normal health, and comparing health state Y with health state X and death, the ignoring of discounting would be equivalent to over-weighting the importance of death. For instance, in question 5, let t_5^d denote the time under discounting. Under discounting, respondents will spend less time in X to express their point of indifference and $t_5^d < t_5^e$. If the impact of discounting is not taken into consideration in the calculation, this leads to an under-estimation of the discounted value for Y (Dolan, Jones-Lee, 1997). Although this under-estimation also occurs in the direct value of Y, the indirect value involves greater under-estimation since the two-stage procedure involves under-estimation at each stage (and an under-estimation also of the implied value for X used in the indirect calculation). The combined effect of this is a reduction in the indirect value below the direct value (appendix A).

In chaining states to death, and comparing health state Y with health state Z and normal health, the ignoring of discounting would be equivalent to over-weighting the importance of normal health. This results in an indirect value for Y that is higher than discounted value for Y (appendix B). In turn, the discounted value for Y is higher than the direct value for Y (Dolan, Jones-Lee, 1997). The combined effect is an indirect value that is higher than the direct value. Part of this effect is offset by any under-estimation of Z which is used to calculate the indirect value for Y.

Both these predicted effects would serve to reinforce rather than undermine the impact of PT on states chained to death, and would also lead to a reduction in the indirect values chained to normal health. Neither of these findings emerged in our data, and so we conclude that the rate of time preference does not appear to explain the findings here.

Our study cannot be used to advocate the TTO method over the SG method, since although we find no differences between the direct and indirect TTO responses we predict this is due to counteracting issues within the method rather than an ability to overcome the loss aversion proposed by PT. For instance, if respondents have a threshold of tolerance before they are willing to sacrifice time, this threshold has the potential to undermine the impact of PT for states chained to death and seems to have been sufficient to undermine it here.

Whether the results will continue to hold for more severe states has yet to be shown. We predict that the threshold of tolerance is less likely to affect responses when the states are more-severe, since respondents are then more likely to sacrifice time for improvements in health. This suggests that the patterns that are observed in the SG method are likely to arise in the TTO method for more-severe states. The pattern of responses observed within the TTO methods, therefore, may be more complex than those found in the SG method since the TTO method is

susceptible to issues beyond PT. This suggests that particular care is needed to devise TTO

questions and to interpret their results. We recommend further work to look at these issues in

more detail. Given the explanatory nature of this work it would be interesting to include

qualitative data to consider the issues that people are focusing upon in the TTO method.

Appendix A

Question 5 compares 10 years in Y with t_5 years in X and dying $(10-t_5)$ years earlier. Let a respondent's rate of time preference be represented by a discount weight, ρ, and let $0<\rho<1$. The discounted value for Y is then calculated from question 5 by equation (1).

$$\sum_{0}^{9}\rho^t V(Y) = \sum_{0}^{t_5-1}\rho^t V(X) \qquad (1)$$

where $t_5 \leq 10$. The geometric progression formula is given as:

$$\sum_{0}^{n-1}a\rho^t = \frac{a-a\rho^n}{1-\rho}\text{, using this in equation (1) to calculate the discounted value for Y:}$$

$$\frac{1-\rho^{10}}{1-\rho}V(Y) = \frac{1-\rho^{t_5}}{1-\rho}V(X)$$

Rearranging it follows that:

$$\frac{V(Y)}{V(X)} = \frac{1-\rho^{t_5}}{1-\rho^{10}} \qquad (2)$$

Given that $0<\rho<1$ it follows immediately that:

$$\frac{V(Y)}{V(X)} = \frac{1-\rho^{t_5}}{1-\rho^{10}} > \frac{t_5}{10} \qquad (3)$$

If we assume a zero rate of time preference in the indirect value then

$$\frac{V(Y)}{V(X)} = \frac{t_5}{10}\text{, and so by equation (3) the indirect value underestimates the discounted value for Y}$$

The indirect $V(Y) = \dfrac{t_5}{10}V(X)$ calculated here, therefore, is lower than the discounted

$$V(Y) = \frac{1-\rho^{t_5}}{1-\rho^{10}}V(X).$$

This effect is reinforced by any under-estimation of the direct value X which forms part of the indirect formula for Y (Dolan, Jones-Lee, 1997).

Although under-estimation also occurs in the direct value for Y, the indirect value involves greater under-estimation since the two-stage procedure involves under-estimation at each stage (and an under-estimation also of the implied value for X used in the indirect calculation). The combined effect, therefore, is a reduction in the indirect value below the direct value.

Appendix B

Question 7 compares 10 years in Y with t_7 years in Z and $(10-t_7)$ in normal health. Let a respondent's rate of time preference be represented by a discount weight, ρ, and let $0 < \rho < 1$. The discounted value for Y is then calculated from question 7 by equation (1).

$$\sum_{0}^{9} \rho^t V(Y) = \sum_{0}^{t_7-1} \rho^t V(Z) + \sum_{t_7-1}^{9} \rho^t V(N) \tag{1}$$

where $t_7 \leq 10$. The geometric progression formula is given as:

$$\sum_{0}^{n-1} a\rho^t = \frac{a - a\rho^n}{1 - \rho}, \text{ using this in equation (1) to calculate the discounted value for Y:}$$

$$\frac{1-\rho^{10}}{1-\rho} V(Y) = \frac{1-\rho^{t_7}}{1-\rho} V(Z) + \left(\frac{1-\rho^{10}}{1-\rho} - \frac{1-\rho^{t_7}}{1-\rho} \right) V(N)$$

Rearranging it follows that:

$$\left(1-\rho^{10}\right) V(Y) = \left(1-\rho^{t_7}\right) V(Z) + \left(1-\rho^{10} - 1 + \rho^{t_7}\right) V(N)$$

$$\left(1-\rho^{10}\right) V(Y) = \left(1-\rho^{t_7}\right) V(Z) + \left(\rho^{t_7} - \rho^{10}\right) V(N)$$

$$V(Y) = \frac{\left(1-\rho^{t_7}\right) V(Z) + \left(\rho^{t_7} - \rho^{10}\right) V(N)}{\left(1-\rho^{10}\right)} \tag{2}$$

Given that $0 < \rho < 1$ it follows immediately that:

$$V(Y) = \frac{\left(1-\rho^{t_7}\right) V(Z) + \left(\rho^{t_7} - \rho^{10}\right) V(N)}{\left(1-\rho^{10}\right)} < \frac{t_7 V(Z) + \left(10 - t_7\right) V(N)}{10} \tag{3}$$

If we assume a zero rate of time preference in the indirect value then

$$V(Y) = \frac{t_7 V(Z) + \left(10 - t_7\right) V(N)}{10}$$

So by equation (3) the indirect value overestimates the discounted value for Y

The indirect $V(Y) = \dfrac{t_7 V(Z) + \left(10 - t_7\right) V(N)}{10}$ calculated here, therefore, is higher than the discounted

$V(Y) = \dfrac{\left(1-\rho^{t_7}\right) V(Z) + \left(\rho^{t_7} - \rho^{10}\right) V(N)}{\left(1-\rho^{10}\right)}$.

In turn, the discounted value for Y is higher than the direct value for Y (Dolan, Jones-Lee, 1997). The combined effect is an indirect value that is higher than the direct value. The extent to which the indirect value for Y is higher than the direct value for Y is mitigated partly by any under-estimation of the direct value for Z which is used to calculate the indirect value for Y in equation (3).

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Table 1. An overview of the questionnaire

Question	(1) Health state	(2) Comparison	(3) Value
TTO			
1	W	N + D	direct V(W)
2	X	N + D	direct V(X)
3	Y	N + D	direct V(Y)
4	Z	N + D	direct V(Z)
5	Y	X + D	indirect^N V(Y)
6	Z	X + D	indirect^N V(Z)
7	Y	Z + N	indirect^D V(Y)
8	X	Y + N	indirect^D V(X)
SG			
1	W	N + D	direct U(W)
2	X	N + D	direct U(X)
3	Y	N + D	direct U(Y)
4	Z	N + D	direct U(Z)
5	Y	X + D	indirect^N U(Y)
6	Y	Z + N	indirect^D U(Y)
7	X	Y + N	indirect^D U(X)

Table 2. The sample

	(1) 21-39	(2) 40-59	(3) Total
Male	9 (30%)	3 (10%)	12 (40%)
Female	8 (27%)	10 (33%)	18 (60%)
Total	17	13	30

Table 3 The summary statistics

Question	(1) Value	(2) n	(3) Mean	(4) Median	(5) Standard deviation
TTO					
1	direct V(W)	30	0.802	0.950	0.248
2	direct V(X)	30	0.856	0.900	0.163
3	direct V(Y)	29	0.635	0.650	0.217
4	direct V(Z)	28	0.457	0.450	0.207
5	indirect^N V(Y)	29	0.644	0.680	0.265
6	indirect^N V(Z)	28	0.481	0.450	0.240
7	indirect^D V(Y)	28	0.679	0.683	0.161
8	indirect^D V(X)	29	0.823	0.835	0.140
SG					
1	direct U(W)	29	0.736	0.750	0.210
2	direct U(X)	30	0.828	0.900	0.171
3	direct U(Y)	29	0.628	0.650	0.223
4	direct U(Z)	28	0.479	0.500	0.219
5	indirect^N U(Y)	29	0.597	0.630	0.230
6	indirect^D U(Y)	28	0.772	0.830	0.200
7	indirect^D U(X)	29	0.843	0.900	0.164

[1]Respondents were excluded from the analysis if they felt that the health states were worse than death. Two respondents felt that health state Z was worse than death and 1 respondent felt that health state Y was worse than death.

Table 4 The Wilcoxon signed ranks test for the TTO method

	Chained to death		Chained to normal health	
	(1) indirect^D V(X)	(2) indirect^D V(Y)	(3) indirect^N V(Y)	(4) indirect^N V(Z)
No. of cases where indirect value > direct value	10	15	15	17
No. of cases where indirect value < direct value	17	11	11	7
No. of cases where indirect value = direct value	2	2	3	4
Total	29	28	29	28
Wilcoxon Z	-1.2853	-1.3715	-0.6223	-1.4571
2-tailed P	0.1987	0.1702	0.5338	0.1451
	accept	accept	accept	accept

[1]Respondents were excluded from the analysis if they felt that the health states were worse than death. Two respondents felt that health state Z was worse than death and 1 respondent felt that health state Y was worse than death.

Table 5. The Wilcoxon signed ranks test for the SG method

	SG chained to death		SG chained to normal health
	(1) indirect^D V(X)	(2) indirect^D V(Y)	(3) indirect^N V(Y)
No. of cases where indirect value > direct value	18	26	12
No. of cases where indirect value < direct value	9	2	14
No. of cases where indirect value = direct value	2	0	3
Total	29	28	29
Wilcoxon Z	-1.4055	-4.1216	-0.8508
2-tailed P	0.1599	0.0000	0.3949
	accept	reject	accept

[1]Respondents were excluded from the analysis if they felt that the health states were worse than death. Two respondents felt that health state Z was worse than death and 1 respondent felt that health state Y was worse than death.
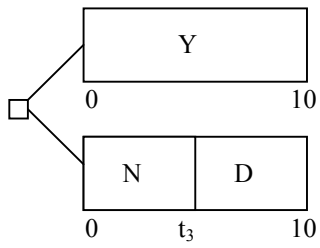
Figure 1. TTO question 3
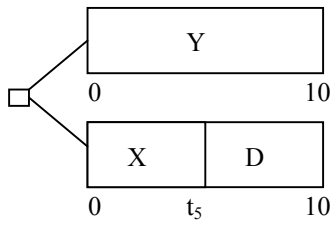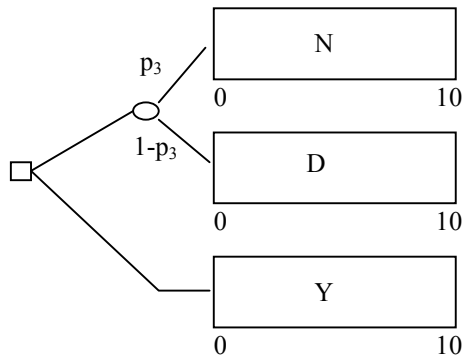

Figure 2. TTO question 5
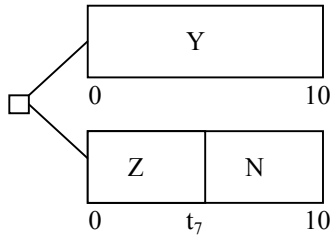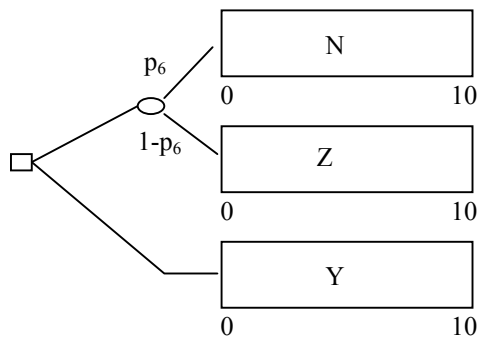

Figure 3. TTO question 7
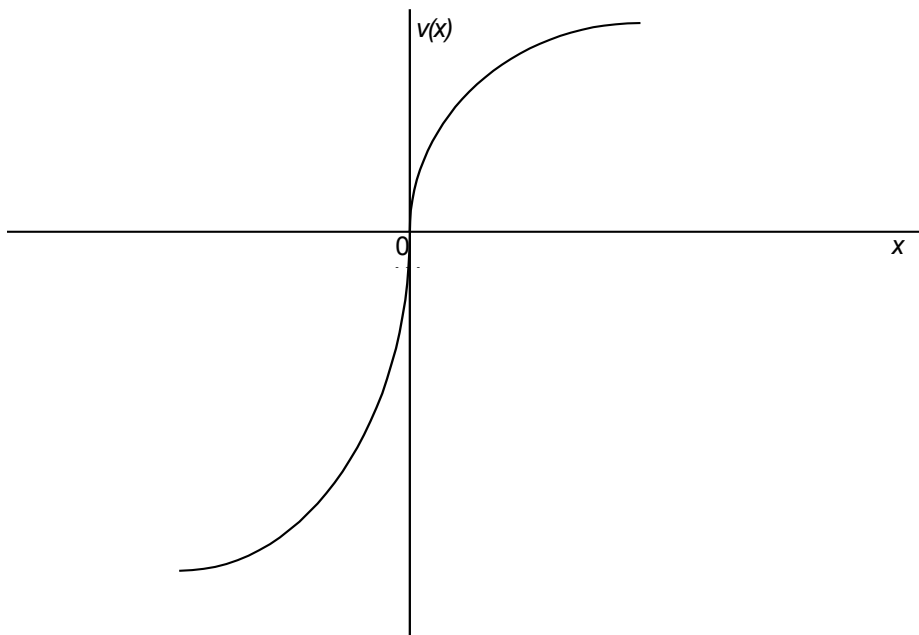

Figure 4. SG question 3

Figure 5. SG question 6

Figure 6. Prospect theory