Would you rather be ill now, or later?

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5 April 2012

Would you rather be ill now, or later?

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ABSTRACT

The Time Tradeoff (TTO) method is used to calculate the quality adjustment of the Quality Adjusted Life Year, and is therefore an important element in the calculation of the benefits of medical interventions. New specifications of TTO, known as 'lead time' TTO and 'lag time' TTO, have been developed to overcome methodological issues of the 'classic' TTO. In the lead time TTO, ill-health is explicitly placed in the future, after a period of good health, while in lag time TTO a health state starts immediately and is followed by a 'lag time' of good health. In this study, we take advantage of these timing properties of lead and lag time TTO. In particular, we use data from a previous study that employed lead and lag time TTO to estimate their implied discounting parameters. We show that individuals prefer being ill later, rather than now, with larger per-period discount rates for longer durations of the health states.

1. INTRODUCTION

It is uncertain whether values derived from preference elicitation tasks partly reflect, not just the value of a health state, but also the preferences individuals have for health impairments to occur now or in the future. Time preferences reflect the value given to the timing of an event (MacKeigan *et al.*, 2003). Any preference for timing, regardless whether it reflects a preference for events occurring sooner or later, has large consequences for the valuation of heath states and by extension for the assessment of the benefit of medical interventions with Quality Adjusted Life Years (QALYs). The quality adjustment of the QALY represents preferences for health states, which can be elicited with the popular Time Tradeoff (TTO) method. Recently, a new specification of this method, called lead time TTO, has been developed, which explicitly places health states in the future, after a so called 'lead-time' of good health (for a complete introduction into the methodology see (Robinson and Spencer, 2006; Devlin *et al.*, 2011; Versteegh *et al.*, 2012; Attema *et al.*, forthcoming a; Devlin *et al.*, forthcoming)). If individuals derive greater utility from good health now and poor health later, the valuation of a life profile where a health state occurs later in life (lead time TTO) is likely to yield higher utility than a life profile where the same health state, with the same duration, starts in the present, rather than in the future, and is followed, rather than preceded, by good health (lag time TTO).

Although credits for the lead time TTO are often given to Robinson and Spencer (2006), it had already been around for at least more than a decade. In 1995, Dolan and Gudex published an article aiming to disentangle time preference from duration effects in TTO. Their experimental approach was an application of lead and lag time TTO, although they did not denote it as such, and their purpose was not to overcome the problem of TTO regarding health states worse than death, which was the main motivation of the study by Robinson and Spencer (2006). Thus, lead and lag time TTO may be new as valuation methods for health states, but have been applied before in the measurement of time preferences.

A first direct measurement of the discounting function for health benefits under certainty was undertaken by Cairns (1992). The method used for this measurement involves the

increase of days in ill-health that a respondent is willing to accept in order to obtain a delay of the onset of this spell of ill-health (delay of illness method [DOIM]). Then, one has to specify a particular parametric shape of the discounting function and assume that there is no discounting within the period of ill-health, which allows one to analytically solve for the discounting parameter. The Direct Method (Attema *et al.*, forthcoming b) is comparable to the DOIM, but needs no parametric assumptions. Furthermore, it does not have to assume there is no discounting during the period of ill-health, which causes discontinuities in the discounting function. Olsen (1994) proposed to measure discounting using two different horizons in the classic TTO. In particular, this approach predicts lower TTO scores for longer durations because individuals are thought to more easily give up life years that occur farther in the future. However, in addition to having to assume a particular parametric shape of the discounting function, this method is not able to capture discounting for the power function.

In addition to the use of two classic TTOs, one may also consider using one lead and one lag time TTO to elicit time preferences, as was applied by Dolan and Gudex (1995). An advantage of this approach is that it is able to also capture power discounting, alongside the measurement of health state utilities by means of a procedure that is uniform for better and worse than dead health states. Here, this approach is applied and used to present empirical support for the hypothesis that individuals prefer being ill later, rather than now, at least for the observed illness durations. We do so by measuring time preferences using a study in which both lead and lag time TTO were applied (Versteegh *et al.*, 2012).

2. DISCOUNTING IN TTO

Within the assumptions of the generalized QALY model, TTO scores represent the value of a health state V(*Q*) by the amount of years, *T-x*, an individual is willing to trade off. Thus, for lead time TTO in a 20 year timeframe, with 10 years in full health (*FH*) and 10 years in the impaired health state (α), assuming no discounting, the utility equation is:

$$10V(FH) + 10V(\alpha) = xV(FH),$$ (1)

which can be solved for V(α), giving:

$$V(\alpha) = \frac{xV(FH) - 10}{10}.$$ (2)

However, if we assume individuals have a preference for timing, life years will be weighted for time preferences according to the function W(*t*), resulting in equation 3:

$$W(10)V(FH) + W(10)V(\alpha) = W(x)V(FH).$$ (3)

The utility equation for lag time TTO is identical, be it that V(*FH*) and V(α) are placed in reversed order.

A crucial issue is the identification of the shape of the discount function W(*t*), or, in other words, to measure how individuals value timing. The discount function can adopt different parametric shapes. Two popular parametric families are the exponential family (implying constant discounting) and the power family (implying hyperbolic discounting, i.e., decreasing discount rates over time). The exponential family can take the following form[1]:

$$W(t) = be^{-rt} + c,$$ (4)

where *r* is the discount rate and *t* the amount of years. Because W(*t*) is unique up to scale and location, we can freely fix *b* and *c*. For convenience, we set these values such that W(0)=1 and W(20)=1. This holds for $b = -1/(1 - e^{-20r})$ and $c = 1/(1 - e^{-20r})$. The power function, instead, can be expressed as[2]:

$$W(t) = bt^{s} + c,$$ (5)

with the power indicating the degree of hyperbolic discounting. For this function, we obtain W(0)=0 and W(20)=1 for the parameter values $b = (1/20)^{s}$ and $c = 0$.

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[1] And W(T)=b*t+c for r=0.

By substituting one of the discount functions given in equations 4 and 5 into equation 3, we get the discounted utility functions for lead time TTO (and the same can be done for lag time TTO). Then, the value of *r* or *s* can be varied until V(α) is the same for lead and lag time TTO. See the appendix for the complete derivation of the discounted utility functions.

3. METHOD

The linear QALY models predicts equal values for two health profiles which are identical in all aspects but the onset of the ill-health period. In the study by Dolan and Gudex (1995), lead and lag time TTO profiles were presented to respondents, which were identical except for the onset of disease. Given that the linear QALY model predicts equal outcomes for those profiles, the "relative preferences over [the two]… scenarios can be seen as tradeoffs between outcomes occurring at different points in time and thus from these responses each respondent's time preference rate for health could be estimated" (Dolan and Gudex, 1995, p.292). Of course, other factors than time preferences may cause differences between lead and lag time TTO, such as loss aversion, because good health is attained after a period of illness in lag time TTO; whereas, in lead time TTO it is lost. Dolan and Gudex (1995) tested several TTO specifications, for example a TTO with a total duration of 10 years, with 9 years lead [lag] time and 1 year disease time. We will denote this approach the 'onset of disease method' (ODM).

3.1. Dataset

We used data from another study, which applied lead and lag time TTO as valuation methods in an online sample of 6222 respondents, reflecting the Dutch general population[3]. Several TTO methods (see table 1) were applied to 100 Dutch EQ-5D-5L health states. The EQ-5D-5L consists of 5 dimensions of health (mobility, self care, usual activities, pain/discomfort and anxiety/depression) and five level answer categories, where level '1' represents absence of problems and level '5' represents extreme problems on that particular health dimension. Health states can be described with numbers for ease of use in reporting. A health state description '11211' signifies a health profile with

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[2] And W(T)=b*ln(t)+c for r=0.

[3] The details of this study and of the TTO procedures are presented in a companion paper (Versteegh *et al.*, 2012).

absence of health impairments in all dimensions, represented by '1', except for slight problems in 'usual activities', represented by '2' in the third digit location.

[Table 1 about here]

The study reported that, in the 20 year time frame, lag time TTO values were always lower than lead time TTO values. In the 15 year time frame (with only 5 years disease duration rather than 10 years disease duration in the 20 year time frame), this difference was much smaller and in 18 out of 100 health states lead time values were higher than lag time values (i.e., time preferences were negative).

3.2. ODM

The ODM offers an 'implied discount rate', as the difference between the two valuation methods is interpreted as an expression of preferences for timing. We applied the ODM to the mean TTO values for each health state, using both exponential discounting and power discounting. Hence, we generated 100 discount parameter estimates for the 15 year time frame, as well as 100 discount parameter estimates for the 20 year time frame for both the exponential discounting and the power model.

The mean discount parameter ($\bar{r}$ and $\bar{s}$) of each TTO type (a, b, c or d) was applied to all 100 health states of the relevant TTO type. The fit of $\bar{r}$ and $\bar{s}$ was assessed with the root of the mean squared error (RMSE). To clarify the procedure we provide a short example in table 2.

[Table 2 about here]

4. RESULTS

Without discounting, the difference between lead time TTO values and lag time TTO values, expressed in terms of RMSE, was 0.189 for the 15 year time frame and 0.273 for the 20 year time frame. Mean time preferences were positive, for both exponential and power discounting, suggesting that respondents consider profiles of health in which ill-health starts in the future to be more desirable than profiles of health in which ill-health

starts immediately. Both exponential and power discounting indicated more per-period discounting for the longer disease duration. Furthermore, both parametric families resulted in an equal but still sizable RMSE, suggesting that time preferences did not fully explain the differences between lead and lag time TTO, or at least not when the same average implied discount rate is used for all health states.

4.1. Exponential discounting

For the disease duration of 5 years (*a* and *c* from table 1) we found a mean yearly discount rate of 0.015 (sd = 0.016). For the disease duration of 10 years (*b* and *d*) we found a mean yearly discount rate of 0.054 (sd = 0.019). RMSE was 0.13 (compared to 0.189 without correcting for mean discount value) and 0.06 (compared to 0.273 without discounting) for the 5 and 10 year disease durations, respectively. There was no clear increasing or decreasing relationship between discount rates and health state severity. As shown in figure 1, time preferences were negative for 18 health states for the 5 year disease duration. The health states did not share common features, such as impairments on specific dimensions of health, to explain this phenomenon.

[Figure 1 about here]

4.2. Hyperbolic discounting

We found a mean power coefficient of 0.925 (sd = 0.079) for the 5 year disease duration and a mean power coefficient of 0.697 (sd = 0.089) for the 10 year disease duration. RMSE was 0.129 (compared to 0.189 without correcting for mean discount value) and 0.06 (compared to 0.273 without discounting), respectively. There was no clear relationship between the magnitude of the power coefficients and health state severity. Figure 2 shows the hyperbolic discount values for all 100 health states. For the 5 year disease duration, 18 health states were associated with negative time preferences (i.e., powers greater than 1).

[Figure 2 about here]

5. DISCUSSION

On average, individuals displayed positive time preferences for health states, indicating that for the disease durations tested here, respondents preferred ill-health to occur later rather than sooner. These results seemingly contradict the findings of Dolan and Gudex (1995), who found negative discount rates for their disease duration of 1 year, also using the ODM. However, the latter observation may indicate a tendency for lower discount rates when the disease duration is shorter, which is in line with the finding in our study that discounting is higher for a 10 year disease duration than for a 5 year disease duration. In terms of preferences for illness, it seems that individuals want to get a health state 'over with' if it is short-lasting (negative time preferences (Loewenstein, 1987; Loewenstein and Prelec, 1991)), and prefer a delayed onset when duration is longer, at least under certainty.

Several attempts have been performed to estimate time preference for health outcomes under certainty.[4] This literature highlights the wide variety of discounting estimates, which are highly influenced by procedural differences. The estimates vary between extremely high discount rates (above 100% per year, (Chapman, 1996; Chapman *et al.*, 1999; Ganiats *et al.*, 2000)) to negative discount rates (Redelmeier and Heller, 1993; Dolan and Gudex, 1995; Ganiats *et al.*, 2000). Moreover, the type of health state under consideration also seems to affect results. Ganiats *et al.* (2000), for example, found considerable differences between time preference in the case of headaches and chickenpox.

The consistent results found in our own study should thus be considered in the light of the diverse discounting literature which is, in itself, less consistent in findings. Due to the variability in procedures of eliciting discount values, it is difficult to conclude on the exact direction and size of the influence of time preferences on health state valuations, but there seems to be some consistency that they *are influenced* by time preferences.

Our study was limited by the mode of administration of the TTO study. In the companion paper (Versteegh *et al.*, 2012), we indicated that the quality data of an online

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[4] In addition, attempts have been made to elicit discounting under uncertainty (e.g. using the certainty equivalence method, e.g. van Osch et al., 2004; Stiggelbout et al., 1994; Martin et al., 2000) or using saved life years (e.g. (Cropper *et al.*, 1991; 1992; 1994; Cairns and van der Pol, 1997a; 1997b; Lazaro Alquezar *et al.*, 2001)), but these are distorted by risk (certainty equivalence) or equity (life saving) considerations, and, hence, are outside the scope of this paper.

TTO is lower than that of a TTO with interviewer guidance present, likely because not all individuals properly understand the task, or prefer to complete the task quickly, rather than thoroughly. Conducting this interview in a face-to-face setting would improve data-quality and strengthen our conclusions concerning time preferences. Finally, the current design was a between-subject design where respondents participated in either the lead time TTO or the lag time TTO. A within-subject design would also strengthen conclusions.

APPENDIX 1:

The full utility equation for lead time TTO (illustrative for the 20 year time frame), corrected for exponential discounting, is:

$$(be^{-10r} + c)V(FH) + (be^{-20r} + c - be^{-10r} - c)V(\alpha) = (be^{-rt} + c)V(FH).$$

(A1)

For lag time TTO, it is:

$$(be^{-10r} + c)V(\alpha) + (be^{-20r} + c - be^{-10r} - c)V(FH) = (be^{-rt} + c)V(FH),$$

(A2)

which, after scaling V(*FH*)=1, can be rewritten to solve for V(α) as equation A3 for lead time TTO:

$$V(\alpha) = \frac{e^{-10r} - e^{-rt}}{e^{-10r} - e^{-20r}};$$

(A3)

and equation A4 for lag time TTO:

$$V(\alpha) = \frac{c + b(e^{-rt} + e^{-10r} - e^{-20r})}{c + be^{-10r}} = 1 + \frac{b(e^{-rt} - e^{-20r})}{c + be^{-10r}} = 1 + \frac{(e^{-20r} - e^{-rt})}{(1 - e^{-10r})}.$$

(A4)

For power discounting, we obtain the following equations. For lead time TTO:

$$(b10^s + c)V(FH) + (b20^s + c - b10^s - c)V(\alpha) = (bt^s + c)V(FH);$$

(A5)

and for lag time TTO:

$$(b10^s + c)V(\alpha) + (b20^s + c - b10^s - c)V(FH) = (bt^s + c)V(FH),$$

(A6)

which can again be solved for V(α), resulting in equation A7 and A8, for lead and lag time TTO, respectively:

$$V(\alpha) = \frac{t^s - 10^s}{20^s - 10^s} \; ; \tag{A7}$$

$$V(\alpha) = \frac{c + b(t^s + 10^s - 20^s)}{c + b10^s} = 1 + \frac{b(t^s - 20^s)}{c + b10^s} = 1 + \frac{t^s - 20^s}{10^s} \; . \tag{A8}$$

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Table 1) TTO specifications in the dataset

	TTO type	Total timeframe	Onset of disease	Duration of disease
a	Lead time TTO	15 years	after 10 years	5 years
b	Lead time TTO	20 years	after 10 years	10 years
c	Lag time TTO	15 years	immediately	5 years
d	Lag time TTO	20 years	immediately	10 years

Table 2) Example of ODM for a 15 year time frame

	TTO type	EQ-5D-5L Health state (α)	Mean xV(*FH*)	Utility value V(α) (TTO value - 10 / 5)	Implied *r* (at which V(α)-a = V(α)-c using exponential discounting)	Mean *r*	Corrected utility values for mean *r*	RMSE of corrected values
a	Lead time TTO	52555	10.3	0.1			0.014	
					0.028			
c	Lag time TTO	52555	8.9	-0.2		0.024	0.05	0.038
a	Lead time TTO	25551	10.1	0.0			0.07	
					0.02			
c	Lag time TTO	25551	9.0	-0.2			0.03	

Figure 1: yearly discount rates for all 100 health states

Figure 2: Hyperbolic discount values for all 100 health states