Obesity and Counseling

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OBESITY AND COUNSELING

A theoretical model is developed addressing habit formation and time-inconsistent preferences in consumption of unhealthy foods. In particular, the effects of counseling in altering the consumption satiation point and lowering individual discount rates are investigated. The model highlights the importance of health counseling and offers support to initiatives such as low-cost obesity screening and counseling.

Key words: Obesity, Counseling, Habit formation, Time-inconsistent preferences.

JEL codes: I12, I18, I31.

With obesity rates nearly doubling from the 1980s to 2008, yielding epidemic proportions globally, it is one of the most widely pressing health problems (WHO, 2012). Empirical analysis suggests that an increase in caloric intake, rather than a change in caloric expenditure, is responsible for much of the obesity trend (Cutler, et al., 2003). Public policies directed at discouraging caloric consumption include taxes on sugar-sweetened beverages (SSBs), [1] educational programs, and product labeling such as nutrition information panel. Given the magnitude and importance of obesity to health outcomes, substantial literature has emerged investigating the effectiveness of these policies (e.g., Coestier et al., 2005; Finkelstein et al., 2012, Lin et al., 2011; Mokdad et al., 2001; Zhen et al., 2011). However, mechanisms for curbing obesity, involving behavioral counseling or therapy, have been largely ignored in economic analysis. Behavioral counseling fundamentally differs from other price or labeling based policies in that it is a mechanism directly aimed at an individual's underlying perception and attitudes toward food consumption. Such behavioral counseling is a foundation of the U.S. Affordable Care Act, which substantially reduces the cost of preventive services for obese patients. However, there is limited or no empirical work in economics investigating the effectiveness of behavioral counseling. One exception is an article by Kan and Tsai (2004), which tests the relationship between obesity and risk knowledge. On the theoretical side, modeling addictive consumption has expanded substantially since the seminal work on rational addiction by Becker and Murphy (1988). Based on this expanded work, a new direction is developing models that address external intervention, which may alter individual's consumption

[1] Gortmaker et al. (2009) defined the SSBs category to include all sodas, fruit drinks, sport drinks, low-calories, and other beverages that contain added caloric sweeteners (sweet tea, rice drinks, bean beverages, sugar cane beverages, horchata, and non-alcoholic wines and malt beverages).

preference and time preference. As a first attempt, a theoretical model is developed that highlights the role of behavioral counseling within the framework of rational addiction.

Three unique contributions result from the theoretical model. First, two plausible explanations are proposed for the failure of taxes on SSBs and information programs aiming to discouraging caloric consumption. One explanation is the presence of habit formation or addiction in certain food consumption (Benton, 2010; Carroll et al., 2011; Davis and Carter, 2009; Gearhardt et al., 2009; Khare and Inman, 2006; Richards et al., 2007; Zhen et al., 2011). Another explanation is individual time-inconsistent preference. Time-inconsistent preference causes failure of realization of weight loss plans (Bleichrodt and Gafni, 1996; Cawley and Ruhn, 2011; Scharff, 2009). Second, the potential role of counseling is formalized in mitigating the mentioned two problems. This effort expands the literature modeling addictive consumption to incorporate counseling as an external intervention, which endogenizes individual consumption preferences and time preferences. Third, results from the model provide support to initiatives such as low-cost obesity screening and counseling and are consistent with new requirements for intensive behavioral intervention for obesity by the U.S. Preventive Service Task Force (USPSTF).

In this paper, the investigation of behavioral counseling is grounded in the health belief theory.[2] It is motivated by the theory that individuals' personal beliefs on the consequences of obesity and the probability of developing conditions caused by obesity may comprise their commitment to health behavior changes. Furthermore, individuals' perceptions as to whether a

[2] Health belief theory is derived from an established body of psychological and behavioral theory, and is a commonly used theory in health education and health promotion. The underlying paradigm is that personal beliefs influence health behavior. Individual beliefs, such as individual perceived seriousness of and susceptibility to the condition, benefits from, and barriers to change in behavior along with cues to action and self-efficacy are the main determinants of health behavior change (Glanz et al., 2008).

new behavior is preferred to existing behavior also affects whether the behavioral change will actually occur. Counseling addresses individuals' unrealistic perception of their own weight, confusion regarding causes and consequences of obesity, and biased expectations of weight loss. It emphasizes that even a small weight loss can significantly reduce diabetes risks[3]. The effectiveness of obesity counseling foreseen in health belief theory is supported in numerous field studies (e.g., Post et al., 2011, Powell-Wiley et al., 2012).

The theoretical model based on health belief theory assumes counseling obese patients will result in weight reduction through two major channels: it alters their consumption preferences and time preferences. Assuming an obese patient is still forward looking but exposed to imperfect information, counseling helps the patient establish an unbiased perception and healthier consumption pattern. In the model, an individual's consumption and time preference are endogenous to counseling. Counseling is a repeated process through time and triggers changes in consumption preferences via changes to individuals' underlying utility function. However, the effects of counseling sessions can be temporary, gradually decaying back to zero resulting in individuals relapsing to their original preference until the next secession occurs.[4] Counseling also affects individual time preferences via lowering time discount factors. Similar to a preference change, an altered time-discount factor also relapses after a counseling secession. Individuals choose the optimal time to join and quit counseling by maximizing the present value of utility through time.

[3] For example, a 5% weight loss reduces type 2 diabetes risk by 60% (Clifton, 2008; Wadden, 2011).

[4] This assumption is consistent with high rate of patient relapse as sustained weight loss is especially problematic—up to 95% of patients regain their weight within five years (Freedman, 2008).

Literature Review

Since Becker and Murphy (1988), the rational theoretical approach has become the standard to developing addiction models in economics. But, the assumption of perfect foresight has also received critiques. Later extensions of rational addiction models are generally motivated by relaxing the fully rational assumption allowing partial awareness of the potential harm associated with consuming an addictive substance. These extensions include uncertainty and regret (Orphanides and Zervos, 1995), bounded rationality (Suranovic et al., 1999), endogenous time preference (Orphanides and Zervos, 1998) and quasi-hyperbolic discounting (Gruber and Köszegi, 2001).

Modeling food consumption within this framework is a recent trend. Different perspectives on the causes of obesity lead to a variety of models. The theoretical work addressing obesity can be divided into three areas. The first is within the framework of household production models. This assumes individuals maximize utility subject to their ability to produce commodities for personal use, their budget constraint, and time constraint. Mancino and Kinsey (2004) incorporate the visceral influences from Loewenstein (1996) into the Becker (1965) household production model to depict how individual's food choices are affected by time delays and situational factors. An individual's utility is assumed to be a function of food consumption, composite non-food consumption, leisure time, and the individual's perceived health status and the visceral factors. The model allows individual's knowledge about health to play a role on how they perceive their own health from a change in bodyweight. An ideal weight is given and deviation from it causes disutility. Their research indicates that although knowledge about the importance of eating well should increase consumer's intention to follow a healthier diet, the intentions can be thwarted by visceral factors such as hunger, a hectic schedule, and where consumers choose to obtain food.

The works of Philipson and Posner (1999) and Lakdawalla and Philipson (2009) develop a similar but simpler dynamic framework addressing the role of technological change in the rise of obesity. They assume individuals derive utility from bodyweight directly, and bodyweight rises with consumption but falls with individual's home or market production activities. Deviation from an ideal bodyweight also causes disutility. They conclude that approximately 40% of weight gain is due to the expansion of food supply, and 60% to the reduction in the physical requirements.

The second area is categorized within the rational addiction framework. Dockner and Feichtinger (1993) expand the addiction capital in Becker and Murphy (1988) model from one to two: eating capital (or addictive capital) and weight capital. The eating capital presents the addictive force causing current consumption to rise with past consumption and the weight capital presents the satiating force driving current consumption to decline as habits accumulate. By introducing weight as another consumption capital, their model is able to explain the cyclical consumption that the Becker and Murphy model fails to demonstrate.

In Levy (2002), eating is neither addictive or a formed habit, individuals take into consideration the probability of dying associated with deviation from physiologically optimal weight when maximizing expected utility over their life time. The model demonstrates a steady state of overweightness given no physiological, psychological, environmental, and sociocultural effects. When the socio-cultural norms are incorporated, the steady state for overweight individuals is lower, and stationary weight of lean individuals is greater than otherwise. Levy

(2003) distinguishes the consumption of health food from junk food and highlights the effects of age on individual's health condition and the role of the relative price of junk-food.

Dragone (2009) generalizes the Levy (2002) model to allow for possible presence of habits in food consumption. The Dragone (2009) model deviates from the traditional method of assuming that past consumption has effects on the marginal utility of current consumption, instead it assumes changes in food consumption are costly. Dragone (2009) shifts the emphasis from studying the role of the level of consumption to changes in consumption. The results indicate that, with consumption habits, following a monotonic path can be too costly if it requires too rapid changes in the amount of food consumption. Thus, a slower convergence to steady state bodyweight is required and it is associated with fluctuations above and below the steady state body weight.

Yaniv (2002) aims at explaining the failure to adhere to a low-fat dietary regimen. Individuals decide on whether or not to adhere to the prescribed diet. They maximize the present value of their expected lifetime utility stream from the consumption of high-fat and low-fat products, taking into account the adverse effect of high-fat consumption. Slightly different from Levy (2002, 2003), adverse effects of high-fat consumption are modeled through the probability of experiencing a heart attack. In Yanic (2009), a rational choice model is developed to examine the effect on obesity of a tax on junk-food and a subsidy to cooking ingredients. Results indicate for non-weight conscious individuals a fat tax will unambiguously reduce obesity, whereas a thin subsidy may increase obesity. For a weight conscious individual, particularly one who is physically active, even a fat tax may increase obesity.

A recent model within the rational framework is developed in Dragone and Savorelli (2012). They continue modeling habit as changing consumption and incorporate the social ideal bodyweight. Their model accounts for the social pressure individuals suffer when bodyweight does not conform to an ideal social weight.

All the work within the rational framework (considering habit or not) view weight gain as the outcome of rational choices that reflect willingness to tradeoff some future health for the present pleasures of less restrained eating and lower physical activity. The individual consumption preference and discount rate are fixed through the life-time maximization. This type of model does not consider the substantial evidences of bounded rationality and time-inconsistent preferences of obesity patients from psychology and behavioral economics (Borghans et al., 2006; Courtemanche et al., 2011; Komlos et al., 2004; Ikeda et al., 2010; Zhang et al., 2008).

The third area raises problems with full rationality and provides an alternative. Suranovic and Goldfarb (2005) develop a behavioral model of food consumption choices that illuminates observed patterns of dieting. The key assumption is excessive computational costs constrain decisions to be made only for the current consumption periods. Unlike the property of adjacent complementarity displayed in the Becker and Murphy model,[5] individuals do consider the future health effects of current consumption. However, they do not consider how this consumption will affect tomorrow's consumption decisions or how future decisions will affect current choice. Consumption habit is incorporated by assuming a habit level of consumption and sudden reductions induce negative effects.

Based on the previous literature, an economic approach is developed for understanding obesity with emphasis on obesity counseling. Individuals are still assumed to be rational and

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[5] "Adjacent complementarity" indicate that due to reinforcement, the quantities of the addictive good consumed in different time periods are complements; as a result, current consumption of an addictive good is inversely related to not only the current price of the good, but also to all past and future prices. It is a critical hypothesis derived from the Becker and Murphy (1988) model of rational addiction.

forward-looking, provided evidence by Gruber & Köszegi (2001). However, full rationality is limited by a time-inconsistent discount rate. Time preference is endogenous to obesity counseling by assuming that counseling triggers a change in individuals' discount rates. The model focus on the effect counseling has on the change in individual behavioral, so the utility framework developed in Dragone and Savorelli (2012), which focus on the change of consumption, is applied.

The model

The objective is to model obesity counseling as a potential mechanism for influencing established consumption habits and the preference discount rate. Individuals' consumption patterns are modeled under habit-formation and inconsistent discount rates. A dynamic model is developed to solve for the optimal starting time of counseling, duration of counseling, and to compare different patterns of counseling. Following Dragone and Savorelli (2012), the individual's non-counseling instantaneous utility of an agent is then stated as

(1) $$U(t) = c(t)[c^F - (c(t)/2)] - 1/2[w(t) - w^H]^2 - (\beta/2)[w(t) - w^G]^2.$$

The first term, $c(t)[c^F - (c(t)/2)]$ is the utility from calories through food consumption $c(t) \geq 0$ at time t and $c^F > 0$ is an individual's satiation point, above which the marginal utility from food is negative. The maximum utility occurs when c is equal to c^F . Consumption below or above the satiation point c^F yields a lower utility level.

The second term in (1), $½[w(t) - w^H]^2$, represents the utility from individual bodyweight. The variable $w(t)$ is bodyweight at time t, and w^H represents a healthy bodyweight. According to WHO guidelines (2000, 2004), when an individual's BMI is between 18.5 and 25, a person is considered to have a normal weight. Deviations from the healthy bodyweight have a negative impact on utility. An overweight person may experience some physical inconveniences such as back pain, while an underweight person may have trouble regulating body temperature. The last term, $(\beta/2)[w(t) - w^G]^2$, refers to the effect of a socially desirable bodyweight w^G. As in Dragone and Savorelli (2012), w^G is assumed to be exogenously determined. The parameter $\beta \geq 0$ measures the intensity of the cost due to a difference between an agent's bodyweight and the socially desirable bodyweight.

This Dragone and Savorelli (2012) non-counseling utility function (1) may be considered in a dynamic framework with counseling by considering a utility stream starting at time s_0 and ending at time s_1 with counseling. Counseling has value in terms of alerting individuals to adjusting their satiation point c^F and their socially desirable bodyweight w^G to maximize their utility stream. This satiation point and their socially desirable bodyweight may maximize their utility at time s_0, but might be too high for maximizing their lifetime utility stream. As they continue through time to consume around this level of c^F and w^G, their utility declines as they realize the long-term consequences of this inflated satiation point and socially desirable bodyweight. At some point this decline in utility may trigger a change in the satiation point, c^F, and their socially desirable bodyweight, w^G. Such a trigger is termed counseling, where it could result from a physical health checkup, a psychological session, and/or external peer or internal pressure. An example are individuals who know their consumption of high calorie junk foods are detrimental to their long-term health, but currently for instantaneous utility are willing to consume them. But through time their continued consumption of junk foods starts to be a concern and at some point they decide to adjust downward their consumption. Thus, within the interval s_0 and s_1, $\partial U / \partial t < 0$.

Non-Learner

For modeling the optimal timing for receiving counseling, first consider the case when obese patients are naïve and do not alter their satiation point, c^F, their socially desirable bodyweight w^G, or time preferences after counseling (non-learners). Some individuals may regardless of counseling not change their preferences, but with counseling, their utility may return to the utility level experienced at s_0. Individuals may under internal or external (friends, family, and coworkers) pressure get counseling to relieve this pressure, but then just disregard it. The relieved pressure then restores their utility to that experienced at s_0.

Consider the case of only one counseling session (cycle) with an individual's discount rate ρ. The present value of one cycle consisting of a utility stream starting at time s_0 and ending at time s_1 is then

(2) $$\Upsilon(s_0, s_1, 1) = \int_{s_0}^{s_1} U(t)e^{-\rho(t-s_0)}dt,$$

where $\gamma(s_0, s_1, 1)$ represents the stream of utility starting at s_0 and ending at s_1 with one counseling session. The optimal terminal time, s_1', is then determined by the condition $U(s_1') = 0$. With no subsequent cycles there is no transversality condition on terminal time, so utility is driven to zero. Individuals will not consider counseling until they do not receive any positive utility from continuing their current level of consumption. If the utility functional never reaches zero, then there is no terminal time and it is an infinite horizon problem. This is the scenario employed by previous research, most recently by Dragone and Savorelli (2012), which then concentrates on determining the optimal trajectory of calories, $c(t)$, through time. Figure 1 illustrates this optimal time, s_1', when utility does dissipate to zero. The cumulative utility increases at a decreasing rate, given utility per unit of time decreases through time. With only one counseling session, the optimal time for counseling is when the utility per unit of time is zero, at s_1'.

Equation (2) may be extended by assuming an individual has the objective of maximizing a stream of utility over an infinity life, $\gamma(s_0, s_1, \infty)$ rather than the one cycle (2) alone with a constant cost C of a counseling session. This cost of counseling is in terms of both explicit cost such as paying for a doctor's appointment and implicit cost involving the disutility of experiencing a counseling session. This stream of utility involves multiple counseling sessions with associated length between each session, s_1. This assumes individuals will not just receive one counseling session throughout their lives but will incur multiple sessions. Examples are individuals having annual physicals or attending WeightWatchers on a regular basis. Without loss of generality, assume utility will start at age zero, $s_0 = 0$ (birth). The present value of the utility stream is then

$$(3)\qquad \Upsilon(0, s_1, \infty) = \Upsilon(0, s_1, 1) - e^{-\rho s_1}C + e^{-\rho s_1}\Upsilon(0, s_1, 1) - e^{-\rho 2 s_1}C + e^{-\rho 2 s_1}\Upsilon(0, s_1, 1) + \ldots$$

$$= [\Upsilon(0, s_1, 1) - e^{-\rho s_1}C]\,[1 + e^{-\rho s_1} + e^{-\rho 2 s_1} + \ \ldots]$$

$$= \frac{1}{1 - e^{-\rho s_1}}\,[\Upsilon(0, s_1, 1) - e^{-\rho s_1}C].$$

This is the present value of a perpetual utility annuity of the amount $[\gamma(0, s_1, 1) - e^{-\rho s_1}C]$ received every s_1 years. The optimal duration between counseling, s_1^*, is then determined by

$$\frac{\partial\,\Upsilon(s_0, s_1, \infty)}{\partial s_1} = \frac{-\rho e^{-\rho s_1}}{(1 - e^{-\rho s_1})^2}\,[\Upsilon(0, s_1, 1) - e^{-\rho s_1}C] + \frac{e^{-\rho s_1}}{1 - e^{-\rho s_1}}\,[U(s_1) + \rho C] = 0.$$

Rearranging terms

$$(4)\qquad U(s_1) = \frac{\rho}{1 - e^{-\rho s_1}}\,[\,\Upsilon(0, s_1, 1) - \,C].$$

$$= \frac{\rho}{1 - e^{-\rho s_1}}\,\psi(s_1).$$

Considering the opportunity cost of lost utility by not having counseling results in (4) where the individual does not reduce utility down to zero when considering just one counseling session (2). The greater future utility (feeling better after counseling the more impatient the individual will be to receive counseling, but this impatience is mitigated by the cost of counseling, C. Figure 1 illustrates this transversality condition; yielding counseling at s_1^*. As illustrated in the figure, consideration of utility from the second and subsequent sessions leads to an earlier time for counseling. This assumes the cost of counseling is less than the associated future utility. For maximizing (3), the individual should seek counseling when the utility of not having counseling equals the flow which could be realized by an immediate counseling session.

Substituting (2) into (4) and rearranging terms yields

$$(5) \qquad U(s_1) = \frac{\rho}{1 - e^{-\rho s_1}} \left(\int_0^{s_1} U(t) e^{-\rho t} dt \; - C \right)$$

$$= \frac{\rho}{1 - e^{-\rho s_1}} \Psi(s_1),$$

where $\Psi(s_1)$ is the net present value of accumulated utility at the time of counseling. The net present value, $\Psi(s_1)$, received is a perpetual annuity received every s_1 years. The recovery factor, $\frac{\rho}{1 - e^{-\rho s_1}}$, converts this annuity into a constant flow of utility. The denominator yields the present value of the annuity and the numerator converts this present value into a continuous flow. Figure 2 illustrates a non-learner's optimal time path for $U(t)$. Utility depreciates with the length of time since the last counseling. At the time thresholds s_1, $2s_1$, …, the non-learner's utility has declined to the point of triggering a counseling. With the counseling, utility is then restored to its initial level $U(0)$.

Case One

As a special case, consider individuals who retain a constant satiation point, c^F, and socially desirable bodyweight, w^G, through time regardless if they receive any counseling. For these individuals, counseling has no value in terms of alerting them to adjusting their satiation point c^F and their socially desirable bodyweight w^G to maximize their utility stream. They either do not realize the long-term consequences of a possible inflated satiation point and bodyweight or discount any long-term consequences to zero. For these preferences, the utility flow U is

$$U = \frac{\rho}{1-e^{-\rho s_1}}\left(U\int_0^{s_1} e^{-\rho t}dt - C\right)$$

$$= \frac{\rho}{1-e^{-\rho s_1}}\left(U\frac{1-e^{-\rho s_1}}{\rho} - C\right)$$

$$= U - \frac{\rho}{1-e^{-\rho s_1}}C.$$

Which implies $C = 0$. The individual will never seek counseling. The optimal counseling is zero. In Figure 2, this corresponds to a constant *U(0)* across time with no counseling.

Case Two

For this second special case, consider a non-learner with a zero discount rate, $\rho = 0$, but does not retain a constant satiation point and socially desirable bodyweight as assumed in case one. Such individuals value current utility and future utility the same. They are not impatient, so they have no time discounting of preferences. Considering (5) and employing the L'Hospital's Rule

$$lim_{\rho \to 0} \frac{\rho}{1-e^{-\rho s_1}} = \frac{1}{s_1}.$$

Thus, (5) becomes

$$U(s_1) = \frac{1}{s_1}\Psi(s_1).$$

The optimal counseling is where the utility at counseling equals the average undiscounted utility over time. Figure 1 provides an illustration of this result. The cumulative undiscounted utility over time is a strictly concave function starting at some initial time. The zero discount solution is s_1^0, which maximizes the average undiscounted revenue over time.

Figure 1 illustrates an individual will get counseling sooner as the discount rate increases. However, in general this relation is indeterminant. From (5)

$$(6) \qquad \frac{\partial\left(\frac{\rho}{1-e^{-\rho s_1}}\Psi(s_1)\right)}{\partial\rho} = \Psi(s_1)\frac{\partial\left(\frac{\rho}{1-e^{-\rho s_1}}\right)}{\partial\rho} + \frac{\rho}{1-e^{-\rho s_1}}\frac{\partial\Psi(s_1)}{\partial\rho}.$$

The first term on the right-hand-side is positive but the second term is negative, given $\frac{\partial\Psi(s_1)}{\partial\rho} < 0$. Thus, the sign of (6) is indeterminant. A rising discount rate, ρ, increases the recovery factor, $\rho/(1 - e^{\rho s_1})$, which increases the cost of delaying counseling. This delay is mitigated by the decline in the present value of future utility as the discount rate increases, $\frac{\partial\Psi(s_1)}{\partial\rho} < 0$. For relatively low counseling costs, the second term will not be sufficient to completely offset a positive response. Thus, a rise in the discount rate will result in an unambiguously earlier counseling.

Learner

Consider the case where individuals are learners and thus permanently modify their satiation point, c^F, along with their socially desirable bodyweight, w^G, after just one counseling session. The utility function (1) developed by Dragone and Savorelli (2012) can be modified for considering such a permanent learner

$$(7) \qquad R(t) = c(t)[c^{FL} - (c(t)/2)] - ½[w(t) - w^H]^2 - (\beta/2)[w(t) - w^{GL}]^2.$$

Assuming counseling will cause a decrease of the satiation point, c^F, and the individual's perception of socially desirable bodyweight w^G, $c^{FL} < c^F$ and $w^{GL} < w^G$. Again denoting s_1 as the starting time of the first and only counseling period, the individual's stream of utility is then

$$\Upsilon_1(s_0, s_1, \infty) = \Upsilon(s_0, s_1, 1) - e^{-\rho(s_1 - s_0)}C + \int_{s_1}^{\infty} e^{-\rho(t-s_0)}R(t)dt.$$

The optimal time, s_1^L, occurs when $U(s_1) = R(s_1) - \rho C$. The first and only counseling session should be postponed until the utility at s_1^L equals the utility that could be obtained from a session, $R(s_1)$, minus the incremental counseling cost, ρC. The higher the value of the utility flow after counseling, the sooner will be the checkup. In contrast, the higher the counseling cost, the longer will be the delay in receiving counseling.

Figure 3 illustrates a learner's optimal utility time path. At the time threshold s_1^L the learner's utility has declined to the point of triggering a counseling session. With the checkup, the learner's utility, $R(s_1^L)$, is higher than the initial level U(0). The learners do modify their utility after counseling, so they do not revert back to the initial activities associated with U(0).

Learner with Relapse

For many dynamic preferences, individuals may at first adjust their preference following counseling, but then through time revert back to some prior preference behavior. Individuals may at first follow the advice and adjust their diet, but over time they return to their pre-counseling diet. This behavior is consistent with the evidence that rebound weight gain is common (Swinburn et al., 2007; Blackburn, 2006; Fleck et al., 2008). Thus, repeated sessions may be required.

The time path of counseling can be modeled by defining the binary control variable θ_k specifying the k[th] counseling session

$$\Theta_k = \begin{Bmatrix} 1\ counseling \\ 0\ otherwise \end{Bmatrix} \text{ with } \theta_0 = 0 \text{ and } k = 1, 2, \ldots \infty.$$

Theoretically, an individual can have an infinite number of counseling sessions as k approaches infinity.

Counseling can change individuals' preferences by altering their satiation point, c^F, (reduce their desired level of caloric intact), by lowing their socially desirable bodyweight, w^G, (realize the social benefits in losing weight), and by changes in the discount rate, ρ, (made aware of the long-term costs of current consumption habits). Considering these potential effects of counseling, after counseling an individual's utility is

$$(8) \qquad R(s_k, u_k, k) = c(t)[e^{r(t-u_k)}c^F - (c(t)/2)] - ½[w(t) - w^H]^2 - (\beta/2)[w(t) - e^{s(t-u_k)}w^G]^2,$$

where s_k and u_k denote the beginning and ending of counseling session k, $k = 1, 2, \ldots \infty.$

Counseling triggers a decrease of the satiation point, c^F, and the individual's perception of socially desirable bodyweight w^G. This is modeled by the exponential adjustment factors $e^{r(t-u_k)}$ and $e^{s(t-u_k)}$, which decrease to one as t increases to u_k. At the time of the counseling session, individuals adjust their satiation points and socially desirable bodyweights downward, but subsequent to the session, these target levels increase exponentially to their previous non-counseling levels. Through time these adjustments dissipate, so, at time u_k the individual's target levels of satiation and socially desirable bodyweight are restored to their pre-counseling levels. The discount parameters $r > 0$ and $s > 0$ measure the intensity of this reversion.

Possible changes in time preference may be realized through different discount rates. Before counseling, utility is discounted by the factor $e^{-\rho t}$, during counseling it reduces to $e^{-\tau t}$.

After counseling it becomes $e^{-\upsilon t}$. So, ρ, τ, and υ denote three different discount rates for the three different stages: before, during, and after counseling. It is assumed $\tau < \upsilon < \rho$ considering that the effect of counseling in lowering the discount rate may still remain after the effective counseling period.

Thus, an individual's generalized stream of utility is

$$(9)\qquad \Upsilon(s_0, s_1, s_2, \ldots, u_1, u_2, \ldots, \infty) = \sum_{k=1}^{\infty}(1 - \theta_{k-1}) \int_{s_{k-1}}^{s_k} e^{-\rho(t-s_0)}U(t)dt$$

$$+ \theta_k \left\{-Ce^{-\tau(s_k - s_0)} + \int_{s_k}^{u_k} e^{-\tau(t-s_0)}R(t)dt + \int_{u_k}^{s_{k+1}} e^{-\upsilon(t-s_0)}U(t)dt\right\}.$$

This utility stream is maximized subject to the change in bodyweight influenced by calories consumed and burned as specified by Dragone and Savorelli (2012).

The generalized set up of (9) can be simplified to the maximization problem in Dragone and Savorelli (2012) by assuming a single constant discount rate without counseling. Specifically, if for all k, $\theta_k = 0$, and $\tau = \upsilon = \rho$, (9) reduces to $U(0,\infty) = \int_0^{\infty} U(t)dt$, which corresponds to equation (3) in Dragone and Savorelli (2012).

The conditions for maximizing (9) determine the optimal levels of the control variables, c(t), and the optimal starting and ending point of counseling, s_k and u_k. Dragone and Savorelli (2012) provide the conditions for determining the optimal time path of c(t). The optimal starting and ending points of for counseling sessions can be determined by treating the control variables as parameters, which transforms the optimal control problem (9) into a calculus of variation problem (Kamien and Schwartz, 1992).

$$(10)\qquad \partial\Upsilon/\partial s_k = \theta_{k-1}\left[e^{-\upsilon(s_k - s_0)}U(s_k) + \int_{u_{k-1}}^{s_k} e^{-\upsilon(t-s_0)}\partial U(t)/\partial s_k\, dt\right]$$

$$+ (1 - \theta_{k-1})[e^{-\rho(s_k - s_0)}U(s_k) + \int_{s_{k-1}}^{s_k} e^{-\rho(t-s_0)}\partial U(t)/\partial s_k\, dt]$$

$$+ \theta_k[\tau C e^{-\tau(s_k - s_0)} - e^{-\tau(s_k - s_0)} R(s_k)$$

$$+ \int_{s_k}^{u_k} e^{-\tau(t-s_0)} \partial R(t)/\partial s_k \, dt] = 0, \quad k = 1, 2, \ldots,$$

(11) $$\partial \Upsilon/\partial u_k = \theta_k[e^{-\tau(u_k - s_0)} R(u_k) + \int_{s_k}^{u_k} e^{-\tau(t-s_0)} \partial R(t)/\partial u_k \, dt$$

$$- e^{-v(u_k - s_0)} U(u_k) + \int_{u_k}^{s_{k+1}} e^{-v(t-s_0)} \partial U(t)/\partial u_k \, dt] = 0,$$

$$k = 1, 2, \ldots,$$

where

$$\partial R(t)/\partial u_k = -\tau c(t) e^{r(t-u_k)} c^F - s\beta w^G e^{s(t-u_k)} [w(t) - e^{s(t-u_k)} w^G] < 0, \; k \geq 1.$$

For interpretation the second and fourth terms in (10), $\int_{u_{k-1}}^{s_k} e^{-v(t-s_0)} \partial U(t)/\partial s_k \, dt$ and $\int_{s_{k-1}}^{s_k} e^{-\rho(t-s_0)} \partial U(t)/\partial s_k \, dt$ are considered zero. This implies the utility derived prior to the start of counseling is not affected by when the counseling starts. It assumes individuals do not adjust their satiation point as the start of counseling nears. In contrast, the second term in (11), $\int_{s_k}^{u_k} e^{-\tau(t-s_0)} \partial R(t)/\partial u_k \, dt$, is not considered zero, given $R(s_k, u_k, k)$ in (8) is a function of u_k, $\partial R(t)/\partial u_k < 0$. The utility following counseling is a function of its ending point u_k. In terms of the when counseling starts, s_k, influencing the utility stream of counseling, $R(s_k, u_k)$, and when counseling ends, u_k, influencing the utility stream of post-counseling, $U(u_k, s_{k+1})$, these influences may not be zero. Specifically, generally the last terms in (10) and (11), $\int_{s_k}^{u_k} e^{-\tau(t-s_0)} \partial R(t)/\partial s_k \, dt$ and $\int_{u_k}^{s_{k+1}} e^{-v(t-s_0)} \partial U(t)/\partial u_k \, dt$ may not be zero. As individuals delay their start of counseling sessions, their utility upon entering counseling may increase. They realize an increase in the value of counseling after having delayed it, $\partial R(t)/\partial s_k > 0$. Only if the aggregate utility for a fixed time interval between s_k and u_k is independent of when counseling starts will $\partial R(t)/\partial s_k$ = 0. Similarly, the marginal utility over the course of post-counseling may change depending on when the counseling period ends, u_k.

The interpretation of (10) and (11) can be developed given the values of the binary control variables for counseling, θ_k, k = 1, 2, … . If θ_k = 0, k = 0, 1, 2, … , there are no counseling sessions and (10) reduces to the Dragone and Savorelli (2012) solution . Considering only one counseling session, θ_1 = 1 and θ_k = 0, for k = 2, … , then (10) and (11) reduce to

(12a) $\partial\Upsilon/\partial s_k = e^{-\rho(s_k - s_0)}U(s_k) + \tau C e^{-\tau(s_k - s_0)} - e^{-\tau(s_k - s_0)}R(s_k)$

$$+ \int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial s_k \, \mathrm{dt}] = 0, \quad \mathrm{k} = 1,$$

(12b) $\partial\Upsilon/\partial s_k = e^{-\upsilon(s_k - s_0)}U(s_k) = 0, \qquad \mathrm{k} = 2,$

(12c) $\partial\Upsilon/\partial s_k$ = 0, k = 3, … ,

(13a) $\partial\Upsilon/\partial u_k = e^{-\tau(u_k - s_0)}R(u_k) + \int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial u_k \; dt$

$$- e^{-\upsilon(u_k - s_0)}U(u_k) + \int_{u_k}^{s_{k+1}} e^{-\upsilon(t-s_0)}\partial U(t)/\partial u_k \, dt = 0,$$

k = 1,

(13b) $\partial\Upsilon/\partial u_k$ = 0, k = 2, … .

The condition for the one counseling in (12a) is determined where $e^{-\rho(s_k - s_0)}U(s_k)$ represents the gain in utility for postponing counsel one period and the remaining terms, $\tau C e^{-\tau(s_k - s_0)} - e^{-\tau(s_k - s_0)}R(s_k) + \int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial s_k$ dt, represent the cost of this postponement. This cost is in terms of lost utility from the postponement, $e^{-\tau(s_k - s_0)}R(s_k)$ minus the incremental counseling cost, $\tau C e^{-\tau(s_k - s_0)}$ and the aggregate counseling period costs $\int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial s_k$ dt. The term $e^{-\tau(s_k - s_0)}R(s_k)$ is the loss in utility from one period postponement of counseling and $\int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial s_k$ dt is the aggregate utility lost from postponement. At the optimal counseling time, s_1, the marginal benefits are just equal to the marginal costs of instigating a counsel. From (12b), when $k = 2$, $U(s_k) = 0$. With no subsequent counseling there is no transversality condition on terminal time, so utility is driven to zero. As with the non-learner optimal condition (2), individuals will not consider counseling until they do not receive any positive utility from continuing their current level of consumption. If the utility never reaches zero, then there is no terminal time and it is an infinite horizon problem.

Similar to (12), the one counseling optimal condition (13a) states the marginal benefits from an additional counseling period, $e^{-\tau(u_k - s_0)}R(u_k) + \int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial u_k \; dt$, are just equal to the marginal costs of the post counseling period, $e^{-\upsilon(u_k - s_0)}U(u_k) + \int_{u_k}^{s_{k+1}} e^{-\upsilon(t-s_0)}\partial U(t)/\partial u_k \, dt]$. The marginal benefits are the added utility from postponing post-counseling one period, $e^{-\tau(u_k - s_0)}R(u_k)$, plus the aggregate period benefits, $\int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial u_k \; dt$. The benefits are then balanced with the costs. The cost of delaying post-counseling one period, $e^{-\upsilon(u_k - s_0)}U(u_k)$, plus any aggregate period cost of postponement.

The condition for continuous counseling, represented as $\theta_k = 1$, $k = 1, 2, \dots$, yields the optimal conditions

(14a) $$\partial\Upsilon/\partial s_k = e^{-\rho(s_k - s_0)}U(s_k) + \tau C e^{-\tau(s_k - s_0)} - e^{-\tau(s_k - s_0)}R(s_k) + \int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial s_k \, dt = 0, \quad k = 1$$

(14b) $$\partial\Upsilon/\partial s_k = e^{-\upsilon(s_k - s_0)}U(s_k) + \tau C e^{-\tau(s_k - s_0)} - e^{-\tau(s_k - s_0)}R(s_k) + \int_{s_k}^{u_k} e^{-\tau(t-s_0)}\partial R(t)/\partial s_k \, dt = 0, \quad k = 2, \dots,$$

The first condition (14a) is the same as in (12a). However, the second condition (14b) with subsequent counseling yields a transversality condition. This second condition is analogous with the non-learner problem (3) where individuals will not just receive one counseling session throughout their lives but will incur multiple sessions. If the pre-counseling discount rate, ρ, is the same as the post discount rate, υ, then the two conditions in (14) collapse into one. In terms of the ending for the counseling time, for the case of continuous counseling, the first condition (13a) holds for all k, $k = 1, 2, \ldots$.

Proposition 1: *Positive counseling cost creates a hurdle rate for counseling sessions.*

With a positive counseling cost, C, (10) indicates a wedge between pre-counseling and counseling utility. The counseling must overcome this cost before it will occur. A hurdle rate exists, which is the minimum acceptable rate of return (utility) that must be achieved before individuals will undertake counseling. The higher the counseling cost, the larger is the hurdle rate. A lower counseling discount rate, τ, relative to the pre-counseling rate, ρ, will mitigate this hurdle rate. If counseling costs are high, for a counseling session to occur the session must trigger a substantial change in individuals' time preference, however, if costs are low, a smaller change in time preference is required. The implication for health policy is given the difficulty in changing individuals' time preferences, lowering the counseling costs maybe an effective way to increase participation. This is consistent with the idea of the Affordable Care Act. Of relevance, Type 2 diabetes screening for adults with high blood pressure, diet counseling for adults at higher risk for chronic disease and obesity screening, and counseling for all adults are included in the preventive services. Also, obesity screening and counseling for children are covered. If going into a clinic for an obesity check-up is free, we should expect the participation rate to be high. In terms of the optimal transition from counseling to post-counseling (11), there is no associated hurtle rate.

Proposition 2*: Continuous counseling shortens relapse duration between counseling sessions.* The optimal conditions for continuous counseling are stated in (14) and (13a) for $k = 1, 2, \ldots$. These conditions may be compared with the discontinuous scenario (12) and (13). Specifically, for $k = 2$, with discontinuous counseling there is no transversality condition (12b). This is in contrast to $k = 2$ with continuous counseling (14b) with transversality condition $\tau C e^{-\tau(s_k - s_0)} - e^{-\tau(s_k - s_0)} R(s_k) + \int_{s_k}^{u_k} e^{-\tau(t-s_0)} \partial R(t)/\partial s_k$ dt. Considering this opportunity cost of increased utility from counseling, individuals will seek counseling earlier. Future counseling sessions will then reduce the relapse duration between counseling.

The importance of continuing counseling leading to reduced relapse time between counseling is consistent with intensive behavioral intervention for obesity recommended by the U.S. Preventive Service Task Force (USPSTF). In order to promote sustained weight loss for obese adults, the USPSTF recommend high-intensity counseling, which is defined as two or more person-to-person sessions per month for at least the first three months of treatment for a total of six counseling sessions per calendar year. Scheduling follow-up contacts to provide ongoing assistance is highlighted in the counseling framework designed for effective intensive behavioral intervention (U.S. Preventive Service Task Force, 2003).

The comparative statics influence of discount rates on the starting and ending of counseling periods may be investigated by assuming aggregate utility for a fixed time interval being independent of when counseling starts and ends, so $\partial R(t)/\partial s_k = \partial U(t)/\partial u_k = 0$.

Proposition 3: *As the wedge between the discount rates ρ and τ widens, individuals will reduce the time interval between counseling.*

Proof: Setting $s_0 = 0$, (14) and (13a) for, $k = 1, 2, \dots$, reduces to

$$e^{-\rho}U(s_1) + \tau C e^{-\tau} - e^{-\tau}R(s_1) = 0,$$

$$e^{-\upsilon}U(s_k) + \tau C e^{-\tau} - e^{-\tau}R(s_k) = 0,\ k = 2,\ \dots ,$$

$$e^{-\tau}R(u_k) - e^{-\upsilon}U(u_k) = 0,\ k = 1,\ 2,\ \dots .$$

The comparative statics conditions are then

(15a) $$\frac{\partial s_1}{\partial \rho} = \frac{e^{-\rho}U(s_1)}{e^{-\rho}\frac{\partial U(s_1)}{\partial s_1} - e^{-\tau}\frac{\partial R(s_1)}{\partial s_1}} < 0,$$

(15b) $$\frac{\partial u_1}{\partial \rho} = 0,$$

(15c) $$\frac{\partial s_1}{\partial \tau} = \frac{-Ce^{-\tau}(1-\tau^2) - e^{-\tau}R(s_1)}{e^{-\rho}\frac{\partial U(s_1)}{\partial s_1} - e^{-\tau}\frac{\partial R(s_1)}{\partial s_1}} > 0,$$

(15d) $$\frac{\partial u_1}{\partial \tau} = \frac{e^{-\tau}R(u_1)}{e^{-\tau}\frac{\partial R(u_1)}{\partial u_1} - e^{-\upsilon}\frac{\partial U(u_1)}{\partial u_1}} < 0,$$

(15e) $$\frac{\partial s_1}{\partial \upsilon} = 0,$$

(15f) $$\frac{\partial u_1}{\partial \upsilon} = \frac{e^{-\upsilon}U(u_1)}{e^{-\tau}\frac{\partial R(u_1)}{\partial u_1} - e^{-\upsilon}\frac{\partial U(u_1)}{\partial u_1}} > 0.$$

From (15a), an increase in the pre-counseling discount rate, ρ, reduce the time interval between counseling and from (15c), a decrease in the counseling period discount rate, τ, also reduces the counseling time interval. This inverse influence the two discount rates have on the timing of counseling leads to Proposition 3.

Corollary 1. *As the wedge between the discount rates τ and υ widens, individuals will prolong the counseling period.*

Proof: From (15d), a decrease in the counseling period discount rate, τ, will delay its end and from (15f), an increase in the post-counseling discount rate, υ, will also delay the counseling period. This inverse influence the two discount rates have on the counseling period ending leads to the corollary.

As indicated in Proposition 3 and its corollary, the greater the effect counseling has on lowering the counseling period discount rate, τ, relative to the pre- and post-counseling discount rates, ρ, and υ, respectively, the longer will be the counseling period. Programs and policies that influence this wedge between the discount rates can have a marked influence on individuals' diets.

Conclusion

Obesity counseling as an external intervention affecting individual consumption and time preference is theoretically modeled. Three main findings are derived from the theoretical model. First, the model demonstrates lower market price of counsel may increase participation in counseling and it is in support of providing affordable preventive services such as type 2 diabetes screening, obesity screening and counseling to the public. Second, it indicates the importance of continuous counseling when taking obesity relapses into consideration. Continuous counseling leads to reduced relapse time between counseling and reinforces weight loss. This find is in supportive of high-intensity counseling recommended by USPSTF.

Third, the model highlights the role of discount rate modification by counseling. The lower the discount rate after counseling, the shorter the time interval between counseling becomes. This finding indicates that counseling should also aim to lower time discount rates for obesity patients. It is suggested that self-control strategies in dieting and exercising should be incorporated in obesity counseling sessions.

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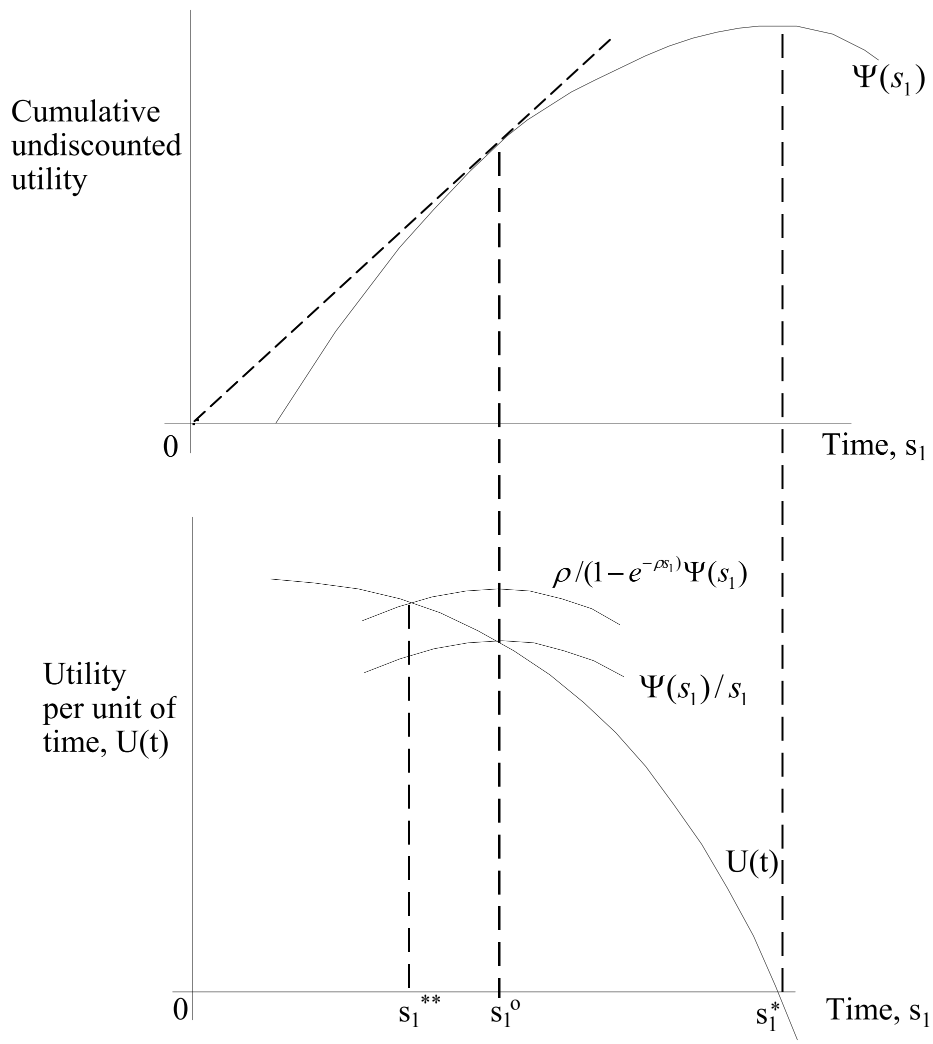

Figure 1. Optimal time for counseling

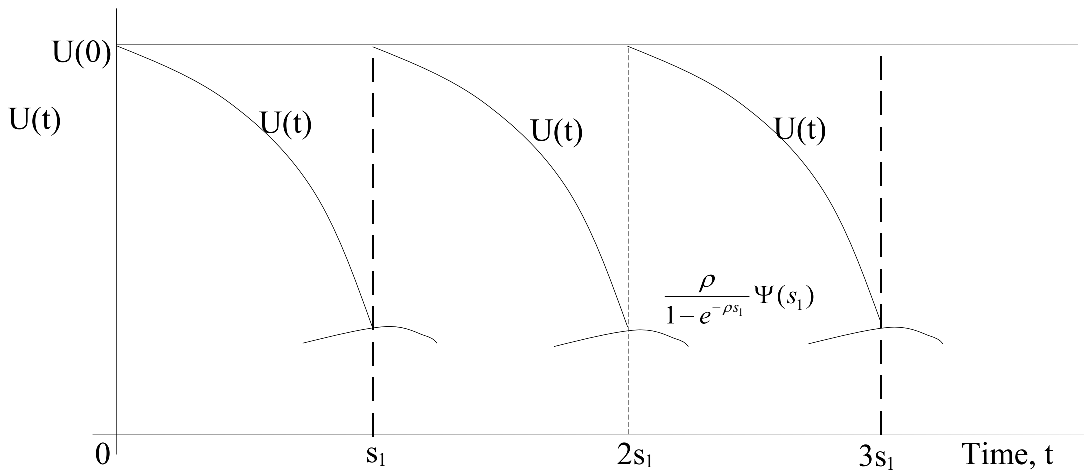

Figure 2. A non-learner's optimal time path

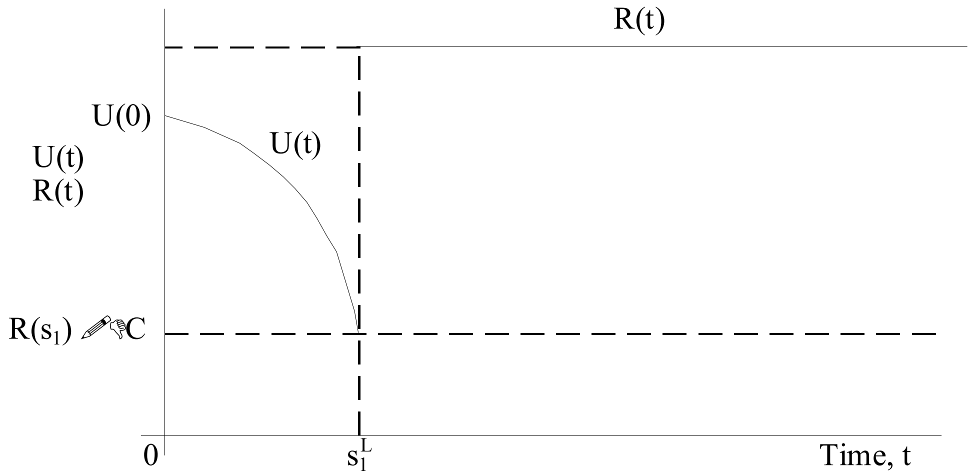

Figure 3. A good learner’s optimal time path