Behavioural Economics

PSYC3310: Specialist Topics In Psychology

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Seminar 7: Intertemporal Choice

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Today

- Examine preferences (**4**), time (**2**), and utility maximisation (**1**) in standard model)

(1)	(2)	(3)	(4)
$\max_{x_i^t \in X_i}$	$\sum_{t=0}^{\infty} \delta^t$	$\sum_{s_t \in S_t} p(s_t)$	$U(x_i^t \mid s_t)$

- Intertemporal choice—the **exponential discounting model**
  - anomalies in the standard Model
  - behavioural economic alternative—quasi-hyperbolic discounting

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$$\max_{x_i^t \in X_i} \sum_{t=0}^{\infty} \delta^t \sum_{s_t \in S_t} p(s_t) \, U(x_i^t \mid s_t)$$

- Intertemporal choice—the **exponential discounting model**
  - anomalies in the standard Model
  - behavioural economic alternative—quasi-hyperbolic discounting

Intertemporal choice

- Time is important in most decisions because the choices we make will have future consequences
- **Intertemporal choices** relate to decisions involving trade-offs between costs and benefits occurring in different time periods e.g.,
  - when purchasing a 1-year warranty for a new tablet computer, you are choosing between a certain loss now and the possibility of suffering a loss later
- Some decisions have immediate benefits and deferred costs (e.g., movie with friends vs. clean house)
- Others have immediate costs and deferred benefits (e.g., comfortable retirement vs. new car)

Time discounting

- People tend to be **impatient**—they prefer immediate rewards to delayed rewards
  - $100 today is preferred to $100 tomorrow; $1000 today is preferred to $1000 next year
- When things in the future do not give you as much utility—from the point of view of today—as things that happen today, we say you **discount the future**
  - the general term is **time discounting**
- The extent to which you discount the future is a matter of preference—known as **time preference**

Exponential discounting: Discount factor

- The standard model explains the fact that people prefer their money sooner rather than later in terms of **exponential discounting**
- Suppose that $u > 0$ is the utility you derive from receiving a dollar today
- From your current point of view (viz. today) the utility of receiving a dollar tomorrow is less than u
- We capture this by multiplying the utility of receiving a dollar today by a parameter δ ($0 < \delta \leq 1$) known as the **discount factor**
- Thus, from your current point of view, a dollar tomorrow is worth $\delta \times u = \delta u$; a dollar the day after tomorrow will be worth $\delta \times \delta \times u = \delta^2 u$

Exponential discounting: Utility streams

- In general, we want to be able to evaluate a whole sequence of utilities, that is a **utility stream**
- Letting t represent time, we will use $t = 0$ to represent today, $t = 1$ to represent tomorrow, $t = 2$ to represent the day after tomorrow, and so on
- We will let u_t denote the utility you receive at time t meaning that:
  - u_0 represents the utility you receive today
  - u_1 represents the utility you receive tomorrow
  - u_2 represents the utility you receive the day after tomorrow, and so on

Exponential discounting: Utility streams

Utility streams for different choice options (viz. **a, b, c, d**) can be represented in table form:

	$t = 0$	$t = 1$	$t = 2$
a	1	0	0
b	0	3	0
c	0	0	4
d	1	3	4

We can determine which option you should choose using the **delta model**

Exponential discounting: The delta model

According to the ***delta function***, the utility $U^0(\mathbf{u})$ of utility stream $\mathbf{u} = \langle u_0, u_1, u_2, ...\rangle$ from the point of view of time t = 0 is:

$$U^0(\mathbf{u}) = u_0 + \delta u_1 + \delta^2 u_2 + \delta^3 u_3 + ... = \sum_{t=1}^{\infty} \sigma^t u_t \qquad (1)$$

Where δ ($0 < \delta \leq 1$) is the discount factor which captures time preference (**patience** = values close to 1, whereas **impatience** = values close to 0)

Exponential discounting: The delta model

- Let's apply the delta model to the utility streams in the table on the earlier slide
- Assume that $\delta = 0.9$ and each utility stream is evaluated from $t = 0$
- The expected utilities are:
  - $U^0(\mathbf{a}) = u_0 = 1$
  - $U^0(\mathbf{b}) = \delta u_1 = 0.9 \times 3 = 2.7$
  - $U^0(\mathbf{c}) = \delta^2 u_2 = 0.9^2 \times 4 = 3.24$
  - $U^0(\mathbf{d}) = u_0 + \delta u_1 + \delta^2 u_2 = 1 + 2.7 + 3.24 = 6.94$
- If given the choice between all four alternatives, you should choose option **d**
- If given the choice between **a**, **b**, and **c**, you should choose **c**

Exponential discounting: The delta model

- What happens if we repeat this process, but this time assume that $\delta = 0.1$?
- The expected utilities are:
  - $U^0(\mathbf{a}) = u_0 = 1$
  - $U^0(\mathbf{b}) = \delta u_1 = 0.1 \times 3 = 0.3$
  - $U^0(\mathbf{c}) = \delta^2 u_2 = 0.1^2 \times 4 = 0.04$
  - $U^0(\mathbf{d}) = u_0 + \delta u_1 + \delta^2 u_2 = 1 + 0.3 + 0.04 = 1.34$
- If given the choice between all four alternatives, you should still choose option **d**
- But now, if given the choice between **a**, **b**, and **c**, you should choose **a**

Exponential discounting: Implications of discount factor

- As this example shows, your discount factor can have a dramatic impact on your choices
- If your discount factor is high—viz. close to one—you exhibit **patience** and do not discount the future much
- If your discount factor is low—viz. close to zero—you exhibit **impatience** and discount the future heavily
- You can see how δ captures time preferences

Exponential discounting: Implications of discount factor

- Economists believe that discount factors can be used to explain a great deal of human behaviour
- If your discount factor is **low**, you are are more likely to spend money, procrastinate, do drugs, and have unsafe sex
- If your discount factor is **high**, you are more likely to save money, plan for the future, say no to drugs and use protection

Exponential discounting: Indifference

- So far, we have used our knowledge of δ to determine a person's preferences over utility streams
- Sometimes we want to go the other way—viz. use a person's preferences to calculate their discount factor
- Discounting is measured by getting participants to choose between an immediate and delayed reward:
  - would you prefer \$100 today or \$110 1-year from now?
  - would you prefer \$100 today or \$130 1-year from now?
  - would you prefer \$100 today or \$160 1-year from now?
  - and so on ...
- As soon as the participant is **indifferent** between an immediate and delayed reward we can calculate his or her discount factor

Exponential discounting: Indifference

- Suppose that you are indifferent between **a** = $100 now, and **b** = $160 in 1-year
- Let's convert the monetary amounts into utilities first: **a** = $100^{0.5}$ = 10; **b** = $160^{0.5}$ = 12.65
- Given you are indifferent between **a** and **b** at time zero, we know that:
  - U^0(**a**) = U^0(**b**)
  - which implies that 10 = 12.65δ
  - which is to say that δ = 10/12.65 = **0.79**
- The calculated discount factor indicates that you are relatively patient

Exponential discounting: Indifference

- Now, let's suppose that you are indifferent between **a** = \$100 now, and **b** = \$1000 in 1-year
- Lets again convert the monetary amounts into utilities first: **a** = $100^{0.5}$ = 10; **b** = $1000^{0.5}$ = 31.62
- Given you are indifferent between **a** and **b** at time zero, we know that:
  - U^0(**a**) = U^0(**b**)
  - which implies that 10 = 31.62δ
  - which is to say that δ = 10/31.62 = **0.32**
- The calculated discount factor indicates that you are relatively impatient

Exponential discounting: Discount rates

Sometimes discounting is expressed in terms of a **discount rate** r rather than a discount factor δ. The conversion is as follows:

$$r = \frac{1-\delta}{\delta} \quad (2)$$

If your discount factor is 0.79 then your discount rate is 0.27. This means you would require an interest rate of 27% to delay receiving the $100 (the interest rate would be 212% if your discount factor is 0.32).

Knowing r, you can calculate δ as follows:

$$\delta = \frac{1}{1+r} \quad (3)$$

Exponential discounting: Limitations

- A major shortcoming of this model is that it assumes that people have **time consistent** preferences:
  - implies that your preferences over two options should not change simply because times passes
  - if you feel (today) that **a** is better than **b**, then you felt the same way about **a** and **b** yesterday, and will feel the same way tomorrow
- The bad news is that people violate this assumption all the time:
  - saying you will give up alcohol ...
  - promising to stop smoking ...
  - purchasing that gym membership ...
  - planning to do your homework ...

Exponential Discounting: Limitations

- Further shortcomings of the model of exponential discounting:
  - speaker 1: sign effect, magnitude effect, & temporal loss aversion
  - speaker 2: delay speed-up asymmetry & preference for improving sequences
  - speaker 3: date-delay effect & violations of independence

Quasi-hyperbolic discounting

- The evidence we have covered suggests that people do not have time consistent preferences
- People tend to be patient for long-term gains, but impatient for short-term gains:
  - on Friday you might plan to do your homework on Saturday, but when Saturday comes you prefer to do it on Monday
  - today you might prefer to reject \$100 tomorrow in favour of \$110 the day after, but tomorrow you change your mind
- We say that there is **time inconsistency** if someone plans to do something in the future, but subsequently changes their mind

Quasi-hyperbolic discounting: Beta-delta model

According to the ***beta-delta function***, the utility $U^0(\mathbf{u})$ of utility stream $\mathbf{u} = \langle u_0, u_1, u_2, ...\rangle$ from the point of view of time $t = 0$ is:

$$U^0(\mathbf{u}) = u_0 + \beta\delta u_1 + \beta\delta^2 u_2 + \beta\delta^3 u_3 + ... = u_1 + \beta \sum_{t=1}^{\infty} \sigma^t u_t \quad (4)$$

Where δ is as before, and β is the **present bias**

Quasi-hyperbolic discounting: Beta-delta model

- The **beta-delta** model is the same as the delta model, except for the inclusion of the parameter β
- When $\beta = 1$, the model reduces down to the delta model
- However, when $\beta < 1$, all outcomes beyond the present time get discounted more than under exponential discounting
- Hence, when $\beta < 1$ more weight is given to today than the future and we say there are **present-biased preferences**
- If you exhibit such preferences, then given the choice between a small earlier reward and a bigger, later reward you will end up choosing the smaller immediate reward (but regret it afterwards)

Quasi-hyperbolic discounting: Present-bias

- Suppose you are on a diet but have to decide between having a piece of cake at a party on Saturday
- Eating the cake gives you a utility of 4
- However, if you eat it, you will have to exercise for four hours on Sunday, giving you a utility of 0 (assuming you are like most people)
- Alternatively, you could skip the cake, giving you a lowly utility of 1, but obtain a utility of 6 on Sunday by watching back-to-back episodes of The Batchelor

Quasi-hyperbolic discounting: Present-bias

	Friday ($t = 0$)	Saturday ($t = 1$)	Sunday ($t = 2$)
a	0	4	0
b	0	1	6

Quasi-hyperbolic discounting: Present-bias

- Let's apply the beta-delta model to this example, with $\beta = 0.5$ and $\delta = 0.67$
- On Friday, the utility of eating the cake **a** and skipping it **b** is:
  - $U^0(\mathbf{a}) = 0 + 0.5 \times 0.67 \times 4 + 0.5 \times 0.67^2 \times 0 = 1.33$
  - $U^0(\mathbf{b}) = 0 + 0.5 \times 0.67 \times 1 + 0.5 \times 0.67^2 \times 6 = \mathbf{1.67}$
- On Saturday, the utility of eating the cake **a** and skipping it **b** is:
  - $U^1(\mathbf{a}) = 4 + 0.5 \times 0.67 \times 0 = \mathbf{4}$
  - $U^1(\mathbf{b}) = 1 + 0.5 \times 0.67 \times 6 = 3$
- On Friday, you would prefer to skip the cake, but come Saturday **impulsivity** causes you to change your mind—time inconsistency at work

Quasi-hyperbolic discounting: Strengths & limitations

- Quasi-hyperbolic discounting can explain time inconsistent preferences
- It can account for the fact that people emphasise their present over their future well-being
- It can also account for the fact that people change their minds about how to balance the present versus the future
- Thus, it can explain why people intend to diet, stop smoking, do homework, and quit drugs, and then fail to do so

Quasi-hyperbolic discounting: Strengths & limitations

- The model can therefore explain a number of phenomena that are inconsistent with the model of exponential discounting
- Yet, there are other aspects of the data reviewed by our speakers that the model cannot explain, such as the sign effect, preferences for improving sequences, and the peak-end rule
- The book chapters in the general reading section describe more elaborate behavioural models that are capable of providing a more complete account of the data—the chapter by **Cartwright (2011)** provides a nice overview of these models