

## Hyperbolic Discounting

### **Definition**

Hyperbolic discounting refers to the tendency for people to increasingly choose a smaller-sooner reward over a larger-later reward as the delay occurs sooner rather than later in time. When offered a larger reward in exchange for waiting a set amount of time, people act less impulsively (i.e., choose to wait) as the rewards happen further in the future. Put another way, people avoid waiting more as the wait nears the present time. Hyperbolic discounting has been applied to a wide range of phenomena. These include lapses in willpower, health outcomes, consumption choices over time, and personal finance decisions.

### **Background and History**

The notion of discounting future rewards relative to immediate pleasure has a long history. People generally want rewards sooner rather than later. Thus, options that delay a reward appear less attractive and people discount them. The neoclassical view of economics assumes that people discount a future reward by a fixed percentage for each unit of time they must wait. If the discount rate is 10% per year, a person should equally like \$100 now and \$110 a year from now. As well, the same person should also equally like \$100 in a year and \$110 in two years. According to this view (called exponential discounting), the amount people discount a future reward depends only on the length of the wait and a discount rate that is constant across different wait times.

Although exponential discounting has been widely used in economics, a large body of evidence suggests that it does not explain people's choices. People choose as if they discount future rewards at a greater rate when the delay occurs sooner in time. To illustrate, many people prefer \$100 now to \$110 in a day, but very few people prefer \$100 in 30 days to \$110 in 31 days.

It appears people would rather wait 1 day for \$10 if the wait happens a month from now.

However, they prefer the opposite if they must wait right now. More generally, the rate at which people discount future rewards declines as the length of the delay increases. This phenomenon has been termed hyperbolic discounting by the psychologist Richard Herrnstein.

There are several reasons why people might rationally choose a smaller reward now over a larger reward later. They may like the sure thing, their preferences could change, or they may have an urgent need such as hunger or paying the rent. Even so, people still seem to show inconsistencies in their choices over time. When choosing between \$100 or \$110 a day later as in the earlier example, people believe that in a month they will want to wait a day for an extra \$10. Yet after a month passes, many of these people will reverse their preferences and now choose the immediate \$100 rather than wait a day for an additional \$10. In sum, even when facing the same exact choice, people act impulsively in the short-term but exhibit greater patience in the long-term.

The amount that people discount future rewards has been mathematically represented in several ways. The classical economic view of exponential discounting reduces a future reward by a factor of  $1 / (1 + k)^t$  where  $k$  is the constant discount rate per time unit and  $t$  is the length of the delay. The amount a future reward is discounted depends only on the length of the delay, given a constant discount rate. Alternatively, hyperbolic discounting reduces a future reward by a factor of  $1 / (1 + kt)^{\beta/\alpha}$  where  $\alpha$  and  $\beta$  are greater than zero. The term “hyperbolic” is used because this formula is the generalized function for a hyperbola. With hyperbolic discounting, the rate of discounting decreases as the delay occurs further in the future. Thus, the amount a future reward is discounted depends on the length of the delay and when the delay occurs. Hyperbolic

discounting will generally discount future rewards more than exponential discounting for short delays, yet less than exponential discounting for long delays.

Two simpler versions of hyperbolic discounting have also been proposed and widely used. First, the psychologist Richard Herrnstein has modeled some behaviors quite well by assuming that  $\alpha$  and  $\beta$  are equal. In this formulation, future rewards are discounted by a factor of  $1 / (1+kt)$ . Second, the economist David Laibson has accounted for several phenomena using a particularly simple form of “quasi-hyperbolic” discounting. Here, future rewards are discounted by a factor of  $\beta k^t$  for any  $t > 0$  where  $\beta < 1$ . This implies that people discount future rewards by a constant factor to reflect the presence of a delay. As well, they also discount by an exponential factor that grows at a constant rate with the length of the delay. Although not truly hyperbolic, this simpler formulation still captures many of the basic aspects of hyperbolic discounting such as greater impulsivity in the short-term.

### **Applications of Hyperbolic Discounting**

Of particular importance to personal well-being, hyperbolic discounting has been linked to the problems of addiction and self-control. As an example, overweight people may realize that they need to improve their health through more exercise and a better diet. For the future, they vow to forego all short-term temptations in exchange for the greater long-term rewards of improved health. Presumably, they prefer this because they use a small discount rate for all rewards in the distant future. However, after their next meal, they can not resist having chocolate cake for dessert. They focus on the instant pleasure the chocolate cake can provide and heavily discount the future rewards of better health. After eating the cake, they may once again intend to follow a diet in the future. They believe that next time they will want to, and be able to, turn down the cake. Although these people really want to follow the regimen necessary for better

health, the immediate reward from short-term deviations drowns out the heavily-discounted future benefits of healthier eating. Their preference for healthy eating simply does not hold up in the heat of the moment. Similar explanations have also been offered to help account for drug addictions, procrastination, and other problems of willpower.

Hyperbolic discounting also has important consequences for how people choose experiences over time. Given a fixed pool of resources (e.g., money or time), people might want to choose a sequence of experiences to maximize their overall enjoyment. Unfortunately, hyperbolic discounting makes this difficult. People fail to take advantage of liked options that become particularly pleasurable only when rarely experienced. For example, the psychologist Richard Herrnstein proposes that people choose alternatives over time such that the average pleasure is the same across every alternative (this is called melioration). Here, people focus too much on how much pleasure an item provides at the current rate of consumption. They should also consider the potential pleasure that could be obtained by waiting to consume an item. For example, a steak dinner might be especially enjoyable when eaten once a month, yet become nothing special when eaten every other day. In contrast, pizza might remain moderately enjoyable regardless of the rate of consumption. By meliorating between the two options, people fail to maximize their enjoyment. They choose their current favorites (e.g., steak) too often rather than keeping them special for a future occasion.

The economist David Laibson has also used hyperbolic discounting to explain why people simultaneously have large credit-card debts at a high interest rate and pre-retirement wealth growing at a lower interest rate. As predicted by hyperbolic discounting, the rewards provided by buying something today often outweigh the discounted displeasure of future payments. This leads to a sizable credit card debt. However, when thinking about their retirement

savings in the far future, people use a much smaller discount rate for delayed rewards. This makes it more attractive to invest in alternatives providing a higher expected return in the long-run. Consistent with hyperbolic discounting, people's investment behavior exhibits patience in the long run and impatience in the short run. People choose to build up sizable credit card debts while also prudently accumulating wealth in homes and retirement programs. The classical economic view of exponential discounting can not easily account for these personal saving decisions using a single constant discount rate.

### **Individual and Contextual differences**

The extent to which people exhibit hyperbolic discounting of future rewards depends on a number of factors. Some people (and species) show more hyperbolic discounting than others across most choice situations. People also tend to show less hyperbolic discounting with age, more favorable social comparisons, and more hedonic rather than utilitarian experiences. Likewise, people find waiting for a larger reward more difficult when an immediate reward is physically close to them, openly visible, or partially sensed (e.g., aroma, noise). Across these diverse conditions, the phenomena of hyperbolic discounting does not disappear, rather it just influences behavior more or less.

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See also Delay of Gratification; Preference Reversals

Further reading

Frederick, S., Loewenstein, G. & O'Donoghue, T. (2002). Time Discounting and Time

Preference: A Critical Review. *Journal of Economic Literature*, 40(2), 351-401.

