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Four days later in Cincinnati: Longitudinal tests of hyperbolic discounting ☆

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ABSTRACT

Hyperbolic discounting of delayed rewards has been proposed as an underlying *cause* of the failure to stick to plans to forego one's immediate desires, such as the plan to diet, wake up early, or quit taking heroin. We conducted two tests of inconsistent planning in which respondents made at least two choices between a smaller–sooner (*SS*) and larger–later (*LL*) amount of money, one several weeks before *SS* would be received, and one immediately before. Hyperbolic discounting predicts that there would be more choices of *SS* as it became more proximate—and, equivalently, that among those who change their mind, "impatient shifts" (*LL*-to-*SS*) will be more common than "patient shifts" (*SS*-to-*LL*). We find no evidence for this, however, and in our studies shifts in both directions were equally likely. We propose that some of the evidence cited on behalf of hyperbolic discounting can be attributed to qualitatively different psychological mechanisms.

> I started for Texas in my car. I had 1/16-ounce of junk with me. I figured this was enough to taper off, and I had a reduction schedule carefully worked out. It was supposed to take twelve days. I had the junk in solution, and in another bottle distilled water. Every time I took a dropper of solution out to use it, I put the same amount of distilled water in the junk solution bottle. Eventually I would be shooting plain water. This method is well known to all junkies[…]. Four days later in Cincinnati, I was out of junk and immobilized. I have never known one of these self-administered reduction cures to work. You find reasons to make each shot an exception that calls for a little extra junk. Finally, the junk is all gone and you still have your habit. William S. Burroughs, *Junky* (1953/2003)

1. Introduction

William S. Burrough's account of his failure to kick his heroin habit describes a form of *inconsistent planning*. He planned to allocate his remaining heroin (1/16 of an ounce) among a sequence of future consumption occasions (shots). His plan was front-loaded, with each shot allocated more heroin than its successor. He failed, because each time he revisited his plan—at the moment of the next scheduled shot—he consumed more heroin than he had originally allocated, at the expense of future shots. Burroughs viewed such failures as universal ("I have never known one of these self-administered reduction cures to work.").

Around the same time as Burroughs described his experience, William Strotz (1955) advanced a formal model of inconsistent planning by decision makers who have a present-biased preference ("that calls for a little extra junk") and the freedom to revise previous plans ("you find reasons to make each shot an exception"). The implications of Strotz's model, which could be drawn directly from Burrough's passage, are depicted in Fig. 1, which shows time, starting with the present, on the *x*-axis, and consumption on the *y*-axis. The three lines show consumption plans (i.e., allocations of all one's future resources) made at different times (τ_0, τ_1, τ_2) by someone with fixed future wealth. These are *optimal* plans, in the sense that they are made to maximize the expected total value of a stream of discounted utility. However, the discount function is "hyperbolic" which means that the decision maker discounts outcomes at a rate that is a decreasing function of delay, so that each successive unit of delay has a smaller proportional impact than the preceding one. For instance, an outcome might be discounted by 5% over the first month of delay; the remaining 95% discounted by a further 4% over the second month; the remainder from that discounted by 3% over the third

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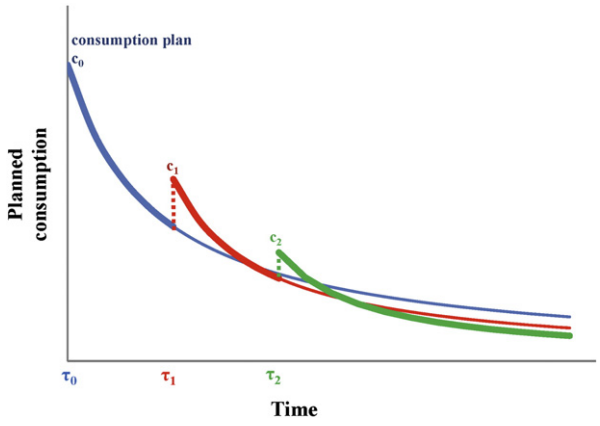

Fig. 1. Inconsistent planning due to myopic or 'hyperbolic' preferences, after Strotz (1955). The figure shows three consumption streams (c_1, c_2, c_3), each having equal net present value assuming to an interest rate of 5%, that would result from hyperbolic discounting with k parameter = .3. The dotted lines show how preferences are revised when new plans are made. The bold lines show the consumption stream that is actually realized.

month, and so on, with what remains always being discounted by proportionally less with each additional delay.

Any positive rate of time discounting will lead to front-loaded consumption plans, such as plan c_0, made at τ_0. Hyperbolic discounting, however, means that when we later revisit that plan, such as at τ_1 in Fig. 1, we will revise it to bring even more consumption forward, further reducing the consumption allocated to the more distant future. This is what Burroughs did, when he consumed more heroin at τ_1 than had been planned at τ_0, and then more at τ_2 than he had planned at τ_1.

Various specifications of hyperbolic discounting have been proposed. Among psychologists, the most familiar is the one proposed by Mazur (1987),

$$V(x,t) = \frac{v(x)}{1+kt} \tag{1}$$

in which $v(x)$ is the value the outcome would have if available immediately, and the parameter k (usually assumed to be positive) reflects discounting for delay. Eq. (1) was used as the basis for Fig. 1. Another highly influential model, especially in economics, is the quasi-hyperbolic function proposed by Phelps and Pollak (1968) and popularized by Laibson (1997), and O'Donoghue and Rabin (1999):

$$V(x,t) = \begin{cases} v(x) & t = 0 \\ \beta\delta^t v(x) & t > 0; 0<\beta, \delta \leq 1 \end{cases} \tag{2}$$

The parameter $\beta<1$ is a 'one time' discount factor applied to all delayed events, while δ is an exponential discount factor which further discounts future events according to the length of their delay. If $\beta=1$ then Eq. (2) is exponential discounting.[1] Several other models have also been proposed which share the hyperbolic feature of time inconsistency (e.g., Killeen, 2009; Loewenstein & Prelec, 1992; Scholten & Read, 2010).

Hyperbolic discounting has been widely discussed as a fundamental characteristic of human motivation. For example, Strotz (1955) supposed that 'most of us are "born" with [such] discount functions' (p. 177). According to Ainslie, who coined the term, "the basic function by which all vertebrates devalue delayed events is hyperbolic" (2005, p. 649). Ainslie and Haslam (1992, p. 71) proposed that "deeply bowed discount functions and consequent temporary preferences for imminent rewards are fundamental properties of motivation." Frank (1988) asserted that hyperbolic discounting 'is apparently part of the hard-wiring of most animal nervous systems.'

2. A study of inconsistent planning

The inconsistent planning frequently attributed to hyperbolic discounting was demonstrated by Read and van Leeuwen (1998), who conducted a study in which respondents chose between junk food (chocolate or beer nuts) or a piece of fruit (banana or apple) on two different occasions. As illustrated in Fig. 2, the first, or *Distant*, choice was made one week prior to consumption, whereas the second, or *Immediate*, choice was made immediately before consumption, enabling respondents to change their original plan. Most respondents were inconsistent, and almost always in the same way—they initially planned to have fruit, but ultimately they changed their mind and took junk food. The respondents acted like stereotypical weak willed dieters, who first plan to eat healthfully, but later succumb to the temptation of fattening foods.

The hyperbolic discounting explanation for such inconsistencies relies on the assumption that the expected short-term benefits ("utility") of junk food exceed those of fruit, but the long term benefits of fruit outweigh those of junk food. This tradeoff is captured in the dieter's proverb "A moment on the lips, a lifetime on the hips." According to hyperbolic discounting, "lip utility" and "hip utility" are weighted similarly when both are significantly delayed (Distant choice), leading many to declare a preference for apples, but when the options are poised to deliver instantaneous utility to the lip (Immediate choice), junk food is chosen.

It is important to appreciate that the differences between the utility profiles is an assumption and not an observation; we directly observe only that preference order changes with the passage of time, but not the reasons for that change. When we explain intertemporal preference reversals with hyperbolic discounting, we risk committing the logical error of the doctor in Moliere's *The Imaginary Invalid*, who "explained" the effect of sleeping powders in terms of their "dormitive virtues." Consider, for instance, someone who

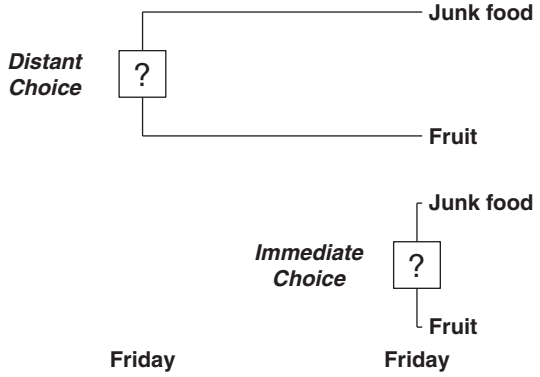

Fig. 2. Design of Read and van Leeuwen (1998). Respondents choose between junk food and fruit on two occasions, one week in advance of consumption, and immediately before consumption.

[1] The two models differ in two key respects. The first concerns the discounting decline profile. The first model holds that the discount rate decreases with time gradually, so that discounting over the first month is greater than that over the second, which is greater than that over the third. The second holds there is a threshold delay which leads to excess discounting, after which there is constant rate discounting thereafter. The time interval corresponding to the "present" is not specified. The second difference between the models concerns long term discounting. Hyperbolic discounting proposes that over the long term the discount rate will be reduced to almost zero, so that while short delays might lead to a lot of discounting, long delays might not lead to appreciably more. This is one reason hyperbolic discounting has been taken up as a good model for the social discount rate (e.g., Gollier, 2002; Harvey, 1995; Weitzmann, 1998). Quasi-hyperbolic discounting proposes that a constant discount rate applies to all delays once the initial delay is past, so even a small discount rate can lead even large outcomes to have zero value which entails disregard for the distant future.