Estimating and decision making for Design projects and Cognitive Bias of Hyperbolic Discounting

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1. Introduction

Human beings are conditioned and designed by society to relate high degree of uncertainty to future. Several behavioral studies have demonstrated that the phenomenon of attaching hazard rate to future events is consistent across habits related to food, drugs, exercising, impulsive shopping and saving money. A person, when planning for long term would think about health and monetary benefits arising out of all of these. But when faced with a choice would prefer to procrastinate. There is sufficient evidence for the fact that humans and animals tend to be more impatient when dealing with reward nearer in time than one due further in future. This phenomenon is called as Hyperbolic Discounting. This paper explores the hyperbolic discounting as a cognitive bias.

Hyperbolic discounting can be defined as the act of valuing intertemporal choices on a hyperbolic scale. Renowned economist Robert Strotz (1956) conducted empirical studies on agents whose preferences change over time. He found that when faced with a choice between two rewards of different values due at different time, an individual tends to choose one which is due after a shorter time delay even though its value is comparatively lesser than the other one which is due at a later stage. As the time when the rewards are due increases person tends to be more patient in choosing the reward. Loewenstein and Thaler (1989) classify such behavior as 'extremely myopic preferences'.

Angeletos, et al. (2001) present an interesting example of a worker "who prefers a 20-minute break in 101 days to a 15-minute break in 100 days. But when both rewards are brought forward in time, preferences exhibit a reversal, reflecting more impatience; the same person would prefer a 15-minute break right now to a 20-minute break tomorrow".

This paper explores the concept of hyperbolic discounting as a bias which leads to irrational behavior from human agents while designing projects. An integrated approach towards project management and human need for instant gratification as a behavioral pattern can prove to be very resourceful for long-term planning and determining strategies, estimates related to deadlines and revenues for critical projects. This paper explores the design approach which would result in minimum deviation from the planned behavior of the model if such intertemporal choices and '*myopic preferences*' (Loewenstein and Thaler, 1989) are taken into consideration.

2. Literature Review

Several researches have been conducted to understand the disconcertingly alluring idea of instant gratification and discounting time at a hyperbolic rate. Robert H. Strotz(1956) was amongst the first few to conduct empirical studies on *dynamically inconsistent* choices due to hyperbolic discounting. He proposed use of commitment as an instrument against tendency to discount time at hyperbolic rate, such as mandatory social security requirement or financial instruments. Victorian economist Jevons (1871/1911 cited in Ainslie, Haslam, 1992: 60) suggests that " To secure a maximum of benefit in life , all future events, all future pleasures or pains, should act upon us with same force as if they were present, allowance being made for their uncertainty . The factor expressing the effect of remoteness should, in short, always be unity, so that time should have no influence. But no human mind is constituted in this perfect way, a future feeling is always less influential than a present one". This brings us to the concept of debiaising and rebiasing (Larrick, 2004). It refers to input of efforts to reduce the illusion of delayed incentives. Debiasing requires effort or corrective action from the agent at present to change the future value of the object. Rebiasing simply involves a "no-effort" strategy and is implemented when people get tired of putting efforts. This theory helps us to formulate the design approach in which will effort is required at time when decisions have to be made.

Cropper and Laibson (1999) present a good argument on the use of hyperbolic discount functions by managers and decision-makers instead of constant exponential discounting techniques. Their research also suggests the intervention by Government in order to protect consumers from making impulsive choices to satisfy their urge for instant gratification. This has direct implication on project managers who choose constant time discounting instead of hyperbolic discounting techniques for cost-benefit analysis.

Laibson cites Strotz(1956) on the commitment device to improvise or rectify the *self defeating behavior.* This research was a breakthrough in itself to bring the change from constant discounting to hyperbolic discounting, but it simply accepts this bias as something which cannot be isolated from human nature and gives no solutions for the managers.

Newell and Pizer (2003, pp. 52-71) state that "Implicit in any long-term cost-benefit analysis is the idea that costs and benefits can be compared across long periods of time using appropriate discount rates". Based on the research by Arrow and Kurz(1970, pp. 331-334) the managers follow the concept of time discounting using a constant exponential discount rate. But empirical research shows that people tend to discount the future hyperbolically, by using different discount rates inversely proportional to time. Lesser the time (when return would be attained) higher the discount rate and vice versa (Ainslie, 1992; Cropper, Portney and Aydede, 1994). Thaler contrasts constant and hyperbolic discount rates and considers that using a constant discount rate, "a reward which loses 10% of its value in 1 year, will lose an additional 10% of its value if delay is increased to 2 years but with hyperbolic discounting, the proportional decay in reward value changes with each new time period and a reward loses more of its value during initial delays than it does in later delays, this phenomenon is referred to as *dynamic inconsistency".* The next section discusses the implications of hyperbolic discounting on Design projects and explores how to minimize the effect of bias using Design models.

3. Estimates and Design with Hyperbolic Discounting as a Cognitive Bias

Projects are evolutionary and complex systems. Researchers indicate (Hart, 1982; Shooman, 1983; Brooks, 1978) that actions and decisions taken by people in project situations are significantly influenced by pressures and perceptions produced by project's schedule. Laibson(1997) proposed a mathematical model for hyperbolic discounting. According to his model exponential discount function, δ^{τ} is known to have a constant discount rate , $\log(1/\delta)$, where τ is the instantaneous discount rate. However, according to Laibson(1997, pp 450) " generalized hyperbolic discount function is characterized by an instantaneous discount rate that falls as τ rises using equation γ / (l + α τ), with α, γ >0". Figure 1 shows the exponential discount function (assuming that δ = 0.97) alongside the generalized hyperbolic discount function (assuming that $\alpha = 10^4$, and $\gamma = 5*10^3$).

According to Devenny(1976, cited in Abdel- Hamid , Madnick, 1984, p.15), past experiences indicate a strong bias on the part of software developers to underestimate the scope of a software project. Project managers make use of 'Safety Factor' for estimates to reduce the effect of bias (Abdel-Hamid, Madnick, 1985). We can try to minimize this 'Safety factor' or level of contingency by use of a design model which has an *Action-centric approach* and not a *Reason-centric approach*. The rationale behind such a proposal is the *dynamically inconsistent* human behavior which can be attributed to cognitive bias of discounting time hyperbolically.

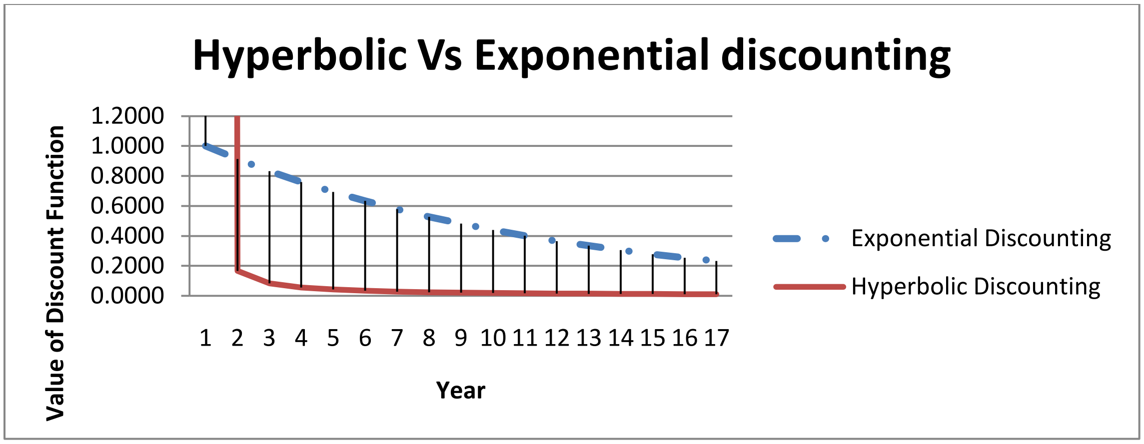

Figure 1. Hyperbolic discounting and Exponential Discounting Source : Laibson (1997)

Ralph (2010, pp.2) states that 'Technical Rationality and the Technical Problem-solving paradigm are consistent with the *cognitivist* view of human action, wherein actions are executed and understood through a plan………….. Plans are prerequisites to action. Unanticipated conditions trigger replanning; evaluation is performed by comparing resulting and planned actions and outcomes'. He proposed an *action-centric* model for software design processes which is called Sensemaking- Coevolution-Implementation. Figure 2. is an overview of the model , the components of which are described in Table 1 (in the Appendix A). This model gives the designer the flexibility to alternate between framing, making moves and evaluating the moves.

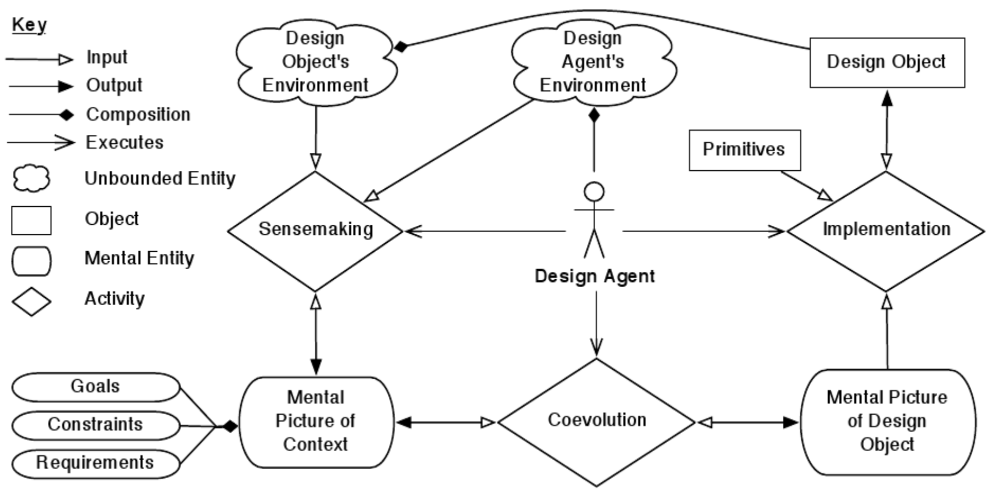

Figure 2: The Sensemaking-Coevolution-Implementation Framework , Source (Ralph,2010b)

Managers tend to follow *naturalist way* of decision-making, the popular term for this is 'gut feeling'. The decision-making paradigm for SCI model is *naturalistic* and not *rational*. Hyperbolic discounting will result in skewed estimates as the need for instant gratification clouts the cognition due to which designer would not be able to view the bigger picture of the problem at hand. Also, while analyzing risks people tend to be more concerned with the risks pertinent to present situation than one which might be faced later. Other frameworks for software design have little or no scope of revaluating the decisions .These models work under illusionary belief that all the decisions are *rational*. The iterative nature of Sensemaking-Coevolution-Implementation framework gives the designer chance to make amendments to the design and the behavioral properties of model.

The *action-centric* approach of SCI model with *reflection-in-action* as core paradigm is consistent with the game played by quasi-hyperbolic agents proposed by Phelps and Pollak(1968), Strotz(1956), Laibson(1998). Laibson's (1998) model supposes an individual as a composite of autonomous temporal selves. These selves then interact as players in a finite-horizon dynamic game. For consideration in our software design approach using SCI framework we can use Laibson's approach of using autonomous temporal selves for Subgame Perfect Equilibrium (SPE) .These agents interact to reach an equilibrium state, a decision which is intersection of the decision of all the players (Temporal selves) . This decision is represented by S = $\prod_{t=1}^{t=n} S_t$. (Figure 3 has been drawn to represent the intersection as perfect decision). The situation under which all the human game players (H) would be honest (Laibson, 1975, pp. 451) about their choices, would approach a near perfect decision or equilibrium.

Figure 3 : Subgame Perfect Equilibrium represented by S = $\prod_{t=1}^{t=n} S_t$

4. Recommendations

The paper proposes modification of SCI framework Ralph(2010) by inclusion of game playing temporal selves as decision agents . The model suggests that Sensemaking and Decision making should not be intertwined (refer Figure 4). Decision making should be performed iteratively every time after Sensemaking is performed. Next step is drawing a mental picture of the context. There is clearly a need to evaluate the decision on which work will be performed in the implementation step before co-evolution. Since with hyperbolic discounting as a bias the preference might change in the process of implementation without being noticed, so clearly identifying the decision is very essential.

To isolate the decision from cognitive bias, decision making should be performed after the Sensemaking is complete, so that design object and design agent environment does not directly influence the decision. The decision makers should work on the mental picture of the context. Sub-game perfect equilibrium will be attained by working on the intersection of decisions taken at the following steps: when goals of the system are defined, when implementation begins, when tests are performed, when deployment takes place. The preference change can be monitored more closely by Sensemaking to make adjustments. This model would minimize the difference in expected behavior and real behavior of design projects and is based on debiasing. There is much scope for further research since this is a theoretical model with no empirical research to support it. Also, the question that whether Hyperbolic discounting is altogether an undesired phenomenon and always results in negative outcomes due to biased decisions is open for debate. The design model is not generic, and its application to projects other than software projects can be explored.

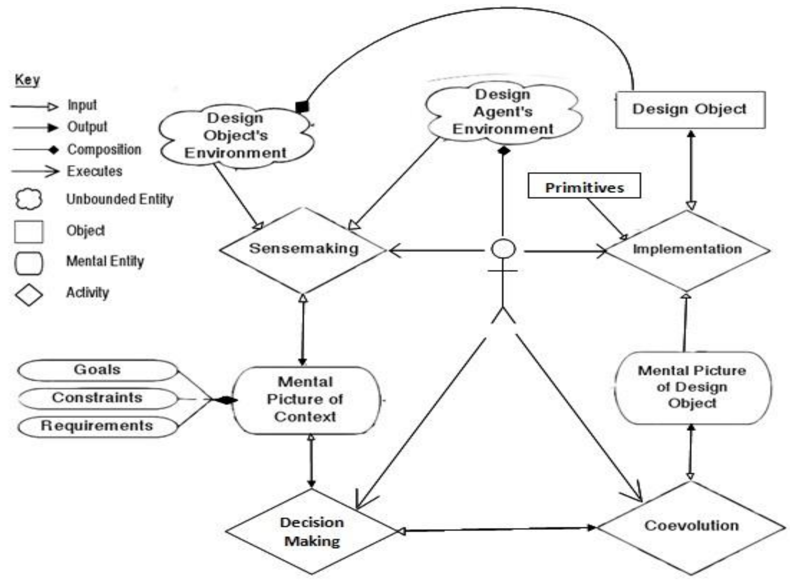

Figure 4: Modification in SCI model to include Decision Making as one of the activity

5. Conclusions

Dynamic inconsistency of human behavior which arises due to cognitive bias of hyperbolic discounting can be detrimental for decision making process. The existing software design models tend to consider the human behavior as rational which in not true in real world. The model for design should allow the agents to behave, decide and function in their natural way. The SCI model is action centric which is more suitable for naturalistic design agents, and hence is a good choice for design project. The paper proposes slight change in SCI model and proposes inclusion of Decision Making as a step. Use of Sensemaking-Decisionmaking-Coevolution-Implementation model allows the decision makers to iterate and re-evaluate the decision.

Appendix A

Table 1: Concept of Sensemaking-Coevolution-Implementation, Source: (Ralph,2010)

Concept	Meanings
Constraints	A restriction on a structural or behavioral property of *design* object
Design Agents	An entity or group of entities that is capable of forming intentions and goals and taking actions to achieve those goals, and that specifies the

	structural properties of the design object
Design Object's Environment	The totality of surroundings in which the design object exists or is intended to exist.
Design Agent's Environment	The totality of surroundings of the design agent
Design Object	A (possibly incomplete) manifestation of the mental picture of design object, composed of primitives, in the design object's environment
Goals	Optative statements (which may exist at varying level of abstraction) about the effects the design object should have on the design object's environment.
Mental Picture of Context	The collection of all beliefs, held by the design agent, regarding the design agent's environment and the design object's environment.
Mental Picture of Design Object	The collection of all belief held and decision made by the design agent concerning the design object.
Primitives	The set of entities from which the design object may be composed
Requirements	A structural or behavioral property that a design object must possess
Sensemaking	The process where the design agent perceives its environment and the design object's environment and organizes these perceptions to create or refine the mental picture of context.
Coevolution	The process where the design agent simultaneously refines its mental picture of design object based on its metal picture of context, and vice versa
Implementation	The process where the design agent generates or updates a design object using its mental picture of design object.

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