INCONSISTENT PLANNING AND THE ALLOCATION OF TASKS OVER TIME*

Sudeep Bhatia^{*}, Megan M. Crawford[‡], Rebecca McDonald[‡], Miguel A. Moreno[‡],
Daniel Read[†]

We test the hypothesis of inconsistent planning proposed by Strotz (1955). In the laboratory, participants allocated time between ‘work’ and ‘leisure’ tasks, and were offered a commitment device. Original plans tended to delay leisure, and to involve a moderate degree of spreading between work and leisure tasks. Most participants preferred commitment over flexibility. Although most were denied commitment, few altered their plans. Those that did make changes tended to further postpone leisure. We find limited evidence of discounting or impatience, contrary to the predictions of most theoretical models of inconsistent planning. Instead, our results imply a preference for improving sequences.

Keywords: *commitment; discounting; inconsistency; improving sequences; myopia; time preference*
JEL codes: *C90, D90, D91*

^{*}University of Pennsylvania, [‡]Edinburgh Napier University, [‡]University of Birmingham, [‡]Texas A&M University-Corpus Christi, [†]University of Warwick

*Corresponding author: Rebecca McDonald, Behavioural Science Group, Warwick Business School, University of Warwick, Scarman Road, CV47AL, UK. Email: r.l.mcdonald@bham.ac.uk

Planning how to allocate duty and pleasure is a challenge most of us face regularly. We choose when to take holidays, when to work overtime, and more generally how to split our time between the things we enjoy and the things we do out of necessity. This allocation of time and resources between enjoyable and less enjoyable activities will rely on intertemporal choices of the form “should I do it now, and if not, when?” How people are likely to plan, and then to carry out their plan, was explored in a classic and highly influential paper by Strotz (1955). Our Figure 1, adapted from Strotz’s Figure 2, summarises his theory. In this paper we describe a laboratory test of this theory.

[FIGURE 1: STROTZ CONSUMPTION PROFILE]

We thank our colleagues, particularly Zhihua Li, for their helpful comments and suggestions. Conference committee members and participants at the Subjective Probability, Utility and Decision Making conference provided valuable insights. We also thank Tyson Hayes for programming support. We gratefully acknowledge funding from the Network for Integrated Behavioural Science, the Leverhulme Trust and Warwick Business School.

Strotz observed that people often do not adhere to their plans, even when their original expectations about the future are confirmed. Consider an agent with a “stock” of enjoyable tasks (or *leisure*) to distribute among a series of boring tasks (*work*). She can first plan how she will distribute that stock, and then begin to consume it. She may sometimes reflect on her plan and consider whether to abide by it.

In Figure 1, the value of the function at each time t shows the planned consumption of the stock of leisure. The first plan is made at $t = 0$, and the figure shows two re-evaluations of the plan, generating new curves beginning at $t = \tau_1$ and τ_2 . The plans are “front-loaded” (i.e. the first derivatives of all three curves are negative) indicating that the decision maker allocates more leisure in the near future and less leisure in the more remote future. This front-loaded allocation is the prediction of theories in which future outcomes are discounted as an increasing function of delay.

At $t = 0$, the first plan is made. Unlike the inconsistent agent in Figure 1, a consistent agent would follow through with this $t = 0$ plan until $t = T$ (the end of the planning horizon), making no adjustments unless external circumstances change. This behaviour is represented by the C_0 curve in Figure 1. Strotz calls this the “harmony” case (p. 172), but suggests it is exceptional, and when people revisit their plans they will typically wish to reallocate the remaining stock in favour of their near future selves at the expense of themselves in the more distant future. In Figure 1, these desires are reflected by the new plans at $t = \tau_1$ and τ_2 , and curves C_1 (if they re-evaluate once) and C_2 (if they re-evaluate twice). This form of inconsistent planning has been referred to as time-inconsistency and explained using models of hyperbolic discounting and quasi-hyperbolic discounting.

Inconsistency in planning can be represented as a conflict of interest between different ‘selves’ within the agent over time. The preferences of the $t = 0$ and the $t = \tau_1$ agents differ regarding consumption at $t = \tau_1$. Strotz proposed that if the $t = 0$ agent recognises this conflict one of two strategies might be adopted. The first is precommitment, in which the $t = 0$ agent binds their future ‘selves’ to the $t = 0$ plan. The second is consistent planning, in which the $t = 0$ agent adopts a plan which its future ‘selves’ will also wish to abide by, essentially using the knowledge of their tendency for inconsistency as a constraint when making the original plan. On the other hand, if the potential for future conflict is not recognised, the $t = 0$ agent will naively make a plan without securing it through precommitment, and may fall victim to inconsistency at $t = \tau_1, \tau_2$ and so on. Following Strotz, O’Donoghue and Rabin (1997) referred to the first class of agents who recognise their propensity for inconsistency as *sophisticates*, and the second class as *naïfs*.

The majority of existing studies of intertemporal inconsistency are laboratory experiments, typically based on choices between pairs of dated outcomes. In these studies, respondents make two or more choices between pairs of delayed outcomes, where one outcome is worse but sooner (WS), and the

other is better but later (*BL*).¹ The interval between the options is held constant but the “front end” delay to *WS* is varied. Hyperbolic discounting predicts that respondents will be more likely to choose *WS* as the front end delay is decreased. That is, they will plan to take *BL* when both options are remote in time, but give into the temptation of *WS* when it is close in time. This matches the prediction in Figure 1 where re-evaluation of the plan at $t = \tau_1$ serves to bring leisure forward in time. Several studies directly tested the prediction of hyperbolic discounting, following the same people over time as they made multiple decisions about the same time point. In such studies, support for the prediction of hyperbolic discounting was mixed. Behaviour consistent with the hyperbolic discounting model was found in Ainslie & Haendel (1983); Halevy (2015); and Sayman and Öncüler (2006: in some conditions). However, studies including Dai & Fischbach (2013) and Read, Frederick & Airoldi, (2012) do not replicate the hyperbolic discounting effect.

The aforementioned studies all involved differing amounts of *money* between *WS* and *BL*. However, the types of real world behaviour motivating us to study inconsistency are almost never in the context of money-now versus money-later. A separate class of studies address this issue, by eliciting choices between “virtue” (e.g., educational, or good for you) and “vice” (e.g., fun, indulgent) options, where the outcomes were available at the same time as one another (so participants chose between the outcomes when both were available now, and again when both were available later). In these studies, apparently *Strotzian* preference reversals are widespread (Read & Van Leeuwen, 2001; Read, Loewenstein & Kalyanaraman, ; Milkman, Rogers & Bazerman, 2009, 2010).

While the previous studies involve option pairs, arguably a more valid framework for testing the Strotz framework is one involving *sequences* of outcomes. A small number of studies have looked at the planning of consumption sequences and have proposed motives in addition to impatience. Loewenstein and Prelec (1993) proposed that people have a preference for improving sequences and a preference for “spreading” (p. 94). The preference for improvement goes contrary to discounting, in that when applied within our framework, it predicts planning work sooner and leisure later. The preference for spreading is a desire to intersperse good and bad outcomes evenly over the planning horizon. Some preference for spreading is compatible with Strotz’s analysis, since he expected even impatient agents to leave some consumption until later in their $t = 0$ plans (see Fisher’s (1930) formalisation of intertemporal consumption, where decisions on the consumption of two goods depend on both time preference and diminishing marginal utility).

Several studies have been conducted in which people indicate their preferred $t = 0$ plan out of a limited menu, and these commonly find that increasing sequences of consumption are often preferred over decreasing ones in a variety of domains: wages (Loewenstein and Sicherman, 1991), discomfort

¹ For money rewards this is synonymous with the usual “smaller sooner” *SS* and “larger later” *LL* terminology.

(Varey and Kahneman, 1990), and health (Chapman, 2000). Other studies have shown preferences for maximally spread out (or constant) sequences. For example, Loewenstein and Prelec (1993) found that people prefer spreading in their planned allocation of fun and boring weekends. They also display a preference for improving sequences, which can be explained by anticipatory utility (for fun weekends) and dread (for boring ones). In a rare study in which respondents allocated their consumption stock over time (stocks of massages), Frederick and Loewenstein (2008) found no strong preference for improvement, but a strong preference for spreading. Overall existing research into sequence planning suggests that the preference for spreading is a strong motive, while a preference for improvement is likely to depend on context.

Studies of sequence preferences have typically focused on the $t = 0$ plan, and not on what happens when the plan is revisited. This is perhaps because the preference for improving and spreading does not necessarily imply planning inconsistency. For instance, an agent whose $t = 0$ plan was increasing would still, at $t = \tau_1$, have an increasing sequence remaining and would not need to adjust the plan to achieve that. A similar argument can be made for spreading – a uniformly spread out sequence is still uniformly spread out even if it is truncated. This does not rule out the possibility of planning inconsistencies, but these motives are not bound to generate inconsistency, unlike the hyperbolic discounting model.

One recent study which looked beyond the $t = 0$ plan is by Casari and Dragone (forthcoming). They conducted an incentivised study in which respondents decided when to allocate a single 20-minute block of unpleasant loud noise in a sequence of three periods spread out over three weeks. Respondents made a $t = 0$ plan and, if they did not choose to experience the noise in the first period, they could bid for the opportunity to revise their plan. Their results suggest a preference for improvement, in that the majority (66.5%) of respondents chose to experience the noise in the first period, and consequently there was little opportunity for plans to change. Of those who did not listen to the noise in the first period, only 22.2% demonstrated inconsistency, and the behaviour cannot be explained within the hyperbolic discounting model. These results are consistent with other studies involving choices between losses now and later – people often prefer to take losses now rather than wait (Hardisty, Appelt, Weber, 2013).

Despite the existence of many studies that consider choices between $t = 0$ plans, and a further abundance of studies where the focus is on inconsistency between choices over time, there is limited evidence addressing both preferences for sequences and intertemporal inconsistency together. Further, there is clearly conflict between most existing discounting models (where good things are preferred sooner) and models of sequence preferences (where good things are preferred later). To address this, in this paper we conduct a study in which participants formulated a $t = 0$ plan by allocating a stock of leisure and work over a time period, and then had the opportunity to alter this plan while it was being

implemented. We measured a preference for commitment by asking respondents to choose between gambles offering a higher or lower probability of plan flexibility. We address three main questions:

- I. What does the $t = 0$ plan indicate about participants' motives (e.g. discounting, improvement, spreading).
- II. Do participants want to be bound to their $t = 0$ plans?
- III. Do participants change their plans and, if so, how? Specifically, do they show evidence of time inconsistency, bringing leisure tasks forward in time and postponing work tasks?

1. Method

We created a simple interface² that allowed participants to plan how they would spend time in the lab, and to continuously update their plan as time progressed. Their time was spent on a mixture of leisure and work tasks. The leisure task was the online³ game 2048 in which participants slide matching coloured tiles together to create higher valued tiles up to a (winning) maximum of 2048 (Figure 2). This game was extremely popular in the summer of 2014 when the experiment was conducted. Figure 3, generated from Google trends, shows Google searches for “2048” from July 2013 to July 2015, with a clear peak around the time of our study. This game is particularly appropriate for studying time allocation because play can instantly be resumed after a pause – there is, therefore, no special benefit of massing or separating blocks of leisure. During the sessions, we maintained neutral framing by always referring to the game as “2048” (as opposed to “leisure”).

[FIGURE 2 HERE: THE GAME 2048]

[FIGURE 3 HERE: GOOGLE TRENDS DATA FOR SEARCHES FOR “2048”]

The work task was an online adaptation of the Festinger and Carlsmith (1959) peg-turning task, suitable as a work task because it is not intrinsically rewarding (Markey, 2013). Figure 4 shows a “peg” as displayed to participants. At random time intervals the pointer on the peg moved to another position, and the participant had to press the spacebar to return the pointer to the off position. To keep their attention, after a five second grace period, one penny per second was deducted from their payment if they failed to move the peg. In the instructions we referred to this as “peg-turning” (as opposed to “work”).

[FIGURE 4 HERE: THE PEG TURNING TASK]

Participants first sampled leisure and work. They had four minutes of practice, alternating between 2048 and peg-turning in one-minute intervals. This was to familiarise participants with how to play

² This interface was programmed in HTML and Javascript and the code can be obtained from the authors on request.

³ <http://gabrielecirulli.github.io/2048/>

the game, how to complete the work tasks, and what one minute of each type of task would be like to experience. Next, they allocated work and leisure tasks along a 40-minute timeline represented as 40 empty slots arranged horizontally along the screen (shown in Figure 5). Participants allocated their twenty “2048” blocks and twenty “peg-turning” blocks into these spaces using the mouse. They could rearrange their blocks until satisfied with their plans.

Two features of our design should be noted. First, following Strotz, people have a fixed stock to distribute over time. In our case we can think of the fixed stock as leisure. Second, we made an attempt to prevent what Strotz called the “expectations of future desires and means of consumption” changing (p. 165). This was achieved through the practice sessions to minimise any discrepancy between participants’ expectations and experience of the 2048 and peg-turning tasks, and by requiring participants to spend all of their 40 minutes on work and leisure with no breaks to minimise the possibility that outside options could change.

[FIGURE 5 HERE: THE PLANNING ROUND]

After creating their plans, participants chose between a pair of gambles: Gamble A offered a 25% chance of their $t = 0$ plan being fixed with no opportunity for reallocation of tasks and a 75% chance of it being flexible, meaning that plans could be changed over the course of the experiment; Gamble B offered a 5% chance of a fixed plan, and a 95% chance of flexibility. We interpret the choice of Gamble A as a preference for commitment. In our instructions to participants we emphasised this interpretation, explicitly indicating that if they wanted to be able to change their plan as they went along they should choose Gamble B, and if not they should choose Gamble A.

Once a gamble was chosen, it was played out and participants were informed of the outcome. All participants then began to carry out their $t = 0$ plan. If the gamble outcome had provided them with flexibility then, at any time τ they could change the position of the blocks that had not yet begun (i.e., for all blocks at $t > \tau$). To alter the plan, participants used a mouse pointer to drag a work or leisure block to a new position and the future blocks adjusted to accommodate the alteration.

After completing the 40 task blocks, participants gave demographic information and answered follow up questions including a manipulation check confirming that the leisure task was preferred to the work task. We elicited two standard measures of time preference, one choice and one matching. The choice measure included nine choices between *WS* and *BL* money amounts, drawn from those in Kirby and Marakovic (1996). In the matching measure, adapted from van den Bergh et al (2008), participants stated the future amount of money (received in one week or in one month) they considered equally good as a fixed amount (£15 or \$15) today.

Participants ($N = 246$) were students from the University of Warwick ($n = 112$) and Texas A&M University-Corpus Christi ($n = 134$). All participants received a show-up fee (£6 or \$6, respectively) and Texas participants also received course credit. In the analysis we pool the samples as they did not demonstrate significant heterogeneity either in characteristics or in behaviour.

2. Results

2.1. Validation of method

After completing the study, participants rated the tasks on a variety of Likert elicitation scales after playing out their individual 40-minute plans. Participants strongly agreed that the work was less stimulating than leisure (85.77% moderately or strongly agreed) and 88.21% moderately or strongly agreed that the game was fun. This validates our conclusions regarding impatience and improving or declining sequences. These, and the rest of the results of the follow-up questions, are presented in Table 1.

[TABLE 1 HERE: validity checks]

2.2. $t = 0$ plans

We first investigated participants' $t = 0$ plans. Two factors were identified as likely to influence the initial planned allocation of work and leisure. These are the preference for decreasing versus increasing sequences of outcomes (equivalently, impatience versus a preference for improving sequences), and the preference for spreading. To quantify the plans with respect to these factors we developed two indices, an "impatience index" which increases with the proportion of leisure in the early part of the plan, and a "spreading index" which measures how much leisure was massed or separated. We first describe these indices, and then give the results.

2.2 i. Impatience index. To calculate the impatience index (II), we assign to each minute of leisure a serial position (s_g), where g is the ordinal position of each block of leisure. For instance, if the first leisure block ($g = 1$) is encountered at $t = 2$, then $s_1 = 2$. The sum of all s_g for a given individual i is denoted ss_{gi} . This sum is minimised if leisure takes up the first 20 minutes, $ss_{gMIN} = 210$; it is maximised if leisure takes up the final 20 minutes, $ss_{gMAX} = 610$. We normalised the index to lie between -1 and 1:

$$II = \frac{(ss_{gMAX} + ss_{gMIN})/2 - ss_{gi}}{(ss_{gMAX} - ss_{gMIN})/2} \quad (I)$$

Equation (1) generalises for any length of timeline. Substituting in the specific values for our study:

$$II = \frac{410 - ss_{gi}}{200} \quad (I')$$

To illustrate, the most impatient plan with $ss_{gi} = 210$ has an II of $\frac{410-210}{200} = 1$; conversely the least impatient plan with $ss_{gi} = 610$ has an II of $\frac{410-610}{200} = -1$. All else equal, if participants discount future utility, they would have $II = 1$. If planning is driven only by a strong for improving sequences, then $II = -1$

2.2.ii. Spreading index. The spreading index (SI) measures alternation between work and leisure within plans. We take the number of times the participant intends to change between tasks and normalise it to lie between 0 and 1, with the SI increasing in the number of alternations.

Let d_i equal the number of changes between work and leisure in an individual's plan, and d_{MIN} and d_{MAX} be the minimum and maximum possible values of d_i (with two tasks these will always be 1 and $T-1$, where T is the total number of time periods). Then the spreading index is:

$$SI = \frac{d_i - d_{MIN}}{d_{MAX} - d_{MIN}} \quad (2)$$

And substituting in the values for our study we have:

$$SI = \frac{d_i - 1}{38} \quad (2')$$

In our case, the minimum value of the SI if a participant plans to change task just once is equal to $(1-1)/38 = 0$, while the maximum, if they alternate their task blocks one after the other, is equal to $(39-1)/38 = 1$.

3. Results

In the $t = 0$ plans, the mean II was -0.13 (95% CI $[-0.18, -0.08]$), and the mean SI was 0.41 , (95% CI $[0.37, 0.45]$). This indicates, in line with Loewenstein and Prelec (1993), that people have a preference for improving sequences ($II < 0$) tempered by a preference for spreading ($SI > 0$).

The II and SI allow us to group participants into types, corresponding to the motives revealed by their original allocations of work and leisure. These are presented in Table 2 and illustrated in Figure 6. We first categorise participants by their II . Any participant for whom $0 < II < 1$ is classed as *Strotzian*, while any participant for whom $-1 < II < 0$ is classified as *Loewenstein-and-Prelec-like* or *LP-like*. Within these categories we split respondents by their SI , by its relation to 0.5. Any participant whose $SI = 0$ or 1, or whose II is -1 , 0 or 1, is classified as “other” since these reflect extremes of impatience, patience or preference for spread expressed by placing all leisure first, or all work first, or alternating the blocks one after the other.

The modal categorisation (54.9%) is as a Loewenstein and Prelec type, with $SI < 0.5$ most common. *Strotzian* types are less common (24.8%), though “other” contains the fewest participants (20.3%).

[TABLE 2 HERE: CATEGORISATION OF INDIVIDUALS ACCORDING TO II AND SI]

[FIGURE 6: HISTOGRAM OF TYPES]

3.1. *Do people wish to precommit?*

We next consider whether participants wished to be bound to their $t = 0$ plan, as they would if they were sophisticated agents choosing a strategy of precommitment.

The commitment device was the gamble with a probability of 5% or 25% of committing the participant to the plan they originally designed. Most participants (76%) chose the higher probability gamble, indicating they preferred to be bound to their plan rather than have the opportunity to change it. This is significantly more than half of the sample ($p < 0.001$), and could indicate sophisticated planners seeking to impose their $t = 0$ preferences on their future selves. Alternatively, participants may have interpreted the low probability of receiving the fixed plan as a signal that this is the superior outcome (Pleskac, 2014), or else the high proportion could be driven by a preference for avoiding further choices, since fixing their plan meant participants would not have to make any further choices about whether or how to change it⁴. The gambles were resolved according to the participants' preferred probabilities and 15.5% of participants received a fixed plan, leaving 84.5% who received a flexible plan, and whose (in)consistency is the subject of the rest of this analysis.

We can categorise participants with flexible plans ($n = 208$) into types by comparing switching behaviour with the choice between the fixed and flexible gambles. The results are presented in Table 3. Participants that indicated a preference for flexible plans (by selecting the gamble with 25% chance of commitment) were significantly ($p = 0.09$) more likely to make changes than those who preferred fixed plans. This is compatible with a model where flexibility is useful to participants since they are learning about their optimal plan as they progress. A more uncharitable interpretation is that they are *Strotzian naïfs* who did not realise their likelihood of making changes, and hence did not opt for the commitment device. In any case, these respondents make up only 14% of the 208 individuals with flexible plans. The modal category (44%) contains those who preferred to have a fixed plan, but did not go on to make any changes. We call these individuals *pessimists* since they underestimate their ability to stick to their original plan. We also identify 29% as *realists* since they preferred commitment and when denied it they went on to make the changes that they had tried to preclude. Finally, 13% opted for flexibility and yet made no changes. This is compatible with *consistent* planners since there is no need for commitment if there will be no temptation to make changes. The

⁴ This may be desirable since choosing is effortful, and brings to mind counterfactuals ("Am I making the right decision?") that are unlikely to enhance enjoyment. Essentially, pre-commitment has many of the advantages of habit, in that it does our future decision making for us.

proportion of *pessimists* and *consistents* is statistically indistinguishable ($p = 0.69$) but otherwise the proportions are all significantly different.

[TABLE 3 HERE: CATEGORISE AS PESSIMIST ETC]

3.2. How plans are revised

The remaining section analyses the behaviour of those 90 participants who made at least one change to their plans.

[FIGURE 7 HERE: SCATTERPLOT OF ORIGINAL AND FINAL *II*]

Figure 7 illustrates changes in *II* from $t = 0$ to $t = 40$. Any value above the 45 degree line signifies increasing impatience, while any value below signifies decreasing impatience. Figure 7 shows that the majority of the sample lies below the 45 degree line, meaning that changes tended to postpone leisure, bringing work closer to the present. For the 90 individuals that made changes, the average change in *II* between the original and final plans is -0.10 (95% *CI* [-0.15, -0.05], $p < 0.001$), confirming a tendency to postpone leisure. The change in *SI* is less obvious from the graphical representation in Figure 8, as the individuals lie both above and below the line indicating that some participants made their plans more consolidated, but some made them more spread. Overall, the average change in *SI* is -0.07 (95% *CI* [-0.11, -0.02], $p = 0.006$). That is, changes tended to make plans much less impatient, and somewhat less spread out, over the course of the experiment. There is no statistically significant effect of the preference for commitment on the change in *SI* and *II*.

[FIGURE 8 HERE: SCATTERPLOT OF ORIGINAL AND FINAL *SI*]

The heterogeneity in the changes made to plans over the course of the experiment might be driven by the individuals' 'Types' as defined by their original plans, and specified in Table 2 and Figure 6. To explore this possibility, we split the sample into their original Type and then asked what proportion of the changes made by each Type brought leisure forward in time, in line with the original Strotz model. Looking at the overall changes (from initial to final plan), just 8 individuals fully comply with the original hypothesis motivated by Strotz (1955) by having an initial plan that allocates more leisure earlier, and then moving leisure earlier as they progress through the experiment. However, there is evidence that *Strotzian* participants made more impatient changes than their *LP-like* peers, and we explore this in the following analysis.

[TABLE 4 HERE: PATIENT/IMPATIENT BY ORIGINAL TYPE]

Table 4 summarises the direction of the individual changes of the 75 individuals that could be classified as *Strotzian* or *LP-like* on the basis of their original plan (i.e. discarding "other") and who made at least one change to their plan during the experiment. The analysis pools the individual

changes made by the participants, so the sample size is 349 in total. 61 out of the 128 changes made by *Strotzians* brought leisure tasks forward. In contrast, only 55 out of the 221 changes made by *LP-like* individuals brought leisure tasks forward. To test the significance of this effect, we ran a Random Effects Probit analysis (controlling for the fact that some individuals made multiple changes) of the likelihood of a change bringing leisure forward, as a function of the individual's original Type. This analysis demonstrates that *LP-like* individuals were significantly ($p = 0.010$) less likely to bring leisure forwards, conditional on making a change, than their *Strotzian* counterparts.

We also analysed how the work/leisure environment influenced the individual changes made in the study. To do this, we ran a further Random Effects Probit regression of the likelihood of making a change on features of the task, specifically being engaged in a leisure task, winning or losing the game in that task, and having a higher score in the game. We found that changes were less likely to be made when a participant is engaged in a leisure task than when they are in a work task ($p < 0.001$).

However, when such a change was made it was significantly more likely ($p < 0.001$) to bring a leisure task forward in time, compared to a change made during a work task. Simply put, participants were more likely to bring game-play sooner when they were currently playing, compared to when they were currently working. Though the majority of changes overall (both during work tasks and leisure tasks) brought work forward, the presence of these in-game impatient changes fits with the Strotz patterns, and suggests a degree of impulsivity. It might also indicate that leisure aroused the "hot" state where impulsive choices are more likely, while work generated a "cold" state where patient choices could be made.

3.3. Discount rates

In the Strotz model, the planned allocation of work and leisure, as well as any inconsistency between planned and realised behaviour, were assumed to be driven by temporal discounting. This could mean that more impatient individuals are more likely to create such 'impatient' plans and, if their time preference is non-exponential, more likely to change their plans (bringing leisure forward) in line with the Strotz hypothesis.

The discounting behaviour elicited through choice (from Kirby & Marakovic, 1996) and matching (from Van den Bergh, et al, 2008) suggests that participants generally did have positive rates of time preference. The mean number of *WS* choices in the choice task was 5 out of 9, though 11 participants always chose the *BL* amount and 16 always chose the *WS*. The mean discount factor from the matching questions was 0.61 (95% *CI* [0.60, 0.61], excluding the 11 respondents whose discount factor was greater than 1. Convergent validity of the measures was reasonable: the Spearman's Rank coefficient is -0.39 ($p < 0.001$ that the measures are independent).

Neither discounting measure could predict the II or the SI of the original plan, suggesting that in our experiment planned behaviour was not driven by temporal discounting alone. However, the probability of making a change was significantly and positively related to the matching measure of discounting (See Model (1) in table (5)). Less impatient individuals were more likely to make a change to their plan. This runs counter to the hypothesis that changes were predominantly made due to impatience, but this is unsurprising given that the majority of changes postponed leisure. For any given change, a higher discount factor (indicating more patience over financial outcomes) is associated with a smaller increase in II (Model 2). Overall, time discounting appears unable to explain planned behaviour, but it can explain some of the alterations that participants made to their plans.

[TABLE 5 HERE: DISCOUNT RATES ANALYSIS]

Time preference measured by the discount factor from the matching questions is also significantly and negatively related to changes in the SI (Model 3). That is, more patient participants were relatively more likely to reduce the spread of their plans.

4. Discussion

Our study presents a novel test of the conflicting literature related to sequence planning and dynamic inconsistency. Participants created a plan for the allocation of leisure tasks and work tasks across their time in the laboratory. These initial plans tended to demonstrate a preference for improvement, since leisure was postponed until later than work. For most respondents, this was tempered by a preference for spreading the outcomes into short blocks, with multiple occasions for switching between task types. On carrying out their plans, most participants had the opportunity to make changes by moving future work and leisure blocks around, yet the majority of respondents chose not to make such changes. Those changes that did occur predominantly postponed leisure, and tended to reduce the spread of the remaining plan.

The main result appears to contradict the intuition in Strotz (1955) since participants' plans did not appear to favour the present self over the future, and since inconsistencies were both relatively rare and in the opposite direction to that predicted by impatience. In the same vein, our results do not mimic the kinds of real life behaviour that we recognise as driven by impatience, such as failure to stick to healthy diets, or procrastination. There are at least three reasons why our results may not reflect the motives of impatience and procrastination. Firstly, our participants had a time horizon of 40 minutes in the lab, limiting the scope for discounting. This makes the improving sequences we observe more likely and reduces the likelihood that preferences would reverse between planning and realising behaviour, compared to a longer time horizon. Secondly, in real-life planning, a person would not typically face a bounded time horizon within which to fit a pre-specified amount of an activity. For example, a procrastinating person may intend to *postpone* the time spent on a project, but

in reality will *reduce* the time spent working instead. Our design ensured that participants had no opportunity to reduce their working time, so may have decided to complete the work task early to make time for leisure later. Finally, our participants made a specific, detailed plan. When plans are made in detail, people tend to be much more successful in achieving their goals than when the plan is left vague (Gollwitzer & Brandstätter, 1997).

In contrast, our results align well with the existing literature on preferences over *sequences* of outcomes. The preference for improvement characterising our participants' initial plans is typical of studies in which subjects choose between outcome sequences, and so we provide new evidence that the same motivations matter when sequence plans are created from scratch. Further, many aspects of real life choices over time reflect a preference for improvement, such as the preference for increasing wage profiles (Duffy and Smith, 2013) or even the preference for happy endings (Ross and Simonson, 1991). A field study by Angeletos et al (2001) provides some clues as to how the results of our study might be reflected in the field. They examined income and consumption data from real households and found that in some respects, consumers' lifetime consumption profiles appeared *Strotzian*, since their consumption closely followed their income (suggesting low self-control in savings), and they overinvested in durables (suggesting they were attempting to precommit). However, the consumption sequences in Angeletos et al. (2001) were largely increasing, reflecting the same motivations that we capture in our study.

Despite a general trend in our data in support of the Loewenstein and Prelec (1993) model and in contradiction to that of Strotz (1955), participants demonstrated significant heterogeneity in their behaviour, in their initial plans, in whether they made changes, and also in the types of changes that were made. Although the majority of changes postponed leisure, we observed some impatient changes. Moreover, these were significantly more likely to occur when the participant was engaged in a game-task than when engaged in a work-task. That is, the occasions when leisure was brought forward were generally when the participant was already at leisure. This means that at least some of the changes in the data appear to be driven by temptation, and we can observe distinct types of inconsistency, which deserve a richer explanatory framework than that available to date.

The motivation for this study was to determine whether individuals' planned consumption of work and leisure would reflect the Strotz model or the Loewenstein and Prelec model of choice over time. We find the latter model to be the best fit, with the caveat that some *Strotzian* behaviour could be observed when analysis was performed at the level of the individual participant. A broader interpretation of our work could allow us to make recommendations about how to keep one's future self in line when making plans about future patterns of behaviour. Our results suggest that making plans that are short-term by breaking a long term goal into shorter stages, fixing the quantity of time to be spent working within a concrete time horizon, and being detailed and specific about planned

behaviour may all help us to avoid falling victim to our inherent inconsistencies. However, our results also highlight how individuals differ significantly from one another in the motives underlying their planned allocation of time, as well as in their ability and desire to be consistent with those plans. Our empirical framework provides a framework within which these questions can be addressed.

PRE-PRINT

REFERENCES

- Ainslie, G., & Haendel, V. (1983). The motives of the will. *Etiologic aspects of alcohol and drug abuse*, 119-140.
- Angeletos, G-M., Laibson, D., Repetto, A., Tobacman, J., & Weinber, S. (2001). The hyperbolic consumption model: Calibration, simulation, and empirical evaluation. *Journal of Economic Perspectives*, 15, 47-68.
- Casari, M., & Dragone, D. (2015). Choice reversal without temptation: A dynamic experiment on time preferences. *Journal of Risk and Uncertainty*, 50, 119-140.
- Chapman, G. B. (2000). Preferences for improving and declining sequences of health outcomes. *Journal of Behavioral Decision Making*, 13(2), 203.
- Dai, X., & Fishbach, A. (2013). When waiting to choose increases patience. *Organizational Behavior and Human Decision Processes*, 121, 256-266.
- Duffy, S., & Smith, J. (2013). Preference for Increasing Wages: How do People Value Various Streams of Income?. *Judgment and Decision Making*, 8(1), 74-90.
- Festinger, L. & Carlsmith, J. M. (1959). Cognitive consequences of forced compliance. *Journal of Abnormal and Social Psychology*, 58, 203-210.
- Fisher, I. (1930). *The Theory of Interest*. NY: Macmillan.
- Frederick, S., & Loewenstein, G. (2008). Conflicting motives in evaluations of sequences. *Journal of Risk and Uncertainty*, 37(2-3), 221-235.
- Gollwitzer, P. M., & Brandstätter, V. (1997). Implementation intentions and effective goal pursuit. *Journal of personality and social psychology*, 73(1), 186.
- Halevy, Y. (2015). Time consistency: Stationarity and time invariance. *Econometrica*, 83, 335-352.
- Hardisty, D. J., Appelt, K. C., & Weber, E. U. (2013). Good or bad, we want it now: Fixed-cost present for gains and losses explains magnitude asymmetries in intertemporal choice. *Journal of Behavioral Decision Making*, 26, 348-361.
- Katherine L. Milkman, T. Rogers, M.H. Bazerman (2009), Highbrow Films Gather Dust: Time inconsistent Preferences and Online DVD Rentals, *Management Science*, 55 (6), 1047 - 1059.

- Katherine L. Milkman, T. Rogers, M.H. Bazerman (2010), I'll have the Ice Cream Soon and the Vegetables Later: A Study of Online Grocery Purchases and Order Lead Time, *Marketing Letters*, 21 (1), 17 – 36
- Kirby, K. N., & Marakovic, N. N. (1996). Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin & Review*, 3, 100-104
- Loewenstein, G. F., & Prelec, D. (1993). Preferences for sequences of outcomes. *Psychological review*, 100, 91-108.
- Loewenstein, G. & Sicherman, N. (1991). Do workers prefer increasing wage profiles? *Journal of Labor Economics*, 9, 67-84.
- Markey, A. (2013). *On boredom: Methodology, correlates and theory*. (U. d. dissertation, Ed.) Pittsburgh: Carnegie Mellon University.
- Milkman, K. L., Rogers, T., & Bazerman, M. H. (2009). Highbrow films gather dust: Time-inconsistent preferences and online DVD rentals. *Management Science*, 55, 1047-1059.
- Milkman, K. L., Rogers, T., & Bazerman, M. H. (2010). I'll have the ice cream soon and the vegetables later: A study of online grocery purchases and order lead time. *Marketing Letters*, 21, 17-35.
- O'Donoghue, T. and Rabin, M. (1997). Addiction and self control, mimeo. Cornell University and UC Berkeley.
- Pleskac, T. J., & Hertwig, R. (2014). Ecologically rational choice and the structure of the environment. *Journal of Experimental Psychology: General*, 143 (5), 2000.
- Pollak, R. A. (1968). Consistent planning. *The Review of Economic Studies*, 35, 201–208.
- Read, D., Frederick, S., & Airoldi, M. (2012). Four days later in Cincinnati: Longitudinal tests of hyperbolic discounting. *Acta psychologica*, 140, 177-185.
- Read, D., Loewenstein, G., & Kalyanaraman, S. (1999). Mixing Virtue and Vice. *Journal of Behavioral Decision Making*, 12, 257-273.
- Read, D., & Van Leeuwen, B. (1998). Predicting hunger: The effects of appetite and delay on choice. *Organizational behavior and human decision processes*, 76(2), 189-205.
- Ross, W. T., & Simonson, I. (1991). Evaluations of pairs of experiences: A preference for happy endings. *Journal of Behavioral Decision Making*, 4(4), 273-282.

Sayman, S. & Onculer, A. (2009). An investigation of time-inconsistency. *Management Science*, 55, 470–482.

Story GW, Vlaev I, Seymour B, Winston JS, Darzi A, Dolan RJ (2013) Dread and the Disvalue of Future Pain. *PLoS Comput Biol* 9(11)

Strotz, R. H. (1955). Myopia and inconsistency in dynamic utility maximization. *The Review of Economic Studies*, 165-180.

Van den Bergh, B., Dewitte, S. & Warlop, L. (2008). Bikinis instigate generalized impatience in intertemporal choice. *Journal of Consumer Research*, 35, 85-97.

Varey, C., & Kahneman, D. (1990). The integration of aversive experiences over time: Normative considerations and lay intuitions. *Journal of Behavioral Decision Making*, 5, 169-186.

Yates, J. F., & Watts, R. A. (1975). Preference for deferred losses. *Organizational Behavior and Human Performance*, 13, 294-306.

Figure 1 Modification of Strotz (1955) consumption profile for inconsistent planning characterised by what we would now call hyperbolic discounting. An original consumption plan (C) is made at $t = 0$, re-evaluating it at $t = \tau_1$ and again at $t = \tau_2$. Each re-evaluation pulls consumption to the proximal future at the expense of the distal future. By $t = \tau_3$ the agent may regret the previous re-evaluations.

Figure 2 The leisure task, “2048”. The player’s score remains on screen. The game pauses when the timeline switches to the other task. A logical next move would be to slide left, combining the two 8 tiles into a 16.

Figure 3 Google trends data demonstrating the popularity of the game “2048”. The blue line represents searches for the game worldwide from July 2013 to the July 2015. Our study took place in the Summer of 2014, while the game was very popular.

Figure 4: The work task, “peg-turning”. Instructions remain on screen for the duration of the task. Time counts down from 5 seconds in the lower left of the screen, and monetary penalties are displayed. The timer pauses during leisure tasks. In this screenshot, the peg is switched off so no immediate action is required.

Figure 5: The planning round. The timeline is represented as a series of empty slots which can be filled with either a peg-turning block or a “2048” block. The blocks can be rearranged as desired. The colours for the tasks blocks were randomised. The “CONTINUE” button activated after all 40 blocks are in the timeline slots. Here, the participant has begun to create a plan with some spreading and a generally improving sequence.

SCHEDULE ROUND

Now it is time to create your schedule. Your schedule tells us when you want to perform each activity for the next 40 minutes.

At the bottom of the screen is a 40 minute timeline. You will spend 20 of those minutes playing 2048, and 20 of them turning pegs.

This time line has 40 separate, 1-minute time slots. Underneath the timeline are 20, 1-minute blocks of 2048 in yellow and 20, 1-minute peg turning blocks in blue. Using your mouse drag the time blocks to the timeline to create the schedule you think will be best for you. You can move the time blocks around until you are satisfied.

For example:

- Two 2048 blocks side by side means you will play 2048 for 2 minutes straight.
- Three peg turning blocks side by side means you will turn pegs for 3 minutes straight.

When you are satisfied with your schedule, please click the CONTINUE button to begin the schedule.

WARNING: DO NOT CLICK THE CONTINUE BUTTON UNTIL YOU ARE FULLY SATISFIED WITH YOUR SCHEDULE.

Timeline:

Peg Turning Slots

2048 Slots

Figure 6: The categorisation into Types according to the original plan. Both *Strotzian* and *LP-like* categorisations require SI not equal to 0 or 1 since these reflect extremes of impatience, patience or extreme preference for spread expressed by placing all leisure first, or all work first, or alternated the blocks one after the other. Then, the categories are distinguished by their II .

Figure 7: Impatience index scatterplot: original and final plans

Figure 8: Spreading index scatterplot: original and final plans.

Table 1: the results of the validity check question that the leisure task was more fun, more stimulating, less boring, and better at keeping participants' attention than the work task.

Questions	Proportion that "agree" or "strongly agree" (%)	Proportion that "disagree" or "strongly disagree" (%)
1. The peg turning task was difficult	2.0	73.1
2. The peg turning task was more boring than the game.	83.7	10.6
3. The peg turning task was meaningless.	44.9	32.2
4. It was difficult to keep my attention on the peg-turning task.	43.9	30.1
5. It was difficult to keep my attention on the game.	6.1	62.2
6. I found the peg turning task less stimulating than the game.	85.8	10.6
7. The game was fun.	88.2	8.9

Note: A 5-point Likert scale was used to code participants' affective responses (1-strongly disagree, 3-neither agree nor disagree, 5-strongly agree).

Table 2: The categorisation of individuals' original $t = 0$ plans as *Strotzian*, *LP-like*, and *Other* according to their II and SI .

Category	Impatience Index	Spreading Index	Frequency (%)	Comments
Discounting and low spread	$0 < II < 1$	$0 < SI < 0.5$	40 (16.3%)	<i>Strotzian</i> $n = 61$ (24.8%)
Discounting and high spread	$0 < II < 1$	$0.5 \leq SI < 1$	21 (8.5%)	
Preference for improvement and low spread	$-1 < II < 0$	$0 < SI < 0.5$	103 (41.9%)	<i>LP-like</i> $n = 135$ (54.9%)
Preference for improvement and high spread	$-1 < II < 0$	$0.5 \leq SI < 1$	32 (13.0%)	
Preference for improvement and no spread	$= -1$	$= 0$	17 (6.9%)	<i>Other</i> $n = 50$ (20.3%)
Neutral for time, medium spread	$= 0$	$= 0.5$	1 (0.4%)	
Discounting and no spread	$= 1$	$= 0$	7 (2.9%)	
Maximum spread	$= \pm 0.05$	$= 1$	25 (10.1%)	

Table 3: Of those who had the opportunity to make changes ($n = 208$), categories of behaviour generated by comparing choice of gamble to whether changes were made.

	Prefer fixed $n = 151$ (73%)	Prefer flexible (24%) $n = 57$ (27%)
Made changes $n=90$ (43%)	<i>Realists</i> $n = 60$ (29%)	<i>Naiifs or Optimal Switchers</i> $n = 30$ (14%)
Did not make changes $n=118$ (57%)	<i>Pessimists</i> $n = 91$ (44%)	<i>Consistent</i> $n = 27$ (13%)

Table 4: The direction of changes (impatient or patient) according to the original plan categorisation. The table shows that a greater proportion of impatient changes were made by those originally classed as *Strotzian*. However, *LP-like* individuals and patient changes were more prevalent overall.

	Original Plan Strotz Changes $n =$ 128	Original Plan L&P Changes $n =$ 221
Changes Impatient $n = 116$	61	55
Changes patient $n = 233$	67	166

Table 5: The influence of standard time preference measures on (i) the probability of making a change (Model 1); (ii) the change in II from a given change in the plan (Model 2); and (iii) the change in SI from a given change in the plan (Model 3). More patient individuals are more likely to make a plan change, their plan changes are generally patient in that they postpone leisure, and they tend to make plans more consolidated.

	Model (1) OLS ($R^2 = 0.018$) $N = 246$ Making a change	Model (2) OLS $R^2 = 0.100$ $N = 401$ Change in II	Model (3) OLS $R^2 = 0.014$ $N = 401$ Change in SI
Matching-based discount factor	0.290* (0.147)	-0.067** (0.026)	-0.050** (0.020)
Choice-based impatience score	0.181 (0.132)	-0.019 (0.025)	-0.011 (0.024)
Constant	0.091 (0.138)	0.029 (0.021)	0.024 (0.020)