Intertemporal Salience Theory: Pre-Analysis Plan

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1 Introduction

Economic decisions which implicate both risk and time are frequent. While experimental evidence demonstrates robust deviations from the canonical model, Discounted Expected Utility (DEU), debate persists on what non-DEU models are appropriate for rationalizing choice. We proposes an extension of atemporal salience theory (Bordalo et al., 2012, 2013b) for the treatment of intertemporal lotteries. The elaborated model rationalizes prominent DEU deviations and delivers additional testable predictions. The model's predictions are explored in three existing data sets (Andreoni and Sprenger 2012, Cheung 2015, Miao andZhong 2015), Roughly 80% of prior experimental deviations from DEU are consistent with intertemporal salience, demonstrating the value of the theory. Here we propose a novel experiment to further distinguish intertemporal salience theory from competing theories.

2 Experiment Design, Hypotheses, and Power

Throughout this experiment, subjects choose from a pair of intertemporal lotteries under different risk conditions. In this case, DEU suggests that decision-makers form a expected utility for each option according to their discounted utility function and objective probabilities of states of nature. On the other hand, intertemporal salience theory depicts that attention is drawn to states of nature depending on absolute payoffs and payoff differences between lotteries in each state. Attention leads to distortions of state probabilities away from their objective likelihoods. Such specific distortion mechanism can generate rather unique behavioral predictions that help us further differentiate our model from others. In this new experiment, we explore such patterns. In addition, we test whether intertemporal salience theory can potentially influence previous result on precautionary saving (Eeckhoudt and Schlesinger 2009, Deck and Schlesinger 2014).

2.1 Design Overview

In this experiment, subjects make six tasks. These tasks can be categorized by three purposes. Task 1 - 3 examine deviation patterns predicted by itnertemporal salience theory. Task 4 - 5 investigate potential effects of intertmporal salience theory on precautionary saving. The last question serves as an attention check.[1]

In task 1-3, subjects are given option A and B. option A gives potential monetary payoffs \$18 in one week and \$ 2 in four weeks from the experiment. Option B gives potential monetary payoffs \$10 and \$10 in one and four weeks respectively. Under each task, one of

[1] The order of these 6 tasks in randomized at individual level. Subejcts will always finish task 1-3 and the attention check before task 4-5.

Task 1

Option	State			
	HH	HT	TH	TT
A	(18,2)	(18,2)	(18,2)	(18,2)
B	(10,10)	(10,10)	(10,10)	(10,10)

Task 2

Option	State			
	HH	HT	TH	TT
A	(18,2)	(18,0)	(0,2)	(0,0)
B	(10,10)	(10,0)	(0,10)	(0,0)

Task 3

Option	State			
	HH	HT	TH	TT
A	(18,2)	(18,0)	(0,2)	(0,0)
B	(0,0)	(10,10)	(10,0)	(0,10)

Table 1: Task 1 - 3

four equiprobable events may happen. Under each event, the sooner, the later, or both payoffs may not be received. For simplicity, we denote the four events by the four outcomes of tossing two fair coins $\{HH, HT, TH, TT\}$[2]. The actual payments for option A and B under each event in task 1-3 are summarized in table 1. For task 1, all payments are certain regarless of events. For task 2, the sooner payments will be paid if the first coin lands on H while the later payment will be paid if the second coin lands on H. For task 3, option A is unchanged relative to task 2 while potential payments of option B are permutated from task 2.

Task 4 and 5 are designed similar to 1-3, but we now focus on atemporal lotteries. Task 4 and 5 still ask subjects to choose from option A and B. Each option will now only provide a single payment in one week. In each task, there are still four equiprobable events labeled with $\{HH, HT, HT, TT\}$, and the actual payments of the two alternatives are changed under diferent events. Task 4 and 5 are summarized in table 2. Notice that, in the language of stochastic domination, in both task 4 and 5, option A third-degree stochastic dominates option B. Comparing both options from task 5 to task 4, option A is identical while option B's payments are permutated.

[2]H stands for coin lands on head while T stands for coin lands on tail.

Task 4

Option	State			
	HH	HT	TH	TT
A	5	5	5	15
B	0	10	10	10

Task 5

Option	State			
	HH	HT	TH	TT
A	5	5	5	15
B	10	10	10	0

Table 2: Task 4 and 5

We now proceed to experimental hypotheses and subsequent statistical analysis[3].

2.2 Hypotheses and Power Calculations

Notice, the variation between task 2 and 3 is similar to task 4 and 5 – option A is unchanged while option B's payments are rearranged. In both cases, the marginal distributions of A and B are fixed while the difference of these two options under each event is changing. Since marginal distribution of A and B are identical for these two pairs, economic decision theories suggesting people analyze every alternative independently predicts that decisions made under task 2 and 3 as well as under 4 and 5 should be unchanged. On the contrary, such variation changes the difference levels between two options under each state. Consequently, intertemporal salience theory predicts very specific behavioral patterns. In the rest of this subsection, we analyze different hypotheses and statistical power for observed differences given a sample size $n = 100$.

In task 1-3, there are in total 8 different choice patterns we can observe:

$$\{A, B\} \times \{A, B\} \times \{A, B\}$$

(A, A, A) and (B, B, B) are consistent with DEU. In addition to these two patterns[4], intertemporal salience theory can also rationalize (A, B, A) and (B, B, A). Thus, to test whether our model's predictions can also generated by random behavior, we investigate the hypothesis that the proportion of subjects choosing one of these four patterns is

[3] Information regarding the attention check question can be found in Appendix 3.1.

[4] Intertemporal salience theory is identical to DEU if subjects are not affected by attention variation.

higher than 0.5. To this end, we conduct a one-sample proportion test. Against the null hypothesis $P = 0.5$, given $n = 100$, to achieve a power level at 0.8, we need at least 64 subjects' choices are consistent with the one of above four.[5]. Furthermore, we may ask a more demanding question: to what extent our model can rationalize deviations from DEU? From previous studies (Andreoni and Sprenger 2012, Cheung 2015, Miao and Zhong 2015), we estimate that around 20% subjects follow DEU. To illustrate statistical accuracy, against the null hypothesis $P = 0.334$ given $n = 80$, we need observe at least 49 subjects to choose either (A, B, A) or (B, B, A) to achieve power $= 0.8$[6]. Due to the simplicity of our experiment, subjects' earlier decisions can affect lator ones. This issue can be alleviated by performing a between-subject comparison. We analyze the first-shot decision for each individual. Specifically we want to test whether the proportion of subjects choosing A in task 2 is lower than in task 3. According to two-sample proportions test, against the null hypothesis of two proportion are equal, given $n = 66$, 30% of subjects in task 2 choosing A, we need at least 63% subjects to choose A in task 3[7].

For task 4 and 5, intertemporal salience theory predicts that subjects choose (A, A) which is consistent with precautionary saving. Nevertheless, the difference level between the two options under each event is more drastic than task 4. Thus, based on mild assumptions, we would expect more subjects choose option A in task 5. According to Deck and Schlesinger 2014, we expect around 40 subjects choose B in task 4. Therefore, to suggest that (B, A) is not random, a one-sample proportion suggest that given $n = 40$, with null hypothesis being the proportion of subjects choosing (B, A) is equal to 0.334 we need at least 73% subjects choosing (B, A). For analysis on the first-choice, we conduct a two-sample proportion test. Suppose 60% subjects choose A in tast 4, we need at least 84.8% subjects choose A in task 5 to reject that there is at most 60% subjects choose A with power $= 0.8$.

3 Appendix

3.1 Appendix A: Attention Check

The attention check question is summarized in table 3. In this task, we ask subjects to make two decisions. The first is to choose between A and B given coin 1 lands on H. The second is to choose given coin 1 lands on T. Notice, given coin 1 lands on H, A dominates B while given coin 1 lands on T, B dominates A. Therefore, if a subject is not able to identify the dominant choice, there might be some misunderstanding during the study.

[5]For power $= 0.85$, we need 65 subjects; for power $= 0.9$, we need 66 subjects.

[6]For power $= 0.9$, we need 51 subjects.

[7]For power $= 0.9$, we need 69%

3.2 Appendix B: Instructions and Material Presented to Participants

Instructions

Earning Money:

You will receive a $10 payment for participating in the study. This participation payment will be split in two and sent to you at two different dates: $5 will be paid in one week, and $5 will be paid in four weeks. These payments are separate from any other payments you receive from this study.

In this study, you will complete six tasks. Each task will ask you to make a decision between two options, OPTION A and OPTION B. In the first four tasks, these two options provide different values of task payments sooner, paid in one week, and task payment later, paid in four weeks. In the last two tasks, these two options provide different values of a single task payment, paid in one week. All you have to do in each task is decide whether you prefer OPTION A or OPTION B.

It is important to note that the payments in this study involve chance. There may be a chance that at either the sooner or later date your task payment will be zero ($0). You will be fully informed of the chance for the sooner and later task payments as well as the relevant payment amounts. You will also be fully informed about how each chance will be determined. Your payment amounts will be determined at the END of the study today. If, by chance, your sooner or later task payment amount is zero on a given date, you will still receive the $5 participation payment on that date.

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Determining Your Payments

The Decision-That-Counts and Coin Flip Events: Once you have completed all six tasks, we will randomly select your decision in one of the six tasks as the decision-that-counts. This will be done in two stages. First, we will pick a number from 1 to 6 at random to determine which task will be relevant for the decision-that-counts. Then we will flip two coins, which we will call Coin 1 and Coin 2. Coin 1 could land Heads (H) or Tails (T). Coin 2 could land Heads (H) or Tails (T). These coins will be flipped using a program which ensures the chances of landing on Heads or Tails are even. With two coins, four possible 'events' may occur:

- HH: Coin 1 lands Heads and Coin 2 lands Heads.
- HT: Coin 1 lands Heads and Coin 2 lands Tails.
- TH: Coin 1 lands Tails and Coin 2 lands Heads.
- TT: Coin 1 lands Tails and Coin 2 lands Tails.

Note the labeling of the four 'events', with 'H' denoting Heads and 'T' denoting Tails for each coin. Because these coins will be flipped using a program which ensures the chances of landing on Heads or Tails are even, each event will occur with 25% chance.

Once we know the event, we will look at your choice in the decision-that-counts. Your choice between OPTION A and OPTION B and the coin flip event will determine your sooner and later payment amounts. When calculating your earnings, we will add your payments to your $5 participation payment for each date. Even if your payment in the decision-that-counts on a given date is zero, you will still receive the $5 participation payment on that date.

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Receiving Payment and Your Identity

Important:
All payments will be sent to you through Amazon eGift card. On the scheduled day, the payment will be sent online by Professor Sprenger and his assistants.

As a reminder to you, the day before you are scheduled to receive one of your payments, we will send you an e-mail notifying you that the payment will be sent. At the end of today's study, we will send an e-mail to you with Professor Sprenger's contact information and a reminder of your payments on each date. If you feel there has been a mistake in processing your payments, please immediately contact Professor Sprenger.

Your Identity:
In order to receive payment, we will need to collect your email address. This information will only be seen by Professor Sprenger and his assistants. As soon as all payments are made, the link between the choice you make and your payments will be destroyed, and the record with your email address will be deleted. Your identity will not be a part of subsequent data analysis.

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Study Details

How It Works:
In this study you will complete six tasks. These tasks ask you make decisions between two options. The first option is called OPTION A. The second option is called OPTION B. All you have to do is decide whether you prefer OPTION A or OPTION B.

For the first four tasks, OPTION A and OPTION B describe combinations of a sooner payment in one week and a later payment in four weeks.

For each option, a different combination of sooner payment and later payment is described under each of the four coin flip events previously discussed: HH, HT, TH, and TT.

For each option, it may be possible for either your sooner task payment, your later task payment, or both to be zero ($0) in one or more of the events.

On the next page, an example task will be presented to you. It may not be an actual decision you will make, but it will be useful for describing how the task works.

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Example Tasks

	Event							
	HH		HT		TH		TT	
	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $
Option A	$6	$14	$6	$0	$0	$14	$0	$0
Option B	$10	$10	$10	$0	$0	$10	$0	$0

Please make your decision:

○ Option A

○ Option B

In this example, OPTION A and OPTION B pay different amounts at different dates in each event. Specifically,

- If HH occurs, OPTION A pays $6 in one week and $14 in four weeks. OPTION B pays $10 in one week and $10 in four weeks.
- If HT occurs, OPTION A pays $6 in one week and $0 in four weeks. OPTION B pays $10 in one week and $0 in four weeks.
- If TH occurs, OPTION A pays $0 in one week and $14 in four weeks. OPTION B pays $0 in one week and $10 in four weeks.
- If TT occurs, OPTION A pays $0 in one week and $0 in four weeks. OPTION B pays $0 in one week and $0 in four weeks.

Your task is to decide whether you prefer OPTION A or OPTION B. You decide by selecting the relevant button below the task. If you prefer OPTION A select the button marked 'OPTION A'. If you prefer OPTION B select the button marked 'OPTION B'.

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Example Tasks

In one of today's tasks you will decide between OPTION A and OPTION B twice: once for if Coin 1 lands H and once for Coin 1 lands on T.

On the next page, an example task will be presented to you. It may not be an actual decision you will make but is useful for describing how the task works.

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Example Tasks

Example Task

	Event							
	HH		HT		TH		TT	
	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $
Option A	$6	$14	$6	$0	$0	$14	$0	$0
Option B	$10	$10	$10	$0	$0	$10	$0	$0

If Coin 1 lands on H, please make your decision:

- Option A
- Option B

If Coin 1 lands on T, please make your decision:

- Option A
- Option B

In this example, OPTION A and OPTION B are the same as in the previous one.

Your task is to decide whether you prefer OPTION A or OPTION B conditional on the result of Coin 1. You decide by selecting relevant buttons below the task.

For example, if you prefer OPTION A given Coin 1 lands on H select the button marked 'OPTION A' from the higher pair. If you prefer OPTION B given Coin 1 lands on T select the button marked 'OPTION B' from the lower pair.

Imagine this question is chosen as the decision-that-count, and two coins are flipped. If Coin 1 landed on H, then your first choice on this screen would determine your payments. If Coin 1 landed on T, then your second choice on this screen would determine your payments.

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Example Tasks

For the last two tasks, OPTION A and OPTION B describe a sooner payment in one week. For each option a different payment is described for each of the four coin flip events previously discussed: HH, HT, TH, and TT. It may be possible for your sooner payment to be zero ($0) in one or more of the events for each option.

On the next page, an example task will be presented to you. It may not be an actual decision you will make but is useful for describing how the task works.

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Example Tasks

Example Task

	Event			
	HH	HT	TH	TT
	1 Week $	1 Week $	1 Week $	1 Week $
Option A	$5	$5	$5	$15
Option B	$0	$10	$10	$10

Please make your decision:

- Option A
- Option B

OPTION A and OPTION B pay different amounts in one week in each event. Specifically,

- If HH occurs, OPTION A pays $5 in one week. OPTION B pays $0 in one week.
- If HT occurs, OPTION A pays $5 in one week. OPTION B pays $10 in one week.
- If TH occurs, OPTION A pays $5 in one week. OPTION B pays $10 in one week.
- If TT occurs, OPTION A pays $15 in one week. OPTION B pays $10 in one week.

Your task is to decide whether you prefer OPTION A or OPTION B. You decide by selecting the relevant button below the task. If you prefer OPTION A select the button marked 'OPTION A'. If you prefer OPTION B select the button marked 'OPTION B'.

Once all of your decisions are made and you submit your responses, we will select the decision-that-counts at random. Then we will flip the two coins previously discussed to determine the coin flip event and your payments. On the next page, we will ask you two questions to ensure that you have understood the study.

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Check Your Understanding!

	Event							
	HH		HT		TH		TT	
	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $
Option A	$6	$14	$6	$0	$0	$14	$0	$0
Option B	$10	$10	$10	$0	$0	$10	$0	$0

Please make your decision:

○ Option A

○ Option B

Question 1

Imagine the example task above was chosen as the decision-that-counts and that someone preferred OPTION A. If event TH occurs, how much would they receive in one week (don't forget the participation payment!)?

Answer:

Question 2

Imagine the example task above was chosen as the decision-that-counts and that someone preferred OPTION B. If event HH occurs, how much would they receive in one week (don't forget the participation payment!)?

Answer:

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Decision 1

	Event							
	HH		HT		TH		TT	
	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $
Option A	$0	$0	$10	$10	$10	$0	$0	$10
Option B	$18	$2	$18	$0	$0	$2	$0	$0

- If HH occurs, OPTION A pays $0 in one week and $0 in four weeks. OPTION B pays $18 in one week and $2 in four weeks.
- If HT occurs, OPTION A pays $10 in one week and $10 in four weeks. OPTION B pays $18 in one week and $0 in four weeks.
- If TH occurs, OPTION A pays $10 in one week and $0 in four weeks. OPTION B pays $0 in one week and $2 in four weeks.
- If TT occurs, OPTION A pays $0 in one week and $10 in four weeks. OPTION B pays $0 in one week and $0 in four weeks.

Please make your decision:

○ Option A

○ Option B

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Decision 2

	Event							
	HH		HT		TH		TT	
	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $
Option A	$10	$10	$10	$10	$10	$10	$10	$10
Option B	$18	$2	$18	$2	$18	$2	$18	$2

- If HH occurs, OPTION A pays $10 in one week and $10 in four weeks. OPTION B pays $18 in one week and $2 in four weeks.
- If HT occurs, OPTION A pays $10 in one week and $10 in four weeks. OPTION B pays $18 in one week and $2 in four weeks.
- If TH occurs, OPTION A pays $10 in one week and $10 in four weeks. OPTION B pays $18 in one week and $2 in four weeks.
- If TT occurs, OPTION A pays $10 in one week and $10 in four weeks. OPTION B pays $18 in one week and $2 in four weeks.

Please make your decision:

○ Option A

○ Option B

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Decision 3

	Event							
	HH		HT		TH		TT	
	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $
Option A	$18	$2	$18	$0	$0	$2	$0	$0
Option B	$10	$10	$10	$0	$0	$10	$0	$0

- If HH occurs, OPTION A pays $18 in one week and $2 in four weeks. OPTION B pays $10 in one week and $10 in four weeks.
- If HT occurs, OPTION A pays $18 in one week and $0 in four weeks. OPTION B pays $10 in one week and $0 in four weeks.
- If TH occurs, OPTION A pays $0 in one week and $2 in four weeks. OPTION B pays $0 in one week and $10 in four weeks.
- If TT occurs, OPTION A pays $0 in one week and $0 in four weeks. OPTION B pays $0 in one week and $0 in four weeks.

Please make your decision:

- [ ] Option A
- [ ] Option B

Next

Decision 4

	Event							
	HH		HT		TH		TT	
	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $	1 Week $	4 Week $
Option A	$18	$2	$0	$0	$0	$2	$18	$2
Option B	$18	$2	$0	$2	$0	$0	$18	$2

- If HH occurs, OPTION A pays $18 in one week and $2 in four weeks. OPTION B pays $18 in one week and $2 in four weeks.
- If HT occurs, OPTION A pays $0 in one week and $0 in four weeks. OPTION B pays $0 in one week and $2 in four weeks.
- If TH occurs, OPTION A pays $0 in one week and $2 in four weeks. OPTION B pays $0 in one week and $0 in four weeks.
- If TT occurs, OPTION A pays $18 in one week and $2 in four weeks. OPTION B pays $18 in one week and $2 in four weeks.

If Coin 1 lands on H, please make your decision:

○ Option A

○ Option B

If Coin 1 lands on T, please make your decision:

○ Option A

○ Option B

Next

Decision 5

	Event			
	HH	HT	TH	TT
	1 Week $	1 Week $	1 Week $	1 Week $
Option A	$10	$10	$10	$0
Option B	$5	$5	$5	$15

- If HH occurs, OPTION A pays $10 in one week and $0 in four weeks. OPTION B pays $5 in one week and $0 in four weeks.
- If HT occurs, OPTION A pays $10 in one week and $0 in four weeks. OPTION B pays $5 in one week and $0 in four weeks.
- If TH occurs, OPTION A pays $10 in one week and $0 in four weeks. OPTION B pays $5 in one week and $0 in four weeks.
- If TT occurs, OPTION A pays $0 in one week and $0 in four weeks. OPTION B pays $15 in one week and $0 in four weeks.

Please make your decision:

○ Option A

○ Option B

Next

Decision 6

	Event			
	HH	HT	TH	TT
	1 Week $	1 Week $	1 Week $	1 Week $
Option A	$5	$5	$5	$15
Option B	$0	$10	$10	$10

- If HH occurs, OPTION A pays $5 in one week and $0 in four weeks. OPTION B pays $0 in one week and $0 in four weeks.
- If HT occurs, OPTION A pays $5 in one week and $0 in four weeks. OPTION B pays $10 in one week and $0 in four weeks.
- If TH occurs, OPTION A pays $5 in one week and $0 in four weeks. OPTION B pays $10 in one week and $0 in four weeks.
- If TT occurs, OPTION A pays $15 in one week and $0 in four weeks. OPTION B pays $10 in one week and $0 in four weeks.

Please make your decision:

○ Option A

○ Option B

Next

Option	State			
	HH	HT	TH	TT
A	(18,2)	(0,2)	(0,0)	(0,0)
B	(18,2)	(0,0)	(0,2)	()0,0

Table 3: Attention Check