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PRESENT BIAS FOR MONETARY AND DIETARY REWARDS: EVIDENCE FROM CHINESE TEENAGERS

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NON-TECHNICAL SUMMARY

Self-control is viewed in economics and other disciplines as a key individual characteristic responsible for effective self-regulation and personal goal attainment. Economists model self-control problems through time-inconsistent preferences. The underlying assumption of the model is that agents have a "present bias" toward current consumption, as the value of all future rewards are downweighed relative to rewards in the present.

Empirical tests of these preferences largely rely on experimental elicitation methods using monetary rewards, with several recent studies failing to find present bias for money. In this paper, in a within-subjects longitudinal experiment, we compare estimates of present bias for money with estimates for healthy and unhealthy foods. Our sample consists of 697 low-income Chinese high school students, a group that not only departs from the university student sample which has been widely studied in prior studies, but also in their age. Self-control established early in life is critical to personal development, yet few studies to date have estimated time preferences in children and adolescents. Our sample is also unique in their socio-economic status. One reason why recent carefully designed studies do not find present bias for money may simply be that the participants with higher income, as some studies document, did not have serious problems of self-control to begin with.

We find strong present bias for both food and money. On average, subjects choose to receive 4.2% (7%) more food (money) on the sooner payment date when the decision is made on that day than when it is made in advance. We see individual measures of time preferences are moderately correlated across reward types. Our experimental measures of time preferences over money predict field behaviours (including BMI, alcohol consumption, smoking, and academic performance) better than preferences elicited over foods.

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ABSTRACT

Economists model self-control problems through time-inconsistent preferences. Empirical tests of these preferences largely rely on experimental elicitation methods using monetary rewards, with several recent studies failing to find present bias for money. In this paper, we compare estimates of present bias for money with estimates for healthy and unhealthy foods. In a within-subjects longitudinal experiment with 697 low-income Chinese high school students we find strong present bias for both money and food, and that individual measures of present bias are moderately correlated across reward types. Our experimental measures of time preferences over money predict field behaviours better than preferences elicited over foods.

Keywords: self-control; quasi-hyperbolic discounting; present bias; adolescents; food rewards

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Introduction

Self-control is viewed in economics and other disciplines as a key individual characteristic responsible for effective self-regulation and personal goal attainment. Lack of self-control is thought to explain suboptimal choices and outcomes in many life domains, including financial decision making, health, and education. Given the importance of self-control, this individual trait is widely studied theoretically and empirically in many different fields.

In the economics literature, researchers usually model problems of self-control through time-inconsistent preferences that predict choices such as planning to go on a diet from next Friday but not going on the diet when next Friday arrives. Two well-known models that can capture such behaviours are the hyperbolic (Loewenstein & Prelec, 1992) and quasi-hyperbolic (Laibson, 1997) discount models. The latter model has attractive analytical features that have contributed to its popularity in economics,[1] and for this reason we focus on it in our paper. The underlying assumption of the model is that agents have a "present bias" toward current consumption, as the value of all future rewards are downweighed relative to rewards in the present, in addition to the standard exponential discounting of delayed rewards. Quasi-hyperbolic discounting has been applied theoretically and empirically to explain problematic behaviours across a wide variety of domains.

In the financial domain, quasi-hyperbolic discounting has been used to explain suboptimal life-cycle consumption, savings, and borrowing behaviours. Even in many developed countries, people do not save enough for retirement: in the US, the median savings of a household approaching retirement was only USD$15,000, compared to median annual expenditure of USD$36,800 (Federal Reserve Board, 2016). This means that a median household approaching retirement had enough saved to last less than 5 months. Such low levels of savings can be explained by present-biased consumption, as the trade-off between earlier or later consumption is more heavily skewed toward early consumption when the decision is made in the present than when the decision is planned in advance (Jones & Mahajan, 2015).

[1] See Frederick, Loewenstein and O'Donoghue (2002) for a comprehensive review of early literature.

In the health domain, economists have applied quasi-hyperbolic discounting to explain behaviours that lead to undesired outcomes such as obesity, unhealthy eating habits, and too little exercise. For example, DellaVigna & Malmendier (2006) found that gym users pay much more for gym facilities than what they actually use, a finding that can be explained through present-biased time preference: people overestimate their future gym attendance, but in the present moment choose not to go to the gym resulting in less usage than planned. Time inconsistency has also been used to explain addiction: Gruber & Kőszegi (2001) show that preferences with respect to smoking are time inconsistent, as individuals find that they are unable to quit despite their best intention to do so, while Schilbach (2019) finds that low-income workers in India are willing to forgo substantial monetary payments to set incentives for themselves to remain sober.

In the domain of work effort, time inconsistent preferences can explain why we end up working less than we intend to. When we plan our work effort for tomorrow, we make a trade-off between the disutility of working and the benefits that work brings. When tomorrow arrives, the costs of work suddenly weigh more heavily while the benefits remain in the future. This leads to procrastination. In a field experiment with Indian data entry workers, Kaur, Kremer, & Mullainathan (2015) find that workers show present bias as evidenced by effort increasing closer to randomly assigned paydays. Augenblick, Niederle, & Sprenger (2015) also find present bias in the allocation of work in a laboratory experiment.

While researchers have applied time inconsistency to explain self-control problems in many domains, most experimental research aimed at quantifying present bias has focused on a single specific reward, namely money,[2] so we do not know whether we would obtain the same results for other rewards. Moreover, much of what we have learned from these experiments has involved students at research universities. University students are relatively homogenous and have made decisions that were good enough to place them at university. It seems that we have largely been studying self-control in those who have most of it. Further, the bulk of existing experimental studies use a cross-sectional design,[3] but as Halevy (2015) and Read, Frederick, & Airoldi (2012) note this design is not a true test of time-inconsistency. Only a longitudinal design permits a test of inconsistent planning, the

[2] For a comprehensive review, see Cohen et al. (2020).
[3] A cross-sectional design compares, at a single point in time, preferences between two or more pairs of temporal prospects, separated by a common interval but preceded by different front-end delays.

key prediction of the quasi-hyperbolic model (Frederick, Loewenstein, & O'Donoghue, 2002). We address each of these issues in our paper.

In this paper, we estimate and compare time preferences for money, healthy foods and unhealthy foods. We thus contribute to the literature by identifying the shape of time preferences for food rewards. While researchers have applied the quasi-hyperbolic model to explain behaviour across a variety of domains, several recent experimental studies find no present bias for money (Andersen et al., 2014; Andreoni, Kuhn, & Sprenger, 2015; Andreoni & Sprenger, 2012a; Augenblick, Niederle, & Sprenger, 2015). This raises two possibilities: either our model of many real-life phenomena that rely on self-control is wrong, or the estimates of that model are domain- or subject pool specific. To our best knowledge, only one study has to date compared present bias for money with another reward type: Augenblick, Niederle, & Sprenger (2015) find little present bias in monetary choices and considerably more for real effort, illustrating how present bias may differ across domains.

With regard to other economic preferences, it has been found that people tend to be less patient (as distinct from present biased) for primary rewards than for money (Estle, Green, Myerson, & Holt, 2007; Odum & Rainaud, 2003; Reuben, Sapienza, & Zingales, 2010; Tsukayama & Duckworth, 2010; Ubfal, 2016) but that risk preferences estimated for money and food rewards are essentially the same (Levy & Glimcher, 2012). These contrasting results for different preferences across domains, highlight the importance of considering each economic preference in each domain separately.

Another unique feature of this paper is that our sample consists of 697 relatively poor adolescents in China. Most previous studies have focused on university students, the so called WEIRD subject pool (Henrich, Heine, & Norenzayan, 2010). WEIRD refers to samples drawn from populations that are White, Educated, Industrialized, Rich and Democratic. One reason why recent carefully designed studies do not find present bias for money may simply be that the participants, having been admitted into top universities, did not have serious problems of self-control to begin with.

Our subjects depart not only from each of the dimensions of the WEIRD samples, but also in their age. Self-control established early in life is critical to personal development, yet few

studies to date have estimated time preferences in children and adolescents.[4] Research in psychology has shown that poor self-control in childhood is associated with a range of damaging behaviours, for example cigarette smoking. Moreover, children with greater self-control are significantly more likely to be from socioeconomically advantaged families (Moffitt, Poulton, & Caspi, 2013).

To identify present bias we conduct a longitudinal experiment in schools. Halevy (2015) distinguishes three properties of standard preferences over temporal payments relative to a dated collection of such preferences. Stationarity implies that the ranking of two temporal payments at time *t* depends only on the difference between the two payments and their relative delay. The standard cross-sectional design is a test of this property. Time invariance implies that preferences are not a function of calendar time. Time consistency requires that the ranking of temporal payments does not change as the evaluation perspective changes from *t* to *t'*. Only a true longitudinal design can test for this property. Halevy (2015) finds that people can be time inconsistent and have stationary preferences at the same time, implying that the results of a cross-sectional design may be misleading.

Finally, conducting our experiment in school allows us to avoid selection into the study as well as attrition from it. Further, with access to administrative data from schools, we test the ability of our experimental measures to predict field outcomes such as academic performance.

697 Chinese high-school students participated in a five-week, incentivised longitudinal experiment[5] using a modified version of the Convex Time Budget design (Andreoni & Sprenger, 2012a) to elicit individual preferences for three reward types: money, healthy food and unhealthy food. Subjects faced the same set of decisions, featuring the same reward amounts delivered on the same dates, at two points in time. In the first session, all choices involved rewards to be received at two dates in the future, while in the second session the sooner rewards were available today. Our design also incorporates a test of rationality in the form of violations of the Generalised Axiom of Revealed Preference

[4] The seminal study investigating the lifelong impact of self-control is Walter Mischel's "marshmallow" test (Mischel & Ebbesen, 1970; Mischel, Shoda, & Rodriguez, 1989), but see McGuire & Kable (2013) and Cohen et al. (2020) for discussion of confounds in the interpretation of this task as a measure of time preference. Sutter et al. (2013) investigate the link between children's and adolescents' time preference for money and field behaviours, however they find little evidence of present bias in their sample.

[5] We conducted our experiment during regular class time toward the beginning of a new semester, and there were no public holidays during the timeline of our experiment.

(GARP). All 697 subjects who started the experiment completed both sessions, resulting in zero attrition.

We highlight several key findings. First, we provide the first estimates of present bias for consumption rewards. On average, subjects choose to receive 4.2% more food on the sooner payment date when the decision is made on that day than when it is made in advance. Our structural estimate of β for healthy food is 0.69 and for unhealthy food is 0.71 (both are significantly less than one).

However, in contrast to most recent literature we also find strong present bias for money in our sample. Subjects choose to receive 7% more money on the sooner payment date when the decision is made on that day than when it is made in advance. Our structural estimate of β for money is 0.65 (also significantly less than one).

Next, in contrast to previous results in the domain of risk, we find differences in the curvature of utility between monetary and primary rewards. For money, we confirm recent findings in the time preference literature that instantaneous utility is close to linear (Abdellaoui et al., 2013; Andreoni & Sprenger, 2012a; Cheung, 2020). However, for both healthy and unhealthy foods we find strong evidence of concave utility (implying a preference to spread rewards evenly over time), more in line with conventional findings in the domain of risk.

At an individual level, we find significantly positive and moderate correlations between individual measures of present bias for all reward type pairs ($\rho \in (0.47, 0.60)$), as well as between individual measures of impatience ($\rho \in (0.59, 0.66)$). Together, these findings imply that conventional choices over money are moderately predictive of choices for food.

Turning to the correlation between experimental measures and field behaviours, our measures of time preferences from monetary rewards predict field behaviours better than estimates from food rewards. Adolescents who make less patient choices for money are more likely to drink alcohol, have lower BMI, and have worse academic performance. In addition, teenagers who are more present biased for money are more likely to drink alcohol and have lower grades.

The paper proceeds as follows: Section II describes our experimental design, Section III explains our empirical approach, Section IV presents the results, and Section IV provides a discussion of our findings.

Experimental Design

Subject Pool

We collected data from 697 adolescents (331 girls; average age 16.1 years, standard deviation 0.15 years) from four public high schools in Guiyang City, China in February and March 2019. We randomly selected 16 classes in tenth and eleventh grades to participate in the study. The University of Sydney Human Research Ethics Committee and principals of each collaborating high school approved the study. Teachers of the participating classes permitted the experiments to be conducted in class during regular school hours. No students opted out, and all participating students and their parents gave informed consent. The experiment was conducted in Mandarin (see Appendix 1 for an English translation of the instructions).

Task

Our experimental task is an extension of the convex time budget (CTB) design of Andreoni and Sprenger (2012a), which allows us to estimate subjects' utility and discounting parameters using data from a single task. To simplify this task, we implement a discrete version of the CTB based upon Andreoni, Kuhn, & Sprenger (2015).

Following the CTB framework, we provide options that allocate amounts of a reward between two payment dates subject to a future-value budget constraint:

$$(1 + r) \times c_t + c_{t+k} = 70,$$

where c_t denotes the amount of reward received at the sooner payment date t, c_{t+k} denotes the amount of reward received at the later payment date $t + k$, and r denotes the simple interest rate between the two dates. Between trials, we systematically vary the interest rate r keeping the future value of the endowment fixed at 70. The back-end delay k was always equal to four weeks.

Figure 1A shows a sample budget with an interest rate of 0%. In that case, regardless of which bundle a subject chooses, the amounts received on the two dates always sum to 70. To discretise this choice, we offer six evenly-spaced options (shown as dots in Figure 1A) along the budget line that a subject can choose from. There were always six options in every trial to keep the difficulty of the choices constant. We exclude corner bundles (i.e. $(c_t, 0)$ and $(0, c_{t+k})$) from the choice set, as previous studies find that subjects who consistently

choose corner bundles generate issues for structural estimation (Harrison, Lau, & Rutström, 2013).

Figure 1B shows the corresponding decision screen for the 0% interest rate trial. As well as stating the amounts of a reward that are available on each payment date, we also visualise these quantities to facilitate comparison of the alternatives. The order of presentation of the six options on the screen was randomised for each subject, and the subject chose their most preferred bundle by clicking on it.

[Insert Figure 1A and 1B here]

The other simple interest rates we use are -9%, 11%, 25%, 43%, 67% and 100% (see Figure 2A for these seven budget sets). As the interest rate varies, a subject's choices trace out a price expansion path in terms of sooner and later rewards, with the optimal choices depending upon both utility curvature and discounting parameters.

We further enrich this framework by adding an additional seven decisions to allow for a test of the consistency of subjects' choices with the Generalised Axiom of Revealed Preference (Varian, 1982), as recommended by Chakraborty et al. (2017). We derive these additional choice sets from a present-value budget constraint:

$$c_t + \frac{1}{1+r} \times c_{t+k} = 56.$$

and in these trials we vary the interest rate while holding the present value of the endowment fixed at 56. The interest rates r for these additional trials are -13%, 0%, 13%, 25%, 38%, 50%, and 63%. Figure 2B shows the complete set of budgets used in our design. The two sets of budget lines intersect one another, allowing us to count the number of times a subject's choices violate GARP. The maximum number of GARP violations in this task is 91, while a random chooser would be expected to commit 12 violations. Note also that the trial with a 25% interest rate is presented twice (with other trials interleaved in between), allowing us to check for the consistency of subjects' choices when making the same decision twice.[6]

[Insert Figure 2 here]

[6] Our design also includes two choice sets with a 0% interest rate (but different sized budgets), allowing for an examination of the income effect.

Timeline

Figure 3 shows the timeline of our five-week longitudinal experiment. In the first session in week one, subjects were presented with decisions where the sooner payment is in one week's time (hence in week two) and the later payment is in four weeks' time (hence in week five). In the second session in week two, the same subjects made the same sets of decisions over bundles of rewards received in weeks two and five, where the sooner payment is now available today.[7] This longitudinal design identifies dynamic inconsistency by comparing initial allocations in week one (when all rewards are in the future) with subsequent allocations in week two (when the sooner reward is in the present). Before making their decisions in week one, subjects were told that they would be making decisions again in week two, and that one out of all their decisions would be randomly selected at the end of session two to be realised for payment. In the third session which took place in week five, subjects did not make any decisions and only received rewards. The experiment dates were between 25 February and 29 March 2019. Over this period, there were no public holidays, school vacations or examinations.

[Insert Figure 3 here]

After completing their decisions, subjects filled out a questionnaire which included demographic characteristics (in the first session) as well as hunger, fatigue and appetite ratings (in both sessions); see Appendix 2 for an English translation of these questionnaires.

Reward types

To compare time preferences for monetary and food rewards, we use a within-subjects design. Each subject faced the same sets of choices for three different reward types: money, healthy food, and unhealthy food. Before making any choices in week one, we asked each subject to choose their preferred healthy food reward and preferred unhealthy reward from three alternatives in each category. We did this to cater for different tastes and hence ensure that all subjects made decisions for foods that they liked. For healthy food, the available options were pecans, raisins, and almonds. For unhealthy food, the options were Skittles, M&M's, and Lays. We chose these food rewards based on a pre-experiment survey of students' favourite snacks.

[7] Figure A3.1 in Appendix 3 shows sample choice screens of the same trial as faced by a subject in week one and week two, respectively; everything is the same except the delays until the reward dates.

To summarise, in a given session each subject made 14 decisions for each of three reward types, with all 42 decisions repeated in two separate sessions. The order of rewards was either healthy-money-unhealthy or unhealthy-money-healthy. This order was randomly selected for each subject in the first session, and then held constant for the second session. Thus, choices over the two food rewards were always separated by choices over money. The experimental interface was programmed using Qualtrics.

Payment

At the end of the second session, one decision of each subject (from either the first or second session) was randomly selected as the one that would count for payment. If this was a money trial, the payments were made in cash. If it was a food trial, the subject received the amounts of food they had chosen. Sooner payments (both money and food) were delivered one hour after the second session. In week five, research assistants returned to the schools at the same time as in week two to deliver the later payments. To protect privacy, regardless of reward type, we used non-transparent zip-lock bags to pack subjects' payments. Therefore, monetary and food rewards were delivered to subjects in the same way.

Since we conducted the experiment during regular class hours in schools, the transaction costs to participate and receive payments are equalised throughout the study. Moreover, since subjects need to come to school anyway we did not pay any additional show-up fee, and their compensation from the study was solely based on the choices that they made.

Empirical approach

We next outline two approaches we adopt to measure subjects' time preferences and utility curvature. Our first approach is to use descriptive measures of time preference and preference for smoothness that are based on simple proportions of rewards allocated to sooner versus later payment dates. These descriptive measures provide evidence on the behaviours we are interested in without needing to commit to specific structural assumptions. However, since descriptive measures cannot always cleanly distinguish between parameters, our second approach is to impose a quasi-hyperbolic discounted utility model (Laibson, 1997) and use multinomial logit regression (Cheung, 2015; Harrison, Lau, & Rutström, 2013) to jointly estimate three parameters: the discount factor δ, present bias β, and utility curvature α. We find that these two approaches yield broadly consistent results.

Descriptive measures

III.A.a Impatience

To investigate subjects' impatience, without confounding it with present bias, we consider decisions made in the first session (week one) which result in bundles of rewards received in weeks two and five. Since all rewards are received in the future, present bias does not play any role. Subjects who select a bundle with a larger proportion of rewards allocated to the sooner payment date (week two) relative to the later date (week five) can be classified as more impatient (equivalently less patient).

Let $c_{i,j}$ be the amount of a reward that a subject would receive in week *i* based on a decision made in week *j*. We define impatience for each of the 14 decisions ($\text{Impatience}_k, k \in [1,14]$) for a given reward type as the proportion of the reward allocated to week two relative to the total amount of rewards in the chosen bundle, when the choice is made in week one:

$$Impatience_k = \frac{c_{2,1}}{c_{2,1} + c_{5,1}}$$

Then, for each reward type separately, to measure an individual's impatience we take the average of $Impatience_k$ for that reward type over all 14 decisions:[8]

$$Impatience = \frac{1}{14}\sum_{k=1}^{14} Impatience_k$$

By construction, this measure takes values between zero (most patient) and one (most impatient).

Present bias

Present bias occurs when an individual allocates a larger proportion of a reward to the sooner date when the sooner payment is immediate relative to when it is delayed, other things equal. To construct a descriptive measure of present bias, we first compare an individual decision made in week two when the sooner payment is today to the same decision made in week one when the sooner payment is delayed. We thus define present bias for a given decision scenario ($\text{Present bias}_k, k \in [1,14]$) as the difference in the

[8] We acknowledge that impatience defined in this manner may be confounded with utility curvature. We address this issue in our structural estimation.

proportion of the reward allocated to week two when making a choice in week two compared to when making the same choice in week one:

$$Present\ bias_k = \frac{c_{2,2}}{c_{2,2} + c_{5,2}} - \frac{c_{2,1}}{c_{2,1} + c_{5,1}}$$

Then, for each reward type separately, to measure an individual's present bias we take the average of Present bias_k for that reward type over all 14 decision scenarios:

$$Present\ bias = \frac{1}{14}\sum_{k=1}^{14} Present\ bias_k$$

By construction, this measure takes values between negative one (most future biased) and one (most present biased).

Preference for smoothness

In addition to their time preferences, a subject's choices in the experiment depend on the strength of their preference to smooth payoffs over time, as captured by the curvature of the utility function in a discounted utility model. A subject who has highly concave utility for a reward will have a strong preference for more mixed (temporally balanced) bundles, while one who has near-linear utility will tend to choose more extreme bundles near the corners of the budget set. To construct a descriptive measure of preference for smoothness, for a given decision trial ($k \in [1,28]$), we calculate the difference between the sum of the amounts of a reward allocated to both dates and the absolute difference in those amounts, normalised by the sum of the amounts:

$$Smooth_k = \frac{(c_1 + c_2) - |(c_1 - c_2)|}{c_1 + c_2}$$

In the limiting case of a corner solution (where one of the cs is zero), the numerator collapses to zero and so Smooth_k goes to zero. At the opposite extreme of perfect smoothing (such that $c_1 = c_2$), it is the absolute difference term that collapses to zero and so Smooth_k goes to one.

Then, for each reward type separately, to measure an individual's preference for smoothness we take the average of $Smooth_k$ for that reward type over all 28 decision scenarios:[9]

$$Smooth = \frac{1}{28}\sum_{k=1}^{28} Smooth_k$$

By construction, this measure takes values between zero (no preference for smoothing) and one (maximum preference for smoothing).

Structural model

To conduct a parametric estimation of the discount factor, present bias, and utility curvature we assume a CRRA utility function and quasi-hyperbolic discount function (Laibson, 1997; O'Donoghue & Rabin, 1999). The instantaneous utility from experimental payments, c, is:

$$u(c) = \begin{cases} \frac{c^{1-\alpha}}{1-\alpha} & \alpha \neq 1 \\ \ln c & \alpha = 1 \end{cases} \qquad (1)$$

The parameter α is CRRA utility curvature, where $\alpha = 0$ indicates linear utility, and $\alpha > 0$ ($\alpha < 0$) indicates concave (convex) utility. With a quasi-hyperbolic discount function, the intertemporal utility from experimental payments c_t received at date t, and c_{t+k} received at date $t + k$, is:

$$U_t(c_t,\, c_{t+k}) = \, u(c_t) + \, \beta^{\mathbf{1}_{t=0}}\delta^k u(c_{t+k}) \qquad (2)$$

The parameter β captures present bias. When $\beta = 1$, the discount function is exponential and there is no present bias, while $\beta < 1$ indicates present bias. The variable $1_{t=0}$ is an indicator of when the sooner payment date, t, is immediate. The parameter δ is the weekly discount factor.

Given the discrete nature of the choice sets in our design, we estimate this model using multinomial logit (MNL) regression (Cheung, 2015; Harrison, Lau, & Rutström, 2013) which compares the discounted utility of a subject's chosen bundle to that of each of the available

[9] There is no significant difference in our measure of preference for smoothness between the two sessions within the same reward type, thus we use data from both sessions to construct this measure.

alternatives.[10] Conditional on candidate values of the parameters being estimated, we use equations (1) and (2) to compute the discounted utility of each of the six alternative bundles. Then, given the bundle chosen by the subject, the multinomial logit probability of the observed choice is given by:

$$\Pr(choice) = \frac{e^{U^*/s}}{e^{U_1/s}+e^{U_2/s}+\cdots+e^{U_6/s}},$$

where U^* represents the utility of the chosen bundle, s is a "noise" parameter, and U_i $(i \in \{1,6\})$ represents the utilities of the six alternative bundles in each trial. The estimates of α, β and δ are chosen to maximise the log-likelihood of the observed choices, with standard errors clustered at the level of the subject.

Results

We present the results in four parts. We first establish that subjects' choices are consistent and rational. We then analyse their time preferences (impatience and present bias) and utility curvature using both descriptive measures and structural estimates as defined in the previous section. Next, we explore the correlation between time preferences for monetary and food rewards. We conduct both in- and out-of-sample prediction analyses to examine to what extent choices for money predict choices for food and vice versa. Finally, we study the relationship between our experimental measures of time preferences and field behaviours: BMI, smoking, alcohol consumption, and academic performance.

IV.A Consistency of subjects' choices with GARP

Table 1 shows the average number of GARP violations and Afriat's critical cost efficiency index (Afriat, 1967) separately for the three reward types and two sessions. For a given reward type and session, the maximum number of possible GARP violations in our design is 91. On average, subjects made 1.72 GARP violations for money, 1.71 for healthy food, and 1.84 for unhealthy food. The number of violations did not significantly differ between any of the reward types or within a reward type between sessions. For all reward types, the Afriat index is 0.98. Although this is significantly less than 1 $(p < 0.01)$, it is close to 1 indicating that our subjects were highly rational. Moreover, their scores are higher than in previous studies with comparable age groups. Harbaugh, Krause, & Berry (2001) found

[10] Our conclusions are qualitatively unchanged if we instead apply the nonlinear least squares estimator used by Andreoni & Sprenger (2012a) for continuous CTB data. Representative agent results for this estimation technique are reported in Table A3.1 in Appendix 3.

Afriat's index to be around 0.95 for children aged between 7 and 11 years, and around 0.94 for undergraduates, both lower than in our study; their experiment design also involved discretised budget sets. Overall, we conclude that our subjects behaved in a highly rational manner allowing meaningful analysis of their preferences.[11]

[Insert Table 1 here]

Time preferences

Impatience

In Figure 4, we plot mean impatience as a function of the interest rate.[12] As the interest rate increases, subjects choose to receive less on the sooner date, consistent with the law of demand.[13] Figure 4 suggests that subjects were less patient for food than for money. Averaged across all interest rates, subjects chose to receive 41.71% of their reward on the sooner payment date for money, 41.87% for healthy food and 41.80% for unhealthy food (detailed data in Table 2). Paired t-tests show that the differences in impatience between money and healthy food, and between money and unhealthy food, are both significant ($p < 0.001$, see Table 3), but that the difference between healthy and unhealthy food is only marginally significant ($p = 0.084$). Our finding that subjects tend to be less patient for primary rewards than for money is consistent with previous studies (Estle et al., 2007; Odum, Baumann, & Rimington, 2006; Odum & Rainaud, 2003; Reuben et al., 2010; Tsukayama & Duckworth, 2010; Ubfal, 2016).

[Insert Figure 4 and Tables 2 & 3 here]

[11] We also conduct a simple consistency check using the interest rate of 25% that was presented twice for each reward in each session. On average, within a given session, 81.2% of subjects chose either the same or a neighbouring bundle in both trials, with 56.6% of subjects choosing the exact same bundle both times. Across all sessions and rewards, the number of subjects who chose the same or a neighbouring bundle was very similar, ranging between 80.0% and 83.1%. There was no significant difference between the two sessions or between reward types. There was also no significant difference in the percentage of rewards that subjects allocate to the sooner date between the first and second time they face this question (40.3% versus 40.0%, $p = 0.34$). Overall, we conclude that our subjects show generally high levels of consistency.

[12] As there was no significant difference between the first and second trials for the repeated interest rate of 25%, we plot the average of these two trials in this graph.

[13] At an individual level, we regress impatience on the interest rate separately for each subject and find that for 436 subjects (62%), the coefficient on the interest rate is significant in line with the law of demand.

In our structural estimates for a representative agent (Table 4), we find that $\delta > 1$ for all three reward types ($p < 0.001$) which implies a negative discount rate. To understand this surprising finding, call a bundle back (front) loaded if in that bundle, a larger proportion of the reward is delivered at the later (sooner) date. In trials with a front-end delay (such that beta is not implicated in choices) and an interest rate of zero, a negative discount rate would manifest itself through subjects selecting back-loaded bundles.[14] Indeed, in zero-interest trials our subjects on average allocate 53.5% to the later date for money and 54% to the later date for healthy and unhealthy food, slightly more than an equal split of 50%. This behaviour is consistent with our estimate of $\delta > 1$. Nonetheless, only 10.33% of our subjects choose the most back-loaded bundle for money (10.47% for healthy food and 9.76% for unhealthy food).[15]

[Insert Table 4 here]

Present bias

In Figure 5, we plot the proportion of the reward allocated to the sooner date against the interest rate, separately for each reward and session. Dots (squares) represent the proportion allocated to the sooner reward in the first (second) session and the solid (dashed) curve represents the predicted aggregate choice behaviour implied by our structural $\beta - \delta$ model in the first (second) session when we estimate reward-specific parameters of that model by MNL at an individual level and predict the choices that maximise each subject's utility in each trial.[16] The difference between allocations in the two sessions represents present bias. The more subjects are time consistent, the closer the solid and dashed curves will be. The fact that the dashed curve is above the solid one for all three reward types indicates that our subjects choose to receive more on the sooner date when the sooner date

[14] In a zero-interest rate trial with front-end delay, an agent with linear utility and a 0% discount rate ($\delta = 1$) would be indifferent between all bundles. An agent with linear utility and a negative discount rate ($\delta > 1$) would choose the most back-loaded bundle. Finally, if an agent has concave utility and a negative discount rate she would choose an interior back-loaded bundle. This last case is what we observe in our data.

[15] At the same time, only 7.6% of subjects choose the most front-loaded bundle for money (5.31% for healthy food, 5.02% for unhealthy food). By contrast, in zero interest rate trials with a front-end delay, 73.2% of subjects in Andreoni & Sprenger (2012a) chose the soonest possible allocation, 68.75% in the certainty condition in Andreoni & Sprenger (2012b), 66.67% in the certainty condition in Cheung (2015), 93.75% in Andreoni, Kuhn, & Sprenger (2015), and 63.33% in the money condition in Augenblick, Niederle, & Sprenger (2015). Each of these studies involved monetary rewards, and estimated $\delta < 1$.

[16] See Section IV.C below for further discussion of these individual estimates.

is today compared to when it is in the future, with the distance between the curves indicating the strength of present bias.

Our descriptive measures (Table 5 and Figure 5) indicate that present bias is strongest for money. The mean of our descriptive measure of present bias for money is 0.0700 (std.dev = 0.28). That is, on average, subjects chose to allocate 7% more money to the sooner date in the second session. The mean of present bias for healthy food is 0.0426 (std.dev = 0.27) and for unhealthy food it is 0.0429 (std.dev = 0.27). Using paired t-tests we confirm a stronger present bias for money than for each primary reward ($p < 0.001$), and no significant difference in present bias between healthy and unhealthy food ($p = 0.811$) (Table 6).

[Insert Figure 5 and Tables 5 & 6 here]

In our structural estimates for a representative agent (Table 4, third column), we find economically and statistically significant present bias for all rewards, consistent with our descriptive analysis. For money we find $\beta = 0.6574$ (std. err. = 0.0356, $H_0: \beta = 1, p < 0.001$), for healthy food $\beta = 0.6959$ (std. err = 0.0459, $H_0: \beta = 1, p < 0.001$), and for unhealthy food $\beta = 0.7161$ (std. err = 0.0425, $H_0: \beta = 1, p < 0.001$). In line with our descriptive measures, β is smallest (present bias is strongest) for money.

Our finding of significant present bias for money differs from recent studies, including Andreoni & Sprenger (2012a), Andreoni, Kuhn, & Sprenger (2015), Andersen et al. (2014) and Augenblick, Niederle, & Sprenger (2015) who all conclude that there is no present bias for money. In the discussion section, we compare our design (study takes place at school during school hours) and subject pool (adolescents from a relatively poor background) with these studies and discuss potential reasons for this difference.

We also find present bias for consumption goods which is a novel contribution of our study. To date, no other study has investigated present bias for primary rewards except Augenblick, Niederle, & Sprenger (2015) who estimate present bias for real effort (aggregate estimate of $\beta = 0.888$). Our estimates of β indicate stronger present bias for food than for real effort.

Preference for smoothness / utility curvature

We find a significantly stronger preference for smoothness for food rewards than for money ($p < 0.001$, Tables 7 & 8). The descriptive measure of preference for smoothness is around

0.59 for food rewards and for money it is around 0.56. A higher score for food indicates a stronger preference for more mixed bundles, and thus more concave utility for food rewards than for money. We do not find any difference in the preference for smoothness between healthy and unhealthy food.

[Insert Tables 7 & 8 here]

The conclusions of our structural estimation (Table 4) are consistent with this descriptive analysis. The estimated utility curvature for money is not significantly different from zero, indicating near-linear utility. This is consistent with findings in Andreoni & Sprenger (2012a), Abdellaoui et al. (2013), Andreoni, Kuhn, & Sprenger (2015), Augenblick, Niederle, & Sprenger (2015) and Cheung (2020). For both healthy and unhealthy food, we estimate significantly concave utility, indicating that our subjects have a preference to smooth food rewards over time.

Relationship between time preferences for money and food rewards

In aggregate, we find that subjects have different preferences for monetary and for food rewards. They are less patient, less present-biased, and have more concave utility for food than for money. In this subsection we use our descriptive measures of impatience, present bias, and utility curvature to understand the extent to which time preferences for money and food are correlated within each individual. Overall, we generally find moderate correlations across reward types.

Using Spearman rank-order correlation analysis and descriptive measures of impatience, we find significantly positive, moderate correlations around 0.61 between individual impatience for all reward-type pairs (Figure 6 panel A). This means that individuals who made less patient choices for money also made less patient choices for food, and those who made less patient choices for unhealthy food also made less patient choices for healthy food. Panel B of Figure 6 illustrates the correlations between individual descriptive measures of present bias for different reward types. They are also significant and moderate at around 0.60. Preference for smoothness is a proxy for utility curvature. As shown in Figure 6 Panel C the correlation between any two reward types is significant and strong (around 0.82).

[Insert Figure 6 here]

We next investigate to what extent the structural estimates for one reward type predict choices for the others. Since most studies in experimental economics rely on monetary incentives, it is important to understand the validity of extrapolating from such studies to different reward domains. We answer this question in two steps. First, we validate our structural estimation in sample. In other words, we ask to what extent our individual structural estimates for a given reward type predict choices for the same individual and reward type. We then use this as a benchmark to assess out-of-sample prediction in the second step.

In Figure 7A and 7B, first row, we plot the observed choice distributions in the first and second sessions, separately for each reward type. Bundles 1 to 6 are indexed according to their relative position along the budget line, with 1 being the most front-loaded and 6 the most back-loaded bundle within any given choice set. We see that in the first session, the choice distribution is similar for the two food rewards with bundle 3 being the modal choice. For monetary rewards, the modal choice is bundle 6 which allocates most to the later date, consistent with the finding that subjects are less patient for food than for money. In the second session, owing to present bias, the tendency to choose bundles 1 and 2 (allocating more to the sooner date) increases for all reward types. We also see that bundles 1 and 6 are less frequently chosen for food than for money, consistent with the finding that subjects have a stronger preference to smooth food rewards over time.

To examine how well our structural estimates explain an individual's choices for the same reward type (in-sample prediction), we calculate the utility of each bundle in each trial using each individual's reward-specific structural estimates, and predict that the individual will choose the bundle with the highest utility in each trial. As illustrated in the second row of Figure 7A and 7B, this predicts the general tendency to pick each bundle type quite well. Across all three reward types, we exactly predict 56.98% of individual choices in the first session and 57.07% of choices in the second.[17] This is our benchmark to compare the ability of estimates based on choices over money to predict choices over food.

The third row of Figure 7A and 7B presents our out-of-sample predicted choice distributions. We use our individual structural estimates for money to calculate the utility of each bundle in each food trial, and predict that an individual will select the bundle with the highest

[17] If we relax the standard of success to predicting either the chosen bundle or an immediately adjacent one, this is achieved for 84.20% of choices in the first session, and 84.12% of choices in the second.

utility.[18] In the first session we now correctly predict 43.63% of choices for food, while in the second session we correctly predict 46.01%. Table 9 confirms that prediction performance is indeed significantly worse when we use estimates from choices over money to predict choices over food ($p < 0.001$ in both sessions).[19]

[Insert Figure 7 and Table 9 here]

Experimental measures and field behaviours

In this section, we assess the predictive power of our descriptive measures of impatience and present bias to explain smoking, alcohol consumption, body mass index (BMI), and academic performance. Information on smoking, alcohol consumption and BMI was collected through self-reports from all 697 adolescents. Grades for the three core units (Chinese, Mathematics, and English) were obtained from the administrative records of the participating high schools.

[Insert Figure 8 here]

Figure 8 summarises our data on BMI and academic performance. 59% of our subjects have BMI in the normal range ($18.5 \leq \text{BMI} \leq 24.9$), while 28% are underweight and 13% are overweight (mean BMI = 21.21, 75th percentile = 22.04, std. dev. = 4.88). Academic performance in China is assessed on a scale from 0 to 100; we combine the grades in the three core units by summing them. An average student in our sample obtained a combined grade of 167 (std. dev = 29.38) and the highest score is 237.5 (around 80%), indicating medium to low academic performance in our sample. Very few subjects (7.174%) reported smoking cigarettes and 13.63% reported drinking alcohol.

To establish if there is any relationship between time preferences and field behaviour, we separately regress each of the field behaviours on the domain specific descriptive measures of impatience (Table 10) and present bias (Table 11). In these regressions, we control for subjects' gender, self-reported wealth, hunger, fatigue, and trust in the experimenter. Tables 10 and 11 report the coefficients on each of the domain specific descriptive measures while the coefficients on the control variables are omitted from these tables.

[18] This procedure implies that each food bundle type will be chosen equally often as the corresponding bundle type in the monetary domain.
[19] Figure A3.2 in Appendix 3 report results on the ability of preferences estimated from choices over food rewards to predict choices over money.

The most prominent associations we find are between the domain-specific impatience measures and alcohol. Adolescents who made less patient choices for money, healthy food or unhealthy food were more likely to drink alcohol. Moreover, adolescents who were less patient for money and unhealthy food had lower grades. Directionally, we see the same relationship between grades and impatience for healthy food, however it is not significant and the coefficient is much smaller. Very few adolescents in our sample report smoking, which is likely why we do not find any significant relationship between impatience and smoking. Subjects who were less patient in the monetary domain had lower BMI ($p = 0.028$).

We found fewer associations between present bias and field behaviours. Subjects who were more present biased for money were more likely to smoke, drink alcohol and had lower grades. Those who were more present biased for healthy food had lower BMI.

To summarise, across the four field behaviours, our measures of patience have stronger associations with field behaviours than our measures of present bias. Time preferences for money predict more field behaviours than food rewards. We explore the implications of these findings in the discussion.

[Insert Tables 10 & 11 here]

Discussion

The model of present-biased time preference is one of the cornerstones of behavioural economics. In this paper, we provide evidence that fills some major gaps in empirical research on this model. Using data from an incentivised, within-subjects, longitudinal experiment in Chinese high schools, we estimate and compare present-bias, patience, and utility curvature for three types of rewards: money, unhealthy food, and healthy food. While researchers have applied the quasi-hyperbolic discount model to explain sub-optimal decision-making in a wide variety of domains, to date empirical evidence of present bias parameters has come predominantly from experiments using money, with many recent studies finding no present bias for money (Andersen et al., 2014; Andreoni, Kuhn, & Sprenger, 2015; Andreoni & Sprenger, 2012a; Augenblick, Niederle, & Sprenger, 2015). This raises the possibility that either present bias is not the right behavioural model, or that present bias is not a feature of the samples and/or rewards used in these studies. While a handful of studies (such as those conducted in developing countries) address the diversity of the sample, ours is the first to provide estimates of present bias for consumption rewards.

We find strong present bias for food rewards. In our experiment, subjects on average allocate 4% more food to the sooner date when that date is today rather than in the future. Structural estimates yield a present-bias parameter of 0.70. To give an indication of the consequences of such preferences, we calculated the caloric intake of our subjects, assuming that they take part in the same experiment every week and compared it to the caloric intake of choosers with no present bias. Compared to time-consistent choosers, our subjects would consume around 120 more calories each week just from our experiment, resulting in 0.79 kilograms increase in weight per year. Holding all else constant, an average high-school student with $\mathrm{BMI} = 21$ would become overweight in less than 5 years. This estimate should be regarded as a lower bound, as it does not incorporate other dietary choices that subjects also make that may involve more temptation. In line with this intuition, Vadeboncoeur, Townsend, & Foster (2015) found that university students can gain up to 4kg in their first year of study, which coincides with the time in life when they start to take responsibility for their own nutrition.

Our finding of present bias for money is also notable. While theoretical studies have applied the quasi-hyperbolic model to explain sub-optimal decision-making across a variety of domains, most recent empirical studies do not find present bias for monetary rewards. We use the same rigorous preference elicitation methods as these studies, but find present bias for money. These contrasting results could be due to differences in the subject pool or to details of the experiment. Instead of university students, our sample consists of Chinese adolescents of low-to-medium socioeconomic status. Their age, ethnicity, and socioeconomic status differ from the subjects in most previous studies. With regard to experimental protocols, we conducted our experiment at schools during regular school hours, whereas subjects in most other studies had to take the initiative to sign up for the experiment and then come to the lab on time. We argue that this latter procedure may generate selection bias, as subjects who are able to show up to a previously scheduled experimental session on time are likely to have good self-control which may explain why previous studies do not find present bias.

Our findings regarding the curvature of utility are notable in light of recent controversy over the nature of utility in choice over time (Abdellaoui et al., 2013; Andreoni & Sprenger, 2012a; Cheung, 2020). Consistent with these recent studies, we find near-linear utility for money in choice over time. This finding stands in sharp contrast to experimental findings in the domain of risk, as well as the long tradition in theory (starting with Bernoulli) that

assumes concave utility in choice under risk, and the strong psychological (Kahneman & Tversky, 1979) and biological foundations of S-shaped utility functions (Rayo & Becker, 2007; Robson & Whitehead, 2020; Tymula & Glimcher, 2020; Woodford, 2012). In contrast, we find concave utility for unhealthy and healthy foods in choice over time. This further underscores the importance of studying different reward domains rather than drawing strong inferences from the study of a single domain alone, namely money.

An important question in behavioural economics is to what extent can we extrapolate findings from studies involving monetary rewards to other domains of decision making. In our experiment, we use an identical method to elicit preferences of each subject for three reward types, allowing for a meaningful within-subject comparison of estimates across rewards. Our within-subject correlations of present bias across reward types are significant but only moderate. Correlations between impatience for money and food can also be classified as moderate, consistent with a study by Reuben et al. (2010). Our results suggest that researchers should be cautious in extrapolating from studies of present bias and patience for money to other domains, at the very least more cautious than when doing so for risk preference.

Our data allow us to relate elicited preference measures to field behaviours including self-reported BMI, smoking and alcohol consumption, as well as academic performance obtained from schools' administrative records. We find that subjects who are less patient and more present biased for money are more likely to drink alcohol and have lower grades, leading to an overall less favourable health and economic outlook compared to subjects who are more patient and less present biased. Similar findings have been found by Sutter et al. (2013). Compared to measures of impatience and present bias for money, impatience and present bias for food are less predictive of field behaviours. Only the discount rate for unhealthy food is associated with alcohol consumption and academic performance.

Finally, while we have framed our paper in the language of the quasi-hyperbolic discount model, we note that our findings are also compatible with other hyperbolic discounting models and may thus be interpreted as evidence of time-inconsistent preferences more generally.[20]

[20] For biological foundations of different discount models, see Kable & Glimcher (2007).

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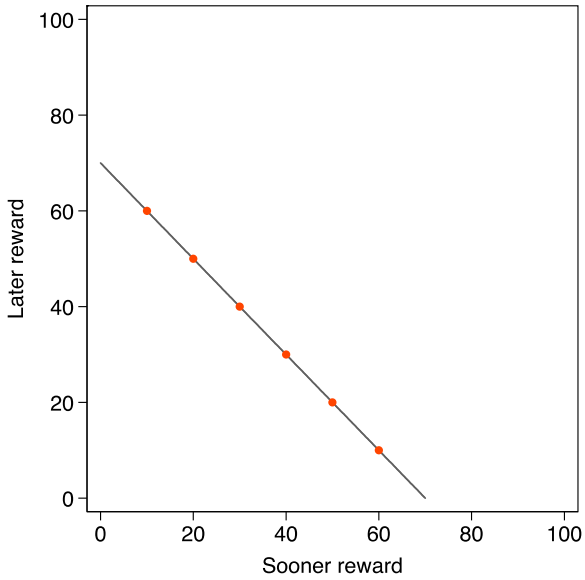
Figures and Tables

Figure 1. Experimental design. A: Budget constraint with 0% interest rate. The six dots on the budget line indicate bundles available to the chooser. B: Decision screen for the 0% interest rate trial. Each row represents one bundle. On the left is the amount received on the sooner date and on the right is the later date. Dots represent the quantity of a reward to be received on that date. The six bundles are presented in random order for each participant.

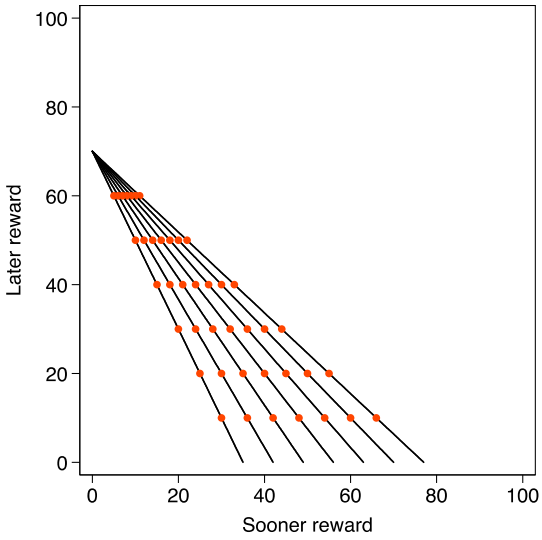
A.



B.

Figure 2. Budget constraints

A. Seven standard budget constraints



B. Complete set of budget constraints

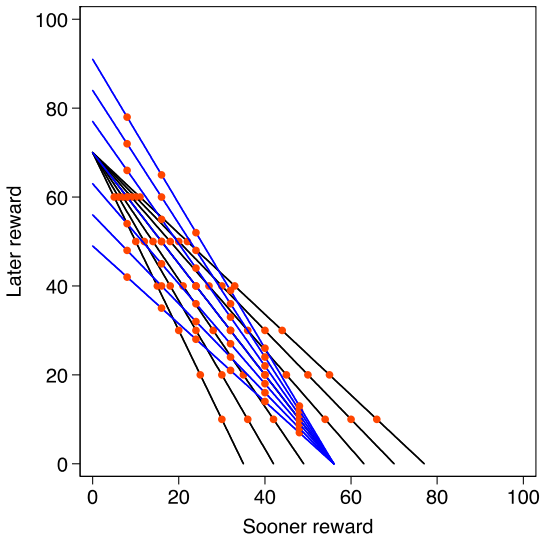


Figure 3. Timeline of the experiment

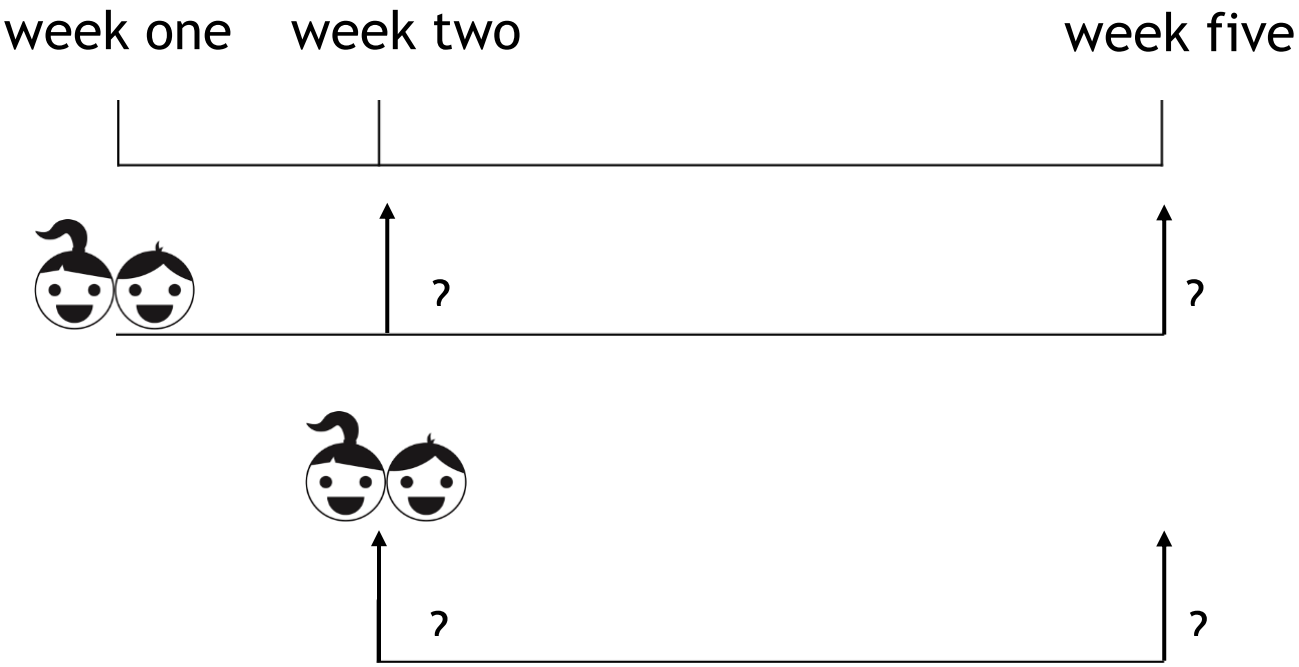


Figure 4. Impatience for different reward types at different interest rates. Dots (squares, crosses) represent the proportion allocated to the sooner reward in the first session for money (healthy food, unhealthy food). Solid (dashed, dash-dotted) curves are the $\beta - \delta$ prediction (individual MNL) for money (healthy food, unhealthy food).

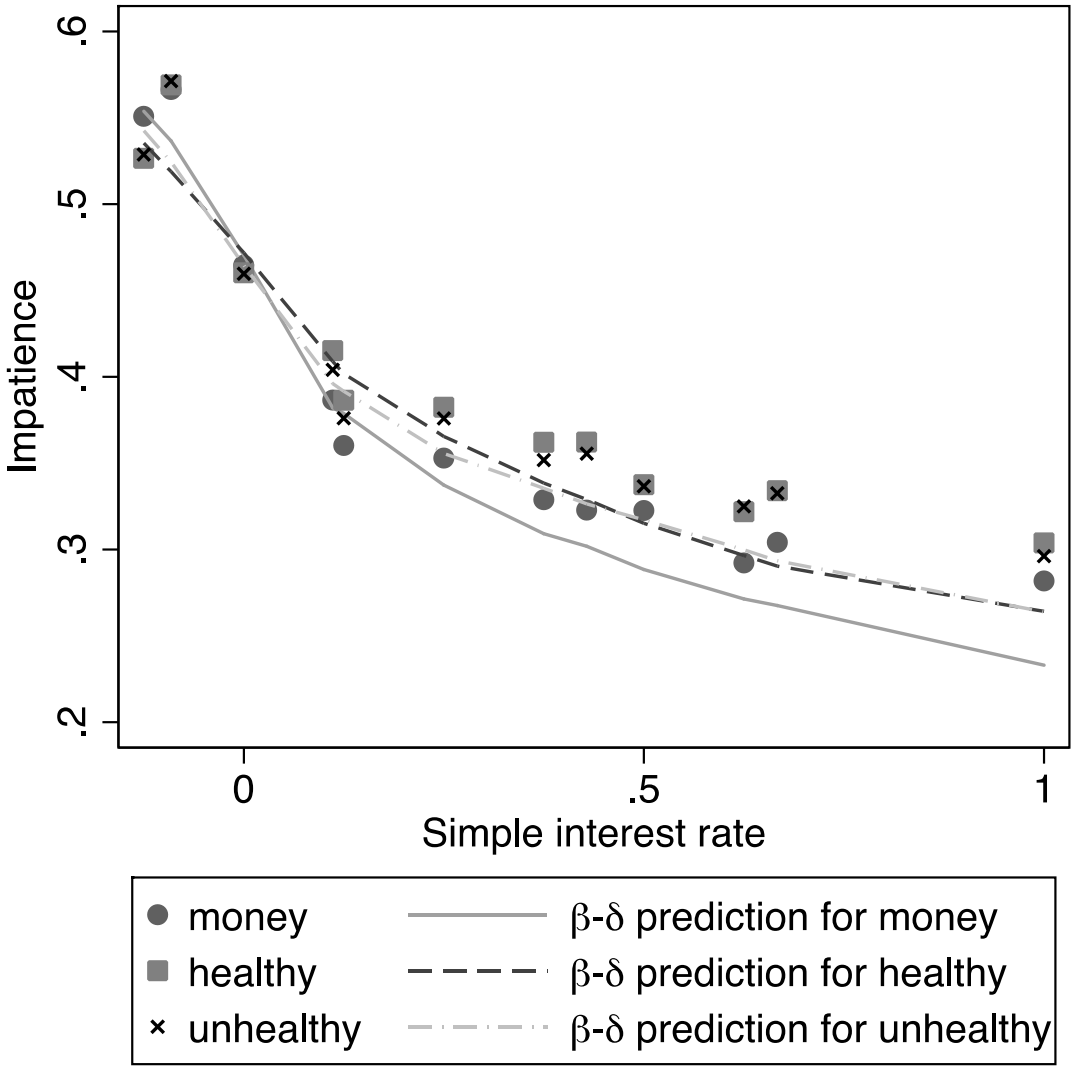


Figure 5. Present bias. Dots (squares) represent the proportion allocated to the sooner reward in week one (two) session. Solid (dashed) curves are the $\beta - \delta$ prediction (individual MNL) for week one (two) session. The difference between allocations in the week one and two sessions represents present bias.

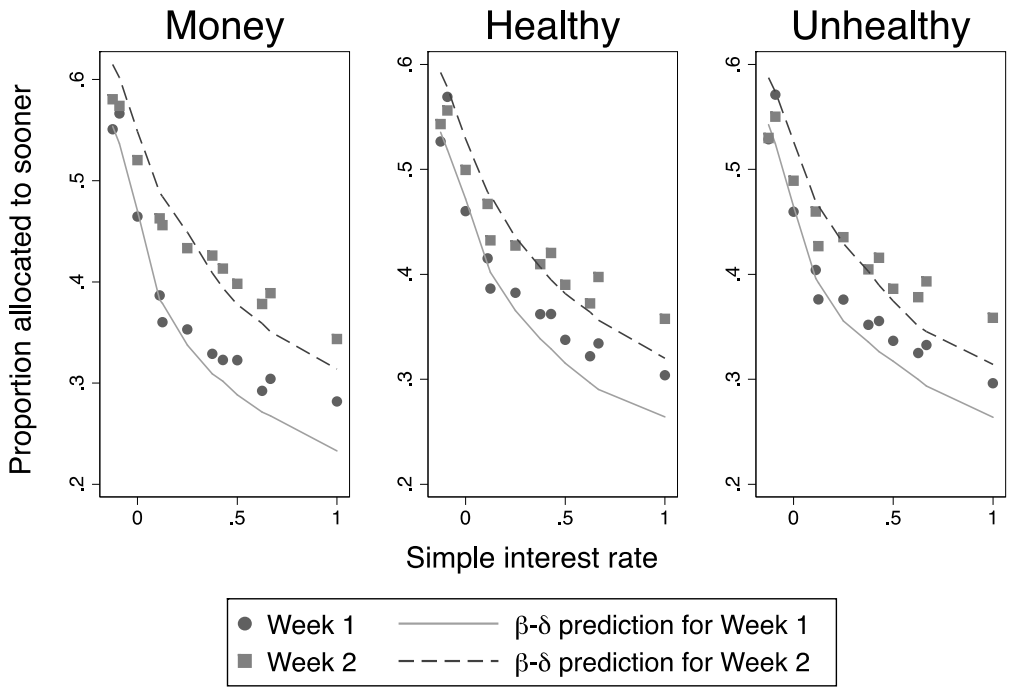
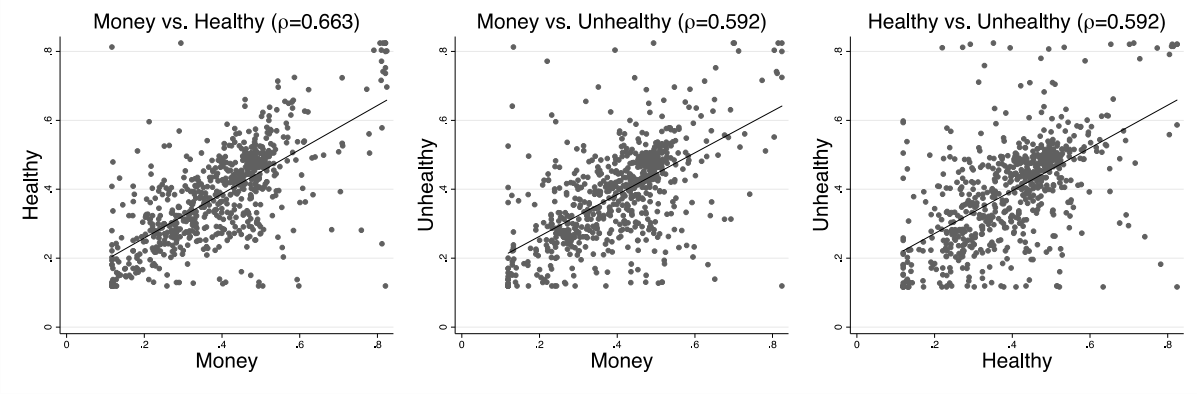


Figure 6. Correlations of individual descriptive measures of impatience, present bias and preference for smoothness across reward types. The line is the best linear fitted line.

A. Impatience



B. Present bias

C. Preference for smoothness / utility curvature

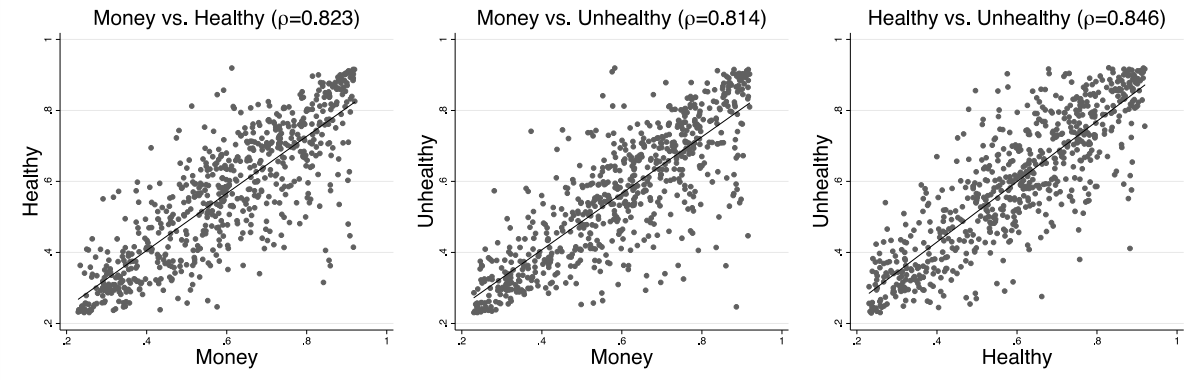
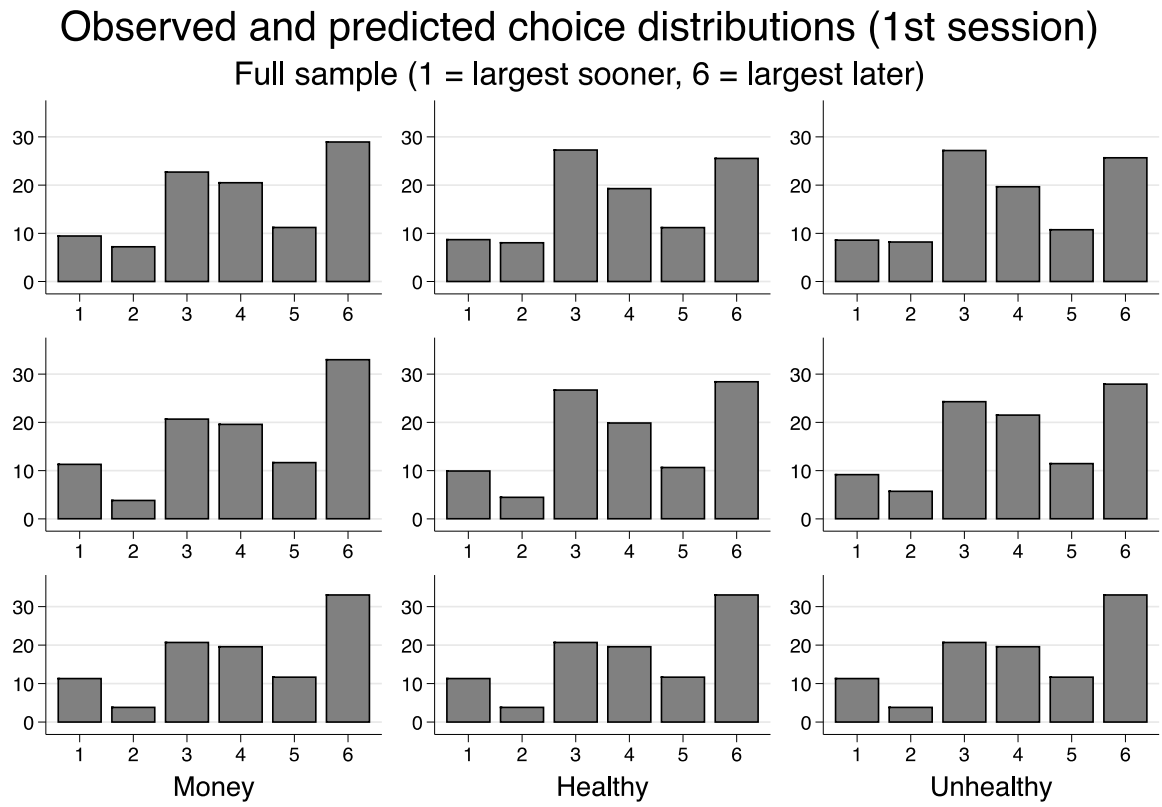


Figure 7. In- and out-of-sample prediction. Bars illustrate the proportion of choices of each bundle type (1 is the most front-loaded bundle and 6 is the most back-loaded). The first row shows the observed choice distributions. The second row shows the in-sample predicted choice distributions. The third row shows the out-of-sample predicted choice distributions.

A.



B.

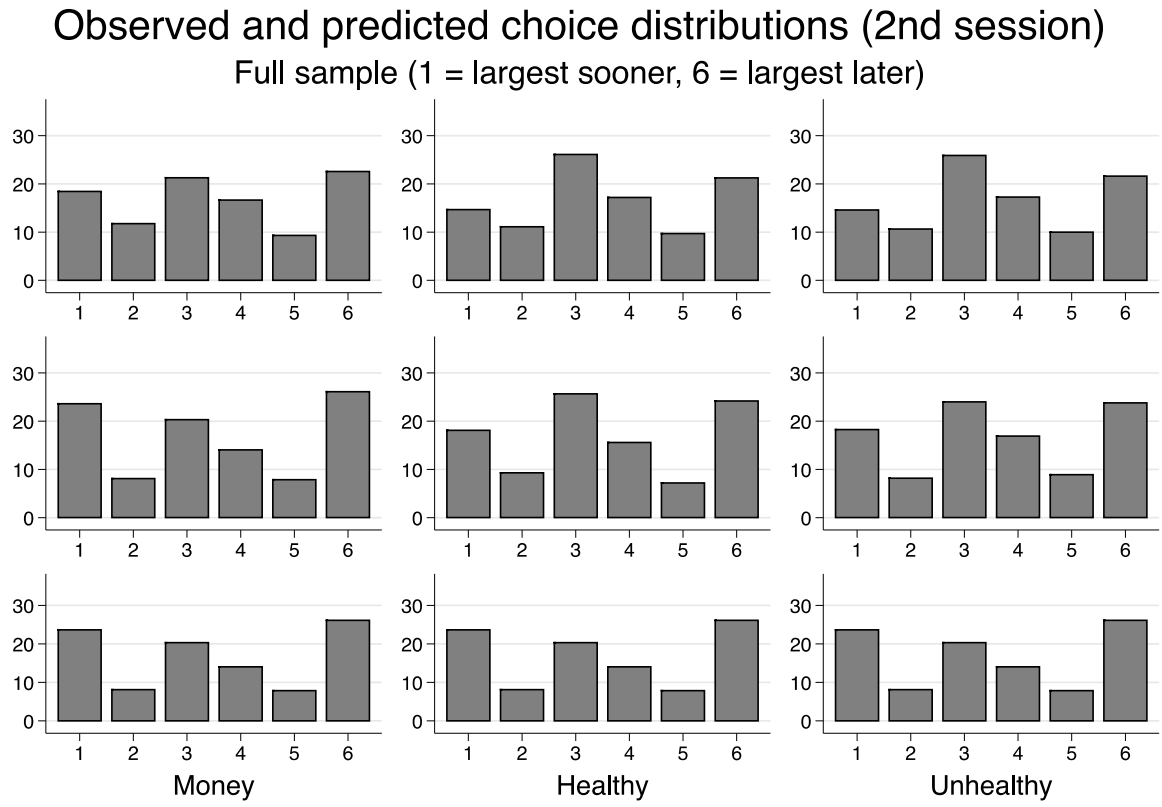
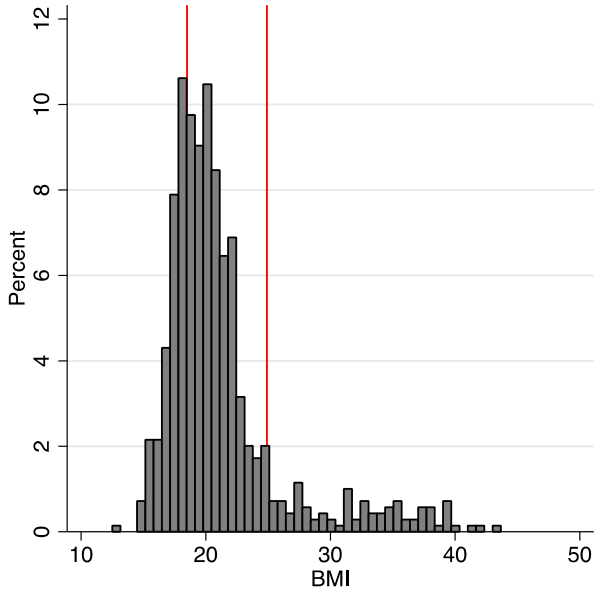

Observed and predicted choice distributions (2nd session)
Full sample (1 = largest sooner, 6 = largest later)
Money
Healthy
Unhealthy

Figure 8. Summary statistics for field behaviours. A: Histogram of BMI, calculated by dividing self-reported weight (in kilograms) by height (in metres) squared. The area between the red vertical lines indicates the healthy range of BMI (18.5 to 24.9). B: Histogram of academic performance (sum of grades for Chinese, Mathematics and English), obtained from schools' administrative data.

A.



B.

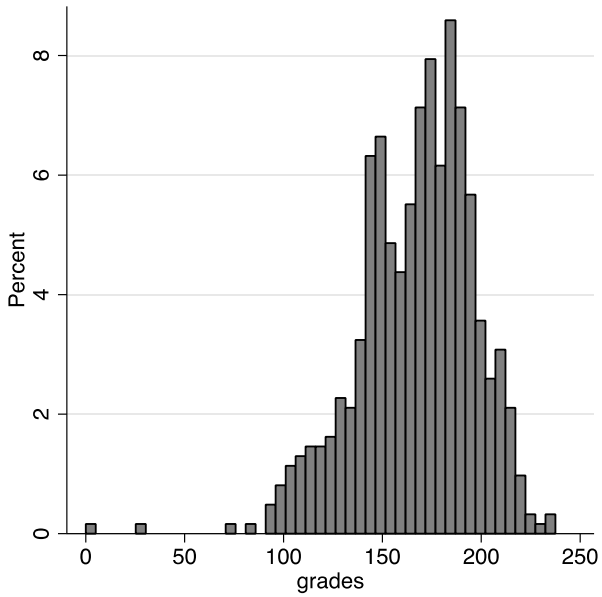


Table 1. Average number of GARP violations and Afriat's index for different reward types in each session

		Average no. of GARP violations	Afriat's index
1st session	Money	1.68	0.98
	Healthy	1.65	0.98
	Unhealthy	1.78	0.98
2nd session	Money	1.75	0.98
	Healthy	1.77	0.98
	Unhealthy	1.90	0.98

Table 2. Summary statistics of individual descriptive measures of impatience, by reward type

	Mean	Sd	25th	75th
Money	0.4171	0.2462	0.1600	0.5714
Healthy	0.4187	0.2332	0.1975	0.5714
Unhealthy	0.4180	0.2332	0.1935	0.5714

Table 3. Significance tests of differences in impatience between reward types

Impatience difference	Means difference	Two-sided t-test p-value
Healthy - Money	0.0016	0.0000
Unhealthy - Money	0.0009	0.0000
Healthy - Unhealthy	0.0007	0.0842

Table 4. Structural estimation results (standard errors in parentheses)

	α	β	δ
Money	-0.0330	0.6574	1.0809
	(0.0797)	(0.0356)	(0.0142)
Healthy	0.3160	0.6959	1.1198
	(0.0850)	(0.0459)	(0.0234)
Unhealthy	0.2983	0.7161	1.1142
	(0.0857)	(0.0425)	(0.0212)

Table 5. Summary statistics of individual descriptive measures of present bias, by reward type

	Mean	Sd	25th	75th
Money	0.0700	0.2839	0.0000	0.2600
Healthy	0.0426	0.2729	-0.1143	0.1556
Unhealthy	0.0429	0.2719	-0.1238	0.1556

Table 6. Significance tests of differences in present bias between reward types

Present bias difference	Means difference	Two-sided t-test p-value
Healthy - Money	-0.0263	0.0000
Unhealthy - Money	-0.0266	0.0000
Healthy - Unhealthy	-0.0008	0.8111

Table 7. Summary statistics of individual descriptive measures of preference for smoothness, by reward type

	Mean	Sd	25^{th}	75^{th}
Money	0.5626	0.1867	0.4020	0.7086
Healthy	0.5953	0.1924	0.4388	0.7524
Unhealthy	0.5950	0.1929	0.4391	0.7564

Table 8. Significance tests of differences in preference for smoothness between reward types

Preference for smooth difference	Means difference	Two-sided t-test p-value
Healthy - Money	0.0328	0.0001
Unhealthy - Money	0.0325	0.0001
Healthy - Unhealthy	0.0002	0.9418

Table 9. Paired t-tests for out-of-sample prediction performance.
$Predict\_m$: prediction performance using estimates for money to predict choices on healthy food or unhealthy food. $Predict\_h$: prediction performance using estimates for healthy food to predict choices on healthy food. $Predict\_u$: prediction performance using estimates for unhealthy food to predict choices on unhealthy food.

		Mean	Std. Err.	95% C.I.	$H_0: diff < 0$
1^{st} session	$Predict_m - Predict_h$	-1.847	0.139	[-2.118, -1.575]	0.0001
	$Predict_m - Predict_u$	-1.760	0.141	[-2.036, -1.484]	0.0001
2^{nd} session	$Predict_m - Predict_h$	-1.613	0.125	[-1.858, -1.367]	0.0001
	$Predict_m - Predict_u$	-1.407	0.126	[-1.656, -1.159]	0.0001

Table 10. Relationship between impatience and field behaviours.
In each regression, the measure of field behaviour is regressed on the descriptive measure of impatience (coefficient reported) and control variables (coefficients not reported).

	BMI	Smoking	Alcohol	Grades
$Impatience_{money}$	-2.9260*	-0.0056	0.1931*	-15.6889+
	(1.3319)	(0.0823)	(0.0961)	(8.3544)
$Impatience_{healthy}$	0.6965	-0.0032	0.1549+	-8.5180
	(1.2145)	(0.0798)	(0.0893)	(7.6845)
$Impatience_{unhealthy}$	-1.8314	0.0379	0.2624**	-14.5334+
	(1.2865)	(0.0806)	(0.0947)	(8.0058)
Controls: gender, wealth, hunger, fatigue, and trust in the experimenter				

Table 11. Relationship between present bias and field behaviours.
In each regression, the measure of field behaviour is regressed on the descriptive measure of present bias (coefficient reported) and control variables (coefficients not reported).

	BMI	Smoking	Alcohol	Grades
$Presentbias_{money}$	0.1324	0.0828+	0.1305+	-10.8028+
	(0.8719)	(0.0501)	(0.0712)	(5.9393)
$Presentbias_{healthy}$	-1.6885*	-0.0172	0.0407	-9.2827
	(0.8101)	(0.0551)	(0.0698)	(6.4625)
$Presentbias_{unhealthy}$	-0.4986	0.0228	-0.0063	-7.9320
	(1.0099)	(0.0554)	(0.0720)	(6.2758)
Controls: gender, wealth, hunger, fatigue, and trust in the experimenter				

Appendix 1

Instructions translated to English. In the experiment, instructions are in Mandarin.

A. Instructions in week one session

Opening instructions

Thank you for taking the time to participate in today's study with the School of Economics, The University of Sydney. The School of Economics has a no deception policy when undertaking experimental studies. This session will run for around 60 minutes. As the session progresses you will be updated with instructions on what will be involved in the next part. Please let the supervisor know if you do not understand something along the way by raising your hand.

The choices you are making during the study are important because some of your payment will be based on them. There are no wrong choices in this experiment. We will ask you to state your preferences, and by responding truthfully, you make sure that you receive your preferred payment.

In this study you will be asked to choose between options that involve receiving different quantities of food or money in one week and in four weeks from today. One of your choices from either this week's decisions or next week's decisions will be paid out for real.

Food preference

Some of your choices will be for different quantities of food, and others will be for different amounts of money. We would like you to receive a food that you like which is why we ask you to choose your preferred food from the options that we offer. It is in your best interest to pick the food you like most, because this is the food that you will be making choices about in the experiment.

Task instructions

Suppose, you picked almonds as your preferred food. You will be deciding between different amounts of almonds received in one week and in four weeks from today. There are six options available one in each of the six rows. Which one do you prefer? The picture below is just an example and thus you cannot click the buttons now.

If this was the decision scenario selected to count towards your payment:

- if you pick the first row, you will get 40 almonds in one week and 30 almonds in four weeks from today.
- if you pick the last row, you will get 60 almonds in one week and 10 almonds in four weeks from today.

Similarly, for the other options. In the real task, you can let us know which option you want by clicking the corresponding row shown on your screen.

In the study you will make many choices like this. Your task is to choose which one of the six options you like most in each decision.

There are no wrong decisions. Everybody has different preferences, so pick the option you like most remembering that each choice may be the one that counts towards your payment.

Payment

At the end of next week's session, one of your choices from either this week's decisions or next week's decisions will be randomly selected by the computer and will determine your payment. You will receive your rewards based on the choice you made in that decision.

Payment example

Suppose that you are paid based on this decision and you chose the fourth row:

In one week, you would receive 42 Skittles; and in four weeks, you would receive 10 Skittles.

Task

You will now be given 42 choices to complete. Remember one of these choices may be paid out at the end of next week's session.

B. Instructions in week two session

Opening instructions

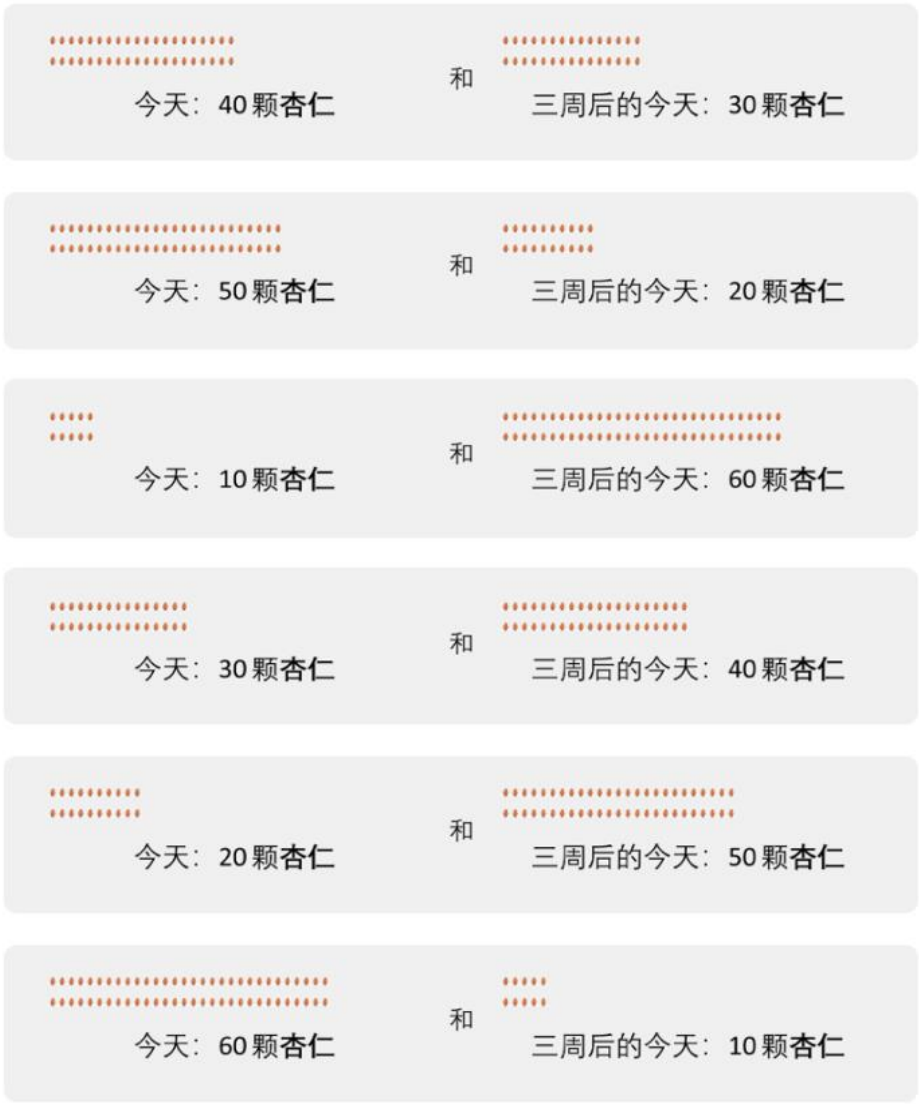
Thank you for taking the time to participate in today's study with the School of Economics, The University of Sydney. The School of Economics has a no deception policy when undertaking experimental studies. This session will run for around 60 minutes. As the session progresses you will be updated with instructions on what will be involved in the next part. Please let the supervisor know if you do not understand something along the way by raising your hand.

The choices you are making during the study are important because some of your payment will be based on them. There are no wrong choices in this experiment. We will ask you to state your preferences, and by responding truthfully, you make sure that you receive your preferred payment.

In this study you will be asked to choose between options that involve receiving different quantities of food or money today and in three weeks from today. One of your choices from either this week's decisions or last week's decisions will be paid out for real.

Task instructions

Suppose, you picked almonds as your preferred food. You are deciding between different amounts of almonds received today and in three weeks. There are six options available represented by six rows. Which one do you prefer? The picture below is just an example and thus you cannot click the buttons now.



If this was the decision that has been chosen to count towards your payment:

- If you pick the first row, you will get 40 almonds today and 30 almonds in three weeks from today.
- If you pick the last row, you will get 60 almonds today and 10 almonds in three weeks from today.

Similarly for the other options. In the real task, you can let us know which one you want by clicking the corresponding row on your screen.

In the study you will make many choices like this. Your task is to choose which one of the six options you like most in each decision.

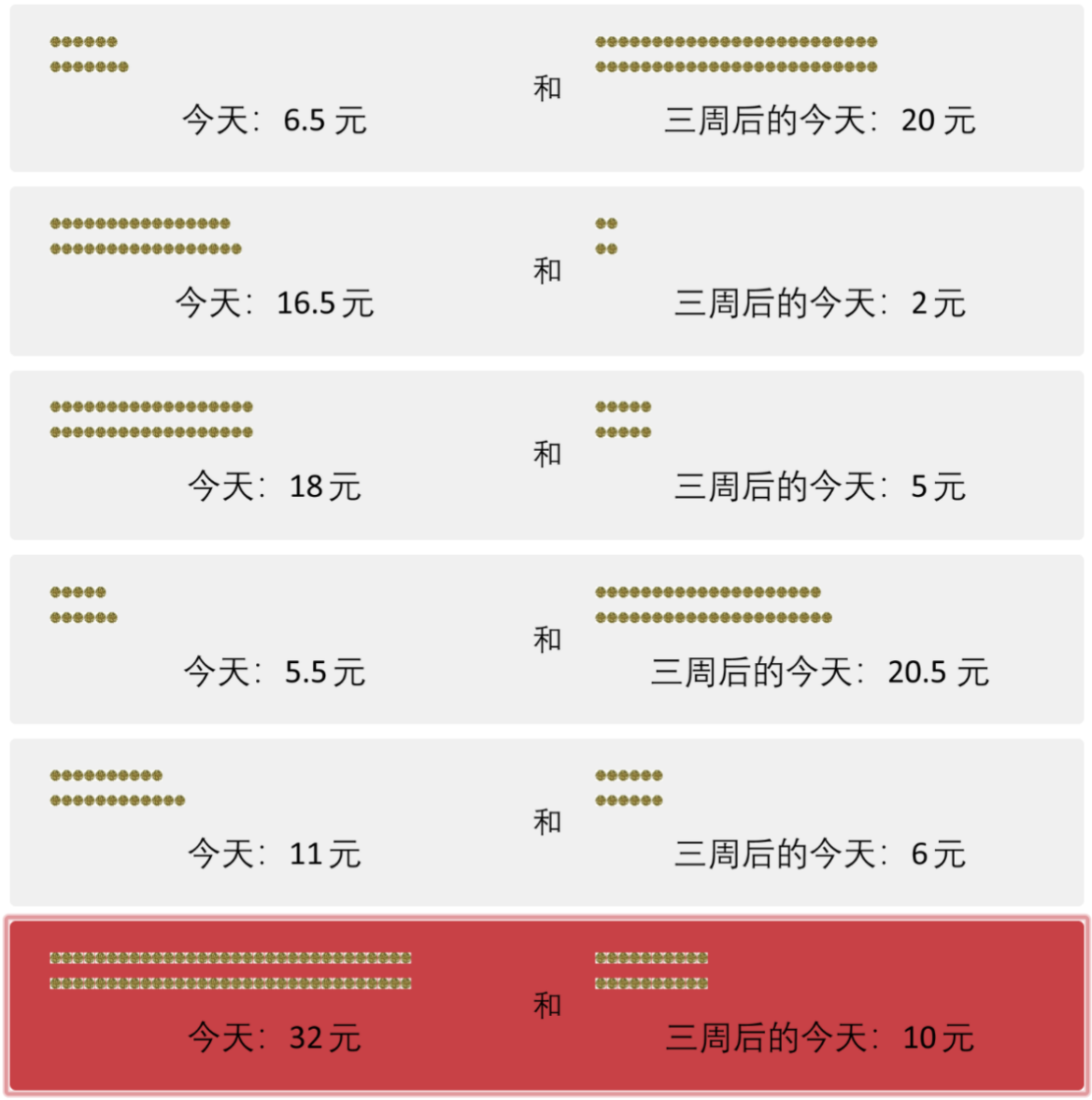
There are no wrong decisions. Everybody has different preferences, so pick the option you like most remembering that each choice may be the one that counts towards your payment.

Payment

At the end of this session, one of your choices from either this week's decisions or last week's decisions will be randomly selected by the computer and that will determine your payment. You will receive your rewards based on the choice you made in that decision.

Payment example

Suppose that you are paid based on this decision scenario and you chose the last row:



Today, you would receive 32 Chinese Yuan, and in three weeks, you would receive 10 Chinese Yuan.

Task

You will now be given 42 choices to complete. Remember one of these choices or one of your choices from last week's decisions will be paid out at the end of this session.

Appendix 2

Questionnaires translated to English. In the experiment, questionnaires are in Mandarin.

A. Questionnaire in week one session

Rate yourself on the following characteristics:

1) How hungry do you feel?

	1	2	3	4	5	6	7	
I am not hungry at all	⊙	⊙	⊙	⊙	⊙	⊙	⊙	I have never been more hungry

2) How full do you feel?

	1	2	3	4	5	6	7	
Not at all full	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Totally full

3) How much do you think you can eat now?

	1	2	3	4	5	6	7	
Nothing at all	⊙	⊙	⊙	⊙	⊙	⊙	⊙	A lot

4) Would you like to eat something **sweet** now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

5) Would you like to eat something **salty** now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

6) Would you like to eat something **savoury** now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

7) Would you like to eat something **fatty** now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

Please rate your selected M&M's(Skittles / Lays) on its characteristics:

1) Visual appeal:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

2) Smell:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

3) Taste, independent of any health considerations:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

4) Aftertaste:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

5) Healthiness, independent of any taste considerations:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

6) How much would you enjoy your selected food right now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

Please rate your selected pecans (raisins / almonds) on its characteristics:

1) Visual appeal:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

2) Smell:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

3) Taste, independent of any health considerations:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

4) Aftertaste:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

5) Healthiness, independent of any taste considerations:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

6) How much would you enjoy your selected food right now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

Please rate your happiness with the following situations:

1) I will be paid in cash:

1	2	3	4	5	6	7

Very happy	◎	◎	◎	◎	◎	◎	◎	Not happy at all

2) I will be paid in M&M's(/ Skittles / Lays):

	1	2	3	4	5	6	7	
Very happy	◎	◎	◎	◎	◎	◎	◎	Not happy at all

3) I will be paid in pecans (/raisins/almonds):

	1	2	3	4	5	6	7	
Very happy	◎	◎	◎	◎	◎	◎	◎	Not happy at all

About yourself:

1) I am a: boy girl
2) I was born on …… (day/month/year)
3) I am …….. years old
4) Which year are you in? ……
5) My height is …… (cm)
6) My weight is …… (kg)
7) How many siblings do you have? ……..
8) How many younger siblings do you have? ……..
9) Are you generally an impatient person, or someone who always shows great patience?

	1	2	3	4	5	6	7	
Very impatient	◎	◎	◎	◎	◎	◎	◎	Very patient

10) Do you agree with the following statement?

"I live for today and do not think about tomorrow."

	1	2	3	4	5	6	7	
Totally disagree	◎	◎	◎	◎	◎	◎	◎	Totally agree

11) How wealthy do you consider yourself?

	1	2	3	4	5	6	7	
Very poor	◎	◎	◎	◎	◎	◎	◎	Very wealthy

12) How much do you trust the experimenter would pay you exactly as showed in the experiment?

	1	2	3	4	5	6	7	
No, not at all	◎	◎	◎	◎	◎	◎	◎	Yes, very much

13) In the last 5 hours, what did you eat? Please specify the name and quantity of food that you have eaten (e.g. bacon and egg roll – one, apples – two, chips – 1 bag, apple juice – 1 cup).

Name of food	Quantity of food

B. Questionnaire in week two session

Rate yourself on the following characteristics:

1) How hungry do you feel?

	1	2	3	4	5	6	7	
I am not hungry at all	◎	◎	◎	◎	◎	◎	◎	I have never been more hungry

2) How full do you feel?

	1	2	3	4	5	6	7	
Not at all full	◎	◎	◎	◎	◎	◎	◎	Totally full

3) How much do you think you can eat now?

	1	2	3	4	5	6	7	
Nothing at all	◎	◎	◎	◎	◎	◎	◎	A lot

4) Would you like to eat something **sweet** now?

	1	2	3	4	5	6	7	
Yes, very much	◎	◎	◎	◎	◎	◎	◎	No, not at all

5) Would you like to eat something **salty** now?

	1	2	3	4	5	6	7	
Yes, very much	◎	◎	◎	◎	◎	◎	◎	No, not at all

6) Would you like to eat something **savoury** now?

	1	2	3	4	5	6	7	
Yes, very much	◎	◎	◎	◎	◎	◎	◎	No, not at all

7) Would you like to eat something **fatty** now?

	1	2	3	4	5	6	7	
Yes, very much	◎	◎	◎	◎	◎	◎	◎	No, not at all

Please rate your selected M&M's(Skittles / Lays) on its characteristics:

1) Visual appeal:

	1	2	3	4	5	6	7	
Good	◎	◎	◎	◎	◎	◎	◎	Bad

2) Smell:

	1	2	3	4	5	6	7	
Good	◎	◎	◎	◎	◎	◎	◎	Bad

3) Taste, independent of any health considerations:

	1	2	3	4	5	6	7	
Good	◎	◎	◎	◎	◎	◎	◎	Bad

4) Aftertaste:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

5) Healthiness, independent of any taste considerations:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

6) How much would you enjoy your selected food right now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

Please rate your selected pecans (raisins / almonds) on its characteristics:

1) Visual appeal:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

2) Smell:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

3) Taste, independent of any health considerations:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

4) Aftertaste:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

5) Healthiness, independent of any taste considerations:

	1	2	3	4	5	6	7	
Good	⊙	⊙	⊙	⊙	⊙	⊙	⊙	Bad

6) How much would you enjoy your selected food right now?

	1	2	3	4	5	6	7	
Yes, very much	⊙	⊙	⊙	⊙	⊙	⊙	⊙	No, not at all

Please rate your happiness with the following situations:

1) I will be paid in cash:

1	2	3	4	5	6	7

Very happy	◎	◎	◎	◎	◎	◎	◎	Not happy at all

2) I will be paid in M&M's(/ Skittles / Lays):

	1	2	3	4	5	6	7	
Very happy	◎	◎	◎	◎	◎	◎	◎	Not happy at all

3) I will be paid in pecans (/raisins/almonds):

	1	2	3	4	5	6	7	
Very happy	◎	◎	◎	◎	◎	◎	◎	Not happy at all

About yourself:

1) Do you agree with the following statement?

"I live for today and do not think about tomorrow."

	1	2	3	4	5	6	7	
Totally disagree	◎	◎	◎	◎	◎	◎	◎	Totally agree

2) Are you generally an impatient person, or someone who always shows great patience?

	1	2	3	4	5	6	7	
Very impatient	◎	◎	◎	◎	◎	◎	◎	Very patient

3) How wealthy do you consider yourself?

	1	2	3	4	5	6	7	
Very poor	◎	◎	◎	◎	◎	◎	◎	Very wealthy

4) How much do you trust the experimenter would pay you exactly as showed in the experiment?

	1	2	3	4	5	6	7	
No, not at all	◎	◎	◎	◎	◎	◎	◎	Yes, very much

5) In the last 5 hours, what did you eat? Please specify the name and quantity of food that you have eaten (e.g. bacon and egg roll – one, apples – two, chips – 1 bag, apple juice – 1 cup).

Name of food	Quantity of food

Appendix 3

Table A3.1 Structural estimation results using nonlinear least squares technique (standard errors in parentheses).

	α	β	δ
Money	0.5994 (0.0211)	0.8456 (0.0158)	1.0338 (0.0053)
Healthy	0.7072 (0.0258)	0.8852 (0.0183)	1.0350 (0.0061)
Unhealthy	0.7202 (0.0280)	0.8820 (0.0180)	1.0408 (0.0061)

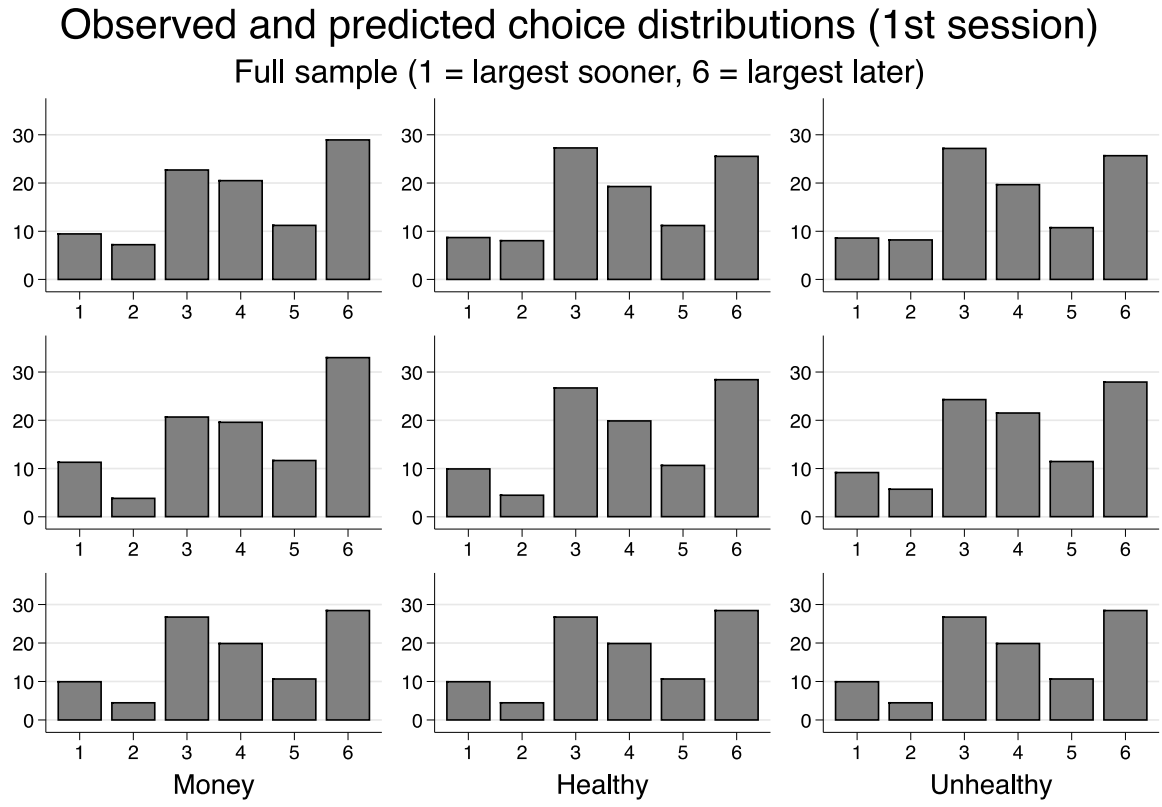
Figure A3.1

A. Sample choice screen in week one session

B. Sample choice screen in week two session

Figure A3.2.1 In-sample and out-of-sample prediction using structural time preference estimates for healthy food. The bars illustrate the proportion of choices of each type of bundle (1 has the largest sooner reward and 6 has the largest later reward among the six available alternatives). The first row shows the observed choice distributions in the sample. The second row shows the in-sample predicted choice distributions. The third row shows the out-of-sample predicted choice distributions. Across all three reward types, we can predict either the chosen bundle or an immediately adjacent one 74.28% (72.77%) for money (unhealthy food) in the first session and 75.99.07% (75.57%) for money (unhealthy food) in the second. Out-of-sample performance for money is not significantly different from that for unhealthy food in the first ($p = 0.314$) and second ($p = 0.767$) session.

A.



B.

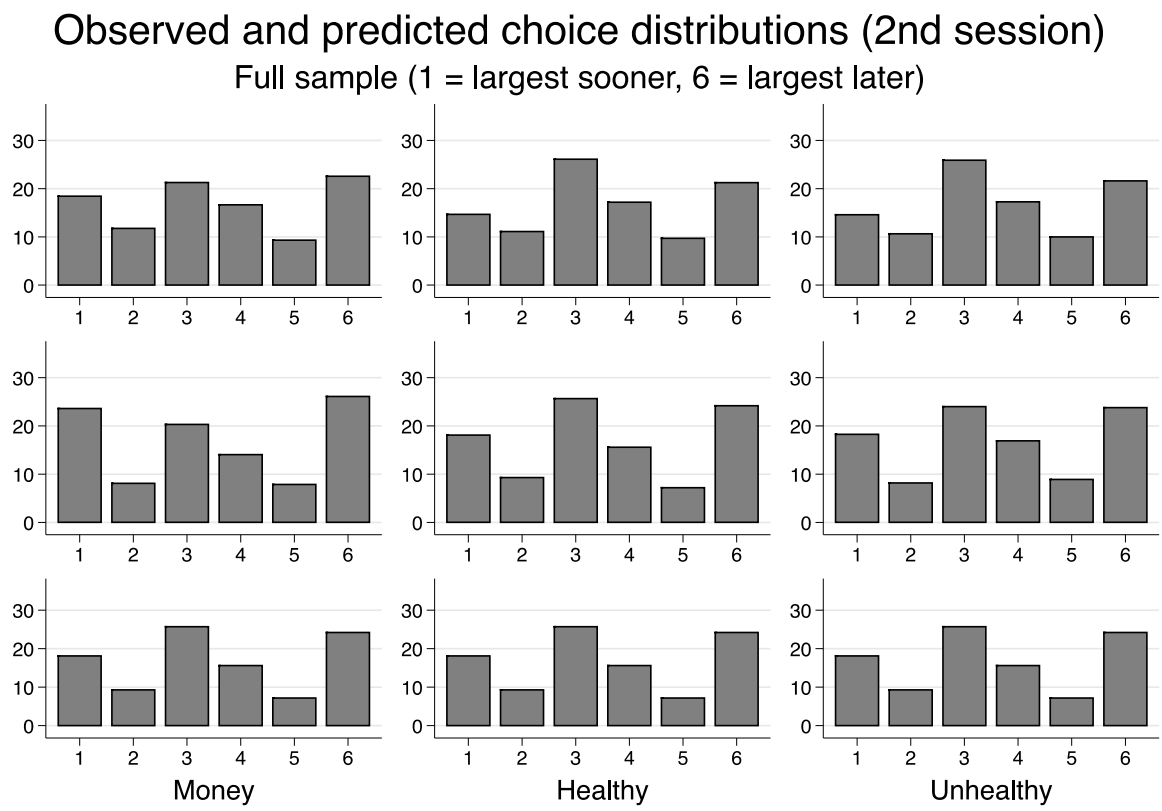
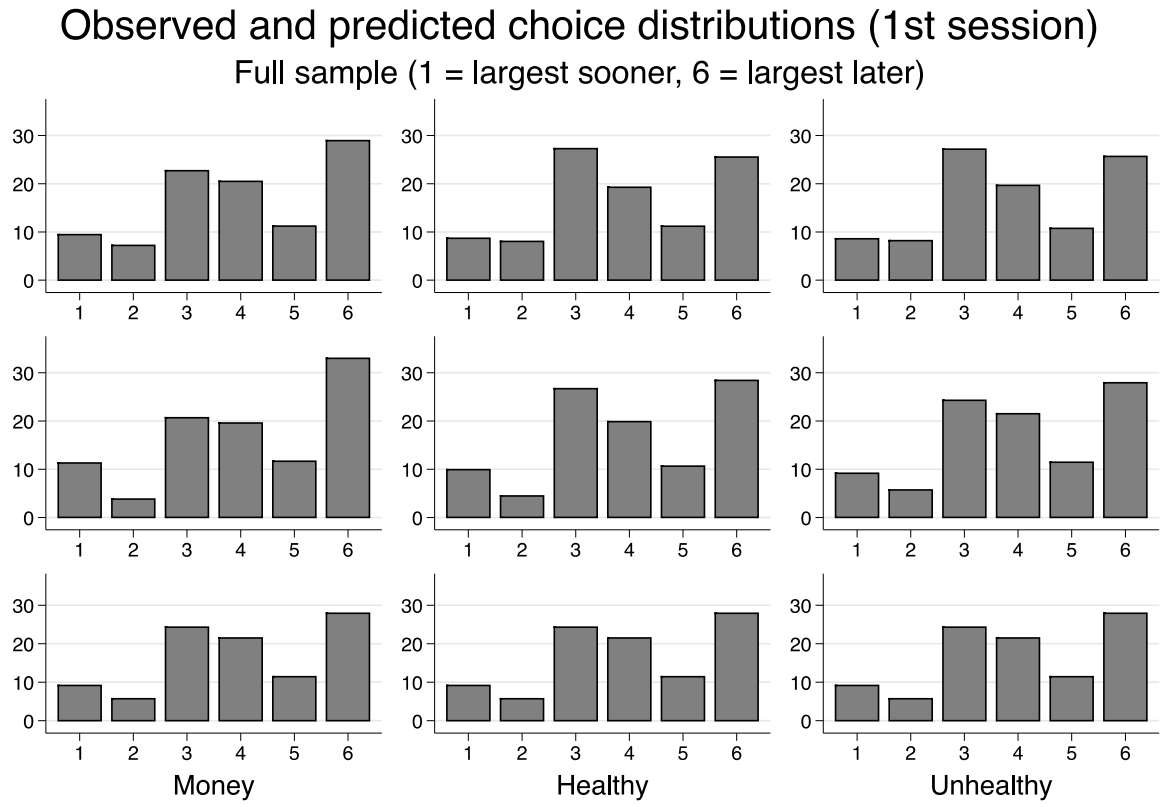
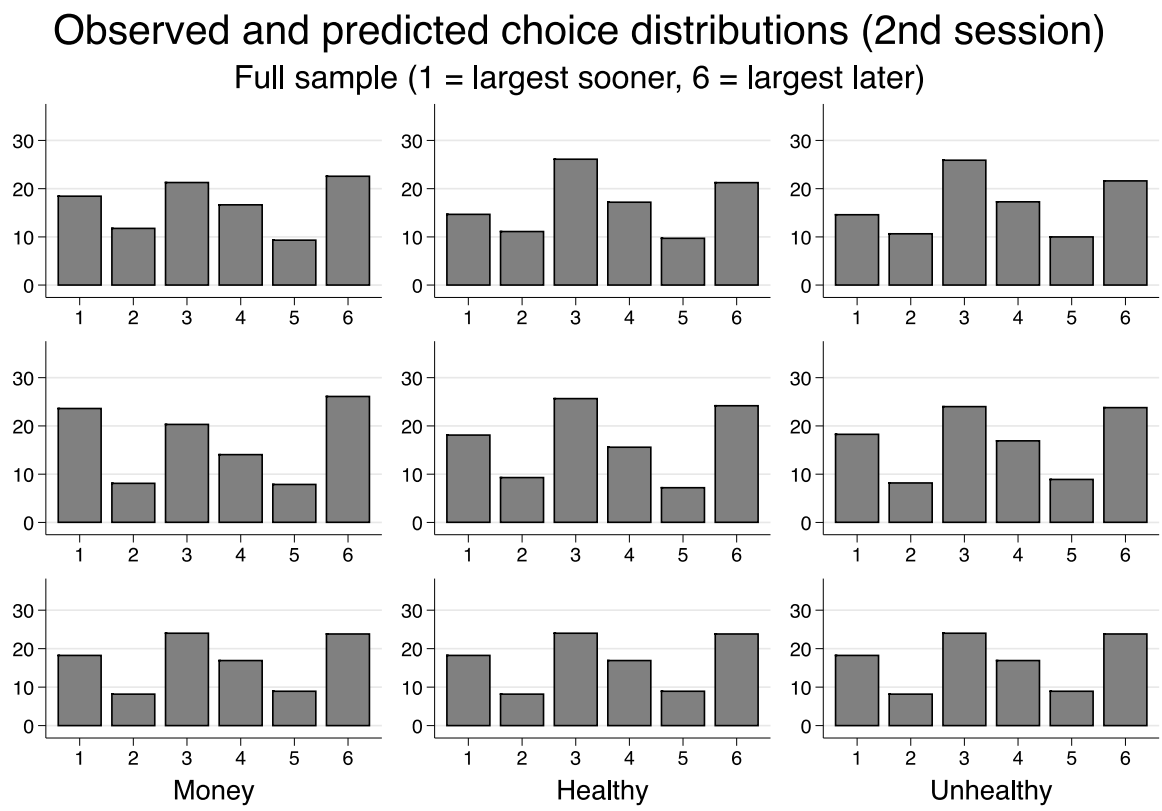

Observed and predicted choice distributions (2nd session)
Full sample (1 = largest sooner, 6 = largest later)
Money
Healthy
Unhealthy

Figure A3.2.2 In-sample and out-of-sample prediction using structural time preference estimates for unhealthy food. The bars illustrate the proportion of choices of each type of bundle (1 has the largest sooner reward and 6 has the largest later reward among the six available alternatives). The first row shows the observed choice distributions in the sample. The second row shows the in-sample predicted choice distributions. The third row shows the out-of-sample predicted choice distributions. Across all three reward types, we can predict either the chosen bundle or an immediately adjacent one 73.66% (69.74) for money (healthy food) in the first session and 75.36% (75.63%) for money (healthy food) in the second. Out-of-sample performance for money is significantly better than that for unhealthy food in the first session($p = 0.008$) but is not significantly different from that for unhealthy food in the second session ($p = 0.850$).

A.



B.


Observed and predicted choice distributions (2nd session)
Full sample (1 = largest sooner, 6 = largest later)
Money
Healthy
Unhealthy