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Scarcity and Predictability of Income over Time: Experimental Games as a Way to Study Consumption Smoothing

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ABSTRACT: Consumer research typically examines discrete financial decisions. These measures are uninformative about behavior over time, like *consumption smoothing*, the extent to which people spend consistently across periods of high and low income. We developed a multi-round game to study consumption smoothing and tested hypotheses about initial resource scarcity and the predictability of income. The game was played by museum visitors across a wide age range (6-80+, $N = 2104$), and by online participants ($N = 1294$) in a pre-registered partial replication. Participants spent their money in the game more smoothly over the multiple rounds when they had abundant rather than scarce initial resources, and this was particularly true when they received income on a predictable schedule. When income was unpredictable, initial scarcity did not hurt performance. We discuss implications for theorizing about the effects of scarcity.

KEYWORDS: consumption smoothing; scarcity; spending; consumption; gamification

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Scarcity and Predictability of Income over Time:
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Most adults receive income periodically (e.g., on a bi-monthly payday). They typically spend some of this income as soon as they receive it, and reserve the balance for spending on other days. The same challenge, writ large, applies as people decide what to spend in light of earning higher income in some years and lower or no income in other years. The technical term that describes this behavior is *consumption smoothing,* defined as the practice of balancing spending and saving to achieve a stable standard of living over time (Friedman 1957).

Many people struggle to balance spending and saving. For instance, in 2017, 40% of American adults could not cover a $400 emergency from savings, and 25% of non-retired American adults had no retirement savings (Board of Governors of the Federal Reserve System 2018). These statistics imply that consumption smoothing represents a fundamental overarching financial challenge, but it has been largely unexamined by consumer researchers.

Financial decision making research typically examines either one-shot save-versus-spend decisions (Cheema and Soman 2006; Sundie et al. 2011; Walsh 2014) or average spending over a period of time (Landis and Gladstone 2017; Tam and Dholakia 2014). Such research is uninformative about how people spread their spending and saving over time. Volatility in access to financial resources makes consumers vulnerable, regardless of their income, and "a multiperiod lens is needed to assess consumer financial vulnerability accurately" (Salisbury et al. n.d., 6). Even when multi-round measures have been employed in previous research (Amar et al. 2011; De La Rosa and Tully 2022; Spiller 2011), outcomes are typically modeled linearly, such that higher (or lower) levels of spending are interpreted as more desirable. Thus, existing consumer research says little about consumption smoothing, which entails spending a moderate and consistent amount, neither too much nor too little, in the context of fluctuating income.

To fill that gap, we drew on an approach developed by behavioral economists: a multi-round game in which participants (sometimes) receive income and decide in each round how much to spend. We found in a pre-study that performance in this game was related to variables of interest for consumer researchers. For instance, people with stronger material values earned lower scores. This suggests the game captures tendencies that also operate outside of a research study and may thus be an appropriate way to measure financial behavior over time. We developed a version that was shorter, easier to understand, and more visually engaging, and used

it in two studies to compare the consumption smoothing of participants who received different initial resources and different timing of income.

The primary contribution of this research is to show that the predictability of income receipt changes the effect of wealth on spending patterns. Specifically, we find that consumers who start with scarce resources consume less smoothly than those who start with abundant resources, and this is pronounced when income arrives on a predictable schedule. In fact, initial scarcity seems to stop consumers from reaping the benefits of predictable income. Our findings build on theoretical predictions about effects of scarcity (Cannon, Goldsmith and Roux 2019) and introduce predictability as a moderator worthy of further investigation.

These findings highlight the value of introducing experimental games into consumer behavior research, another key contribution of our work. We employed a game based on approaches used in economics research, but the duration and complexity of those measures limited their use to small samples of university lab participants. Our game not only replicates previous findings, but also makes it feasible to collect a large sample of respondents across a wide age range in a community setting, enabling researchers to study new questions about consumption smoothing and to engage more representative groups of participants.

Finally, this research contributes to theorizing about decisions to spend versus save. Studying consumption smoothing highlights that there are costs to both low and high spending; low spending with high savings may mean that people lose out on some of the happiness or utility they could have had. Measures that model these costs over time, like our game, should position researchers to better understand and advise on spending decisions.

Consumption Smoothing and its Measurement

In early work on consumption smoothing, economists argued that people prefer a consistent standard of living over time (Ando and Modigliani 1963; Fisher 1930; Friedman 1957). Thus, they are advised and expected to save little when young and perhaps even to take on debt, but to save a lot in midlife (Choi 2022).

Whether people actually behave in line with these predictions has been of great interest (Browning and Lusardi 1996; Choi 2022), and consumption games were developed as a way to feasibly test the theoretical models. These games extend for many rounds, with each round typically representing one year. Participants receive income in some rounds and not in others (or receive larger and smaller amounts of income across rounds). They score points by “spending” in

a round; points can be thought of as the utility or happiness that results from spending. Typically, scores increase as spending increases, but with diminishing returns, like in Figure 1. The total game score is the sum of the score in each round. Thus, the highest scores result when participants divide their total spending as evenly as possible over the rounds, rather than spending a lot in some rounds and little or nothing in others.

[Insert Figure 1 here]

Research provides mixed evidence as to whether deviations from smooth consumption are due more to under-saving (Ballinger, Palumbo and Wilcox 2003; Brown, Chua and Camerer 2009; Carbone 2005) or over-saving (Hey and Dardanoni 1988); some studies find a mix of both (Carbone and Hey 2004). Because the optimal level of consumption depends on future income receipt, which is uncertain, it is impossible to calculate optimal behavior while playing a consumption game (Sorkin 2019). Nevertheless, going beyond questions of whether people *do* smooth their consumption, these games can be used to compare smoothing under different conditions.

For instance, Feltovich and Ejebu (2014) used a 60-round game to see how consumption smoothing was affected by having information about others' performance. Showing a leaderboard with the top scorers in each round produced a roughly 8% drop in scores, because it led lower-ranked players to spend more than they should. This higher spending improved their scores in the short term (albeit at a lower rate of return) but left these players with less to spend in future rounds, so they earned lower scores overall. For instance, see Figure 1 and imagine that a player who would otherwise have spent 20 in one round and 20 in the next instead spent 40 in one round and 0 in the next. Feltovich and Ejebu's test followed from, and their results were consistent with, the well-established finding that when consumption is public, people often spend more than they should in order to conform to or surpass others (Clingingsmith and Sheremeta 2018; Frank 2005; Kurt, Inman and Argo 2011; Ordabayeva and Chandon 2011; Veblen 1899).

Even when results are consistent with existing theorizing, there are several advantages offered by the data from the game. First, they address the concern that single-shot decisions might have been different if observed over time—for example, people make different allocations in one-shot versus repeated dictator games (Engel 2011). Second, games avoid complications from individual differences in preferences (Koehler, Langstaff and Liu 2015). In the real world, some people are happy to spend $100 and others find it painful, which can make it difficult to

compare their financial decisions. In the game, spending produces a specified number of points, so spending a particular amount can be treated as similarly rewarding for all participants. Moreover, by separating spending decisions from information about what one is spending *on*, the game measures consumption smoothing without variance due to preferences for larger or smaller houses, longer or shorter commutes, and so on.

However, consumption games also have drawbacks. They are more time-consuming and expensive to run than typical studies in consumer behavior.[1] Participants must engage with a complex set of instructions; if they do not understand the task or scoring function, then their decisions are not very informative. These constraints mean that such games are typically administered under controlled conditions such as a university lab with a small and relatively homogenous group of participants. These elements may preclude their use to study effects of the size typically of interest to consumer behavior researchers (Peterson, Albaum and Beltramini 1985; Simmons 2014), or to engage with more representative groups of consumers.

What Affects Consumption Smoothing?

Setting aside the methodological challenges of employing consumption games, there are theoretical questions that such measures could illuminate. One such topic is whether scarcity hurts or helps consumption smoothing. From a pragmatic perspective, it seems likely to hurt. People with few financial resources may use everything to meet immediate needs, rather than saving for future consumption (Shefrin and Thaler 1988); if income is not forthcoming, this consumption will be hard to sustain. Additionally, any spending "mistake" is more costly for people with scarce resources, because they have less of a cushion to compensate, and deviations of a few dollars from time to time are proportionally larger for someone with scarce resources.

However, in addition to these practical challenges, there are psychological effects of scarcity that could potentially help consumption smoothing. Cannon and colleagues (2019) identified two divergent consequences of experiencing scarcity. The first is a scarcity-reduction effect: people who believe their financial situation can be changed prioritize acquiring or carefully consuming the scarce resource (Fernbach, Kan and Lynch Jr 2015; Hamilton et al. 2019; Shah, Mullainathan and Shafir 2012). If people are otherwise inclined to under-save, the

[1] For instance, Feltovich and Ejebu (2014) report that sessions typically lasted 90 minutes and participants earned an average of £17.06, equivalent to $29 in 2023. Brown, Chua and Camerer (2009) report that participants earned an average of $45, equivalent to $62 in 2023.

scarcity reduction effect might help consumption smoothing. The second is a control-restoration effect; people who believe their situation cannot be changed instead prioritize restoring their feelings of control, which leads to lower self-regulatory behavior (Chaplin, Hill and John 2014; Mani et al. 2013). If people are inclined to over-save, the control restoration effect might help consumption smoothing.

The theoretical argument about divergent psychological effects of scarcity suggests that scarcity's effects on consumption smoothing may depend on the predictability of future resources. People tie their spending to their receipt of income; accordingly, more frequent payments help to smooth consumption (Berniell 2018; Parsons and Van Wesep 2013; Shapiro 2005; Stephens Jr 2003). This occurs in part because frequent payments make it easier to predict that one can meet expenses (De La Rosa and Tully 2022). Of course, being able to predict something will happen is not the same as believing one can change it, and the latter belief is the key determinant of responses to scarcity in the Cannon et al. (2019) model. However, predictability can make events seem more controllable (Grillon et al. 2004; Nelson and Hajcak 2017). When things seem controllable, people believe they can invest resources to save; in uncontrollable situations, they do not, and turn instead to alternative goals (Griskevicius et al. 2013; Mittal and Griskevicius 2014). Taken together, this suggests that people with scarce resources and predictable income will focus on scarcity reduction and saving; people with scarce resources and unpredictable income will focus on control restoration and spending. Whether these effects are enough to compensate for the practical challenges of scarcity is an empirical question.

THE PRESENT RESEARCH

We now return to the challenges of measuring consumption smoothing. Our initial step was to see whether scores on a typical game measure are related to measures that consumer behavior researchers commonly employ. We administered the game used by Feltovich and Ejebu (2014) in a lab to 103 members of a university participant pool (see Online Appendix, section A), paying participants based on their scores. Game scores–and thus earnings–were correlated with self-reported subjective numeracy and (lower) material values. This suggests that behavior captured by a consumption game overlaps at least somewhat with measures that consumer behavior researchers have linked to real financial decisions. Moreover, game scores were uncorrelated with measures that capture general tendencies to spend versus save: the spendthrift-

tightwad scale (Rick, Cryder and Loewenstein 2008) and a Frugality scale (Lastovicka et al. 1999). Those null correlations imply the game does not favor a general strategy of high or low saving. Together these results suggest it is appropriate to use such games to learn about financial decisions over time.

Our second step was to find a way to use a consumption game with a larger and more representative group. We worked with a programmer to develop a short engaging game, adopting the basic approach and scoring function from previous research, but simplifying instructions, and adding visuals, sound effects, and gamified elements (e.g., participants designed and named their own emoji avatar). The resulting game could be played in roughly 10 minutes by participants as young as 8-10. We then deployed this game in a 6-week residence at a museum, randomly assigning a small (scarce) or large initial endowment and providing income in only some rounds, according to different timings (one predictable, two unpredictable).

This step introduced two new challenges to validity. First, our game had only 12 rounds, with each representing one month of a year, compared to the 60-80 rounds, each representing one year, used in typical behavioral economics games. Would the short game be sufficient to observe effects on consumption smoothing? And second, in the museum setting we were unable to pay participants based on their performance. Would they still engage sufficiently? To address these two questions, we incorporated a third manipulation, to see whether we could replicate Feltovich and Ejebu's (2014) finding that consumption smoothing was lower when participants saw a leaderboard of top performers. Replicating their effect in this setting would give useful evidence of the validity of the short game administered without pay.

STUDY 1: COMMUNITY SAMPLE AT A MUSEUM

Data and materials for all studies are available at https://osf.io/n69vp/?view_only=7680acd05e4c439f9a8c15d97ca49f7d.

Method

Participants. The research took place at the Science Museum in London, UK as part of the museum's Live Science research partnership. The study was approved by the authors' university research ethics committee [REC ref. 000775]. Participants were museum visitors; entrance is free. Data was collected 4 days a week for 6 weeks, and the sample size was the maximum number of participants who could be recruited and completed the game ($N = 2104$). Participants' self-reported ages ranged from 6 to 100 ($M_{Age} = 23$ years, $SD = 12.84$, $\text{Median}_{\text{Age}} = 21$ years). Of

the 1894 who reported their gender, there were 962 female (51%), 909 male (48%), and 23 other-gendered participants (1%), who reported being from the UK (74%) or other countries (27%).

Procedure. Participants gave their age, provided informed consent, and read or listened to the game instructions. They learned: "In this game you make decisions about money. Money is called gold in the game. The way that you use your gold affects how many points you earn in the game. You want to earn as many points as you can by the end of the game." To save time and for simplicity, the full gold-to-points function was not described, but participants were told:

> Imagine that the gold you spend is being used for things like having a place to live, food to eat, clothes to wear, and things to do during that month. If you don't spend any gold, you won't have any of those things, and life would be pretty hard. So, if you don't spend any gold, or spend very little, you will actually get negative points that month. When you spend more gold, you'll earn more points. But, the exact amount of points you get from spending your gold changes depending on how much you spend. For example, if you spend 0 gold in a month, you get -327 points. If you spend 10, you get -35 points. If you spend 20, you get 100 points. If you spend 30, you get 173 points.

These examples were illustrated visually in the game instructions, as seen in images on our OSF repository.

The full gold spent-to-points function, depicted in Figure 1, was borrowed from Feltovich and Ejebu (2014):

$$Score = k + \Theta \frac{[\alpha(\epsilon + c_t)]}{1 - \sigma}$$

As did the cited authors, we used k = 34, σ = 3, ϵ = 30, α = 0.01, Θ = 12.[2] We multiplied their formula by 10 and rounded to whole numbers to make scores easy to work with. Points were combined additively. For example, spending 20 pieces of gold in each of 12 rounds gives a total score of 1200 (12*100 points). Spending 40 pieces of gold in 6 rounds and 0 pieces in 6 rounds gives a score of -654 (6*218 points + 6*-327 points). Participants earned higher scores

[2] Feltovich and Ejebu (2014) write: "This is a minor variation of a constant relative risk aversion (CRRA) utility function with coefficient σ. The parameter ϵ represents a fixed, exogenous source of income, and is restricted to be positive in order for ut to be defined even when ct is zero. The parameters $\alpha > 0$, $\theta > 0$ and k represent an affine transformation on the utility function, and thus have no theoretical impact on decision making; we use these simply to scale the utility function for the experiment…"

the more they spent consistently across rounds and avoided rounds of low or no spending. There was no borrowing, so participants could only spend income received plus any saved from previous rounds. Savings earned no interest.

Participants designed and named an avatar to represent them in the game. In each round, they decided how many pieces of gold to spend by moving a slider bar with endpoints of 0 and their total available funds (see Figure 2). There was no information about what they were spending on, other than the general information previously provided in the instructions.

[Insert Figure 2 here]

Design. Based on previous projects at the museum, we expected to collect roughly 2000 responses and designed the study to have at least 500 observations for each level of each of three manipulations. We used a 2 (initial endowment: small, large) x 3 (income schedule: predictable, late, early) x 4 (information about others: none/individual, above-average group, average group, below-average group) quasi-randomized design.

Initial Endowment. Participants were randomly assigned to receive either 20 (small endowment) or 80 (large endowment) pieces of gold in the first round. Instructions stated that everyone started the game with between 20 and 80 pieces of gold. Upon receiving their endowment, participants were sent a message that reinforced their assignment to condition (e.g., for the small endowment, "That's not very much!"), such that the small endowment condition should produce a sense of scarcity (Cannon et al. 2019).

Income Schedule. Participants were randomly assigned to one of three different income schedules (predictable, late, early). In each round (or "month") participants either received 50 pieces of gold, or nothing. In the predictable income stream participants received income in alternating rounds (predictable income: E01010101010, where E is the initial endowment and rounds with income are denoted with 1). In the late income stream participants received most of their income in the late rounds of the game (late income: E00100110111). In the early income stream participants received most in the early rounds (early income: E11011001000). (Note that the late income stream provided six rounds of income; others provided only five.) Participants were not told their income schedule, so its predictability or unpredictability only became apparent during the course of the game.

Information about Others. Participants played either an individual or group version of the game. In the individual version, there was no information about other players' scores. In the

group version, participants saw a leaderboard (see Figure 2, section E) which compared their score to seven other players.

In the first two weeks of the study all participants played the individual version. Their scores were used to populate the group version. For the following two weeks all participants played the group version. In the final two weeks participants were randomly allocated to the group or individual version.

Although our primary objective with this manipulation was to replicate an effect of leaderboard versus no leaderboard, given the large sample size, we incorporated a further variation. Within the group version, participants were randomized into one of three types of groups, composed of above-average performers, average, and below-average performers. Details are in the Online Appendix, section B.

Outcome Measure. The manipulations of initial endowment and income schedule affect the number of points it is possible to earn. Therefore, we used as primary dependent variable the proportion of points a participant earned, out of the maximum possible they could have earned. The maximum possible scores were calculated with dynamic programming. We started from the final round (where the optimal decision is to spend all available gold) and worked backward, using the optimal choice in each round for every possible level of available gold to find the optimal choice in the prior round, until reaching the first round. Some participants earned negative scores, so before dividing to calculate the proportion, we added 3924, the largest negative value a participant could have earned (i.e., if spending 0 in every round), to both the numerator and denominator. It is worth noting that because optimal behavior depends on the schedule of income, it is impossible to compute while playing the game, so participants who earned their maximum possible score were lucky as well as skilled (Sorkin 2019). On average participants earned 85% of their maximum possible score (range 0 to 1, $M = .85$, $SD = .13$).

Post-game Questionnaires. After the game, participants were presented questions, starting with gender (male, female, other) and country of residence (UK, other). They were free to discontinue participation at any time (87% of sessions were fully complete). We then administered several measures to see how consumption smoothing as measured by the game relates to financial tendencies and outcomes outside of the study setting. Due to space constraints as well as inconsistent patterns of correlations in this and the subsequent study, we do not discuss these

questionnaire measures in more detail here. Some results are discussed in the Online Appendix, Section B. The full set of measures is available on our OSF repository.

Results

Measure Validation. To validate the game measure in this community sample and setting, we wanted to replicate findings from past research. Feltovich and Ejebu (2014) found lower scores with a leaderboard than without. To look for this effect, we compared results in our individual condition (where participants saw no leaderboard) to results in group conditions (where participants saw a leaderboard), controlling for main effects of the other manipulations. Just as in Feltovich and Ejebu's (2014) study with a longer version and more extensive instructions, our participants performed better if they had played the individual version (adjusted marginal M = .855) rather than one of the three group versions (adjusted marginal M = .841), $F(1, 2099) = 6.52$, $p = .01$, partial $\eta^2 = .003$. (Comparisons of the separate group conditions are in the Online Appendix, Section B.)

Theory Testing. We next tested the effects of scarcity and income predictability. We used an ANOVA with the main effects of endowment, income stream, and group condition, plus the interaction effect of endowment by income stream. There was a main effect of endowment, $F(1, 2095) = 14.19$, $p < .001$, partial $\eta^2 = .007$, a main effect of income stream, $F(2, 2095) = 5.88$, $p = .003$, partial $\eta^2 = .006$, and a interaction effect of endowment by income stream, $F(2, 2095) = 4.39$, $p = .013$, partial $\eta^2 = .004$. (The group condition results are reported in the prior section.)

Estimated marginal means are in Figure 3. The main effects are evident in this figure: participants with a small endowment did worse, on average, and participants with predictable income did better, on average. However, the effect of initial scarcity depended on income stream. Pairwise comparisons with Sidak adjustment indicated that participants with a small endowment performed worse than participants with a large endowment when they received early income, $p = .03$, or predictable income, $p < .001$, but not when they received late income, $p = .92$. Only participants with a large endowment benefitted from predictability, scoring higher in this condition than with early income, $p = .001$ or late income, $p = .02$. For participants with a small endowment, predictable income was equivalent to early income, $p = .55$ or late income, $p = .37$.

[Insert Figure 3 here]

Adding gender (as a factor: male, female, other), country (as a factor: UK, other) and age (as a covariate) slightly increased the effect sizes of endowment and income stream, and slightly

reduced the effect size of the interaction, but all effects remained statistically significant and the conclusions were unchanged (see Online Appendix, Table OA.B2).

Participants with a small endowment did not outperform participants with a large endowment, in any income stream. This suggests that any psychological effects of scarcity, whether focused on scarcity reduction or control restoration, did not compensate for the practical challenges of very limited initial resources.

In Table 1 we summarize our interpretation of the effects, following the reasoning outlined in the literature review. Note that in this table, we describe results for participants with small endowments and late income as "moderate," and those for participants with small endowments and early or predictable income as "low," reflecting that the middle gray bar in Figure 3 looks somewhat taller than the left and right bars, although they are not significantly different. If participants with small endowments did better with late than early income, what could explain this, given that incomes for both were unpredictable? In hindsight, "unpredictability" probably became apparent sooner under the late income stream. In the first seven rounds of the game, income in the early stream (E110110) was actually as predictable as income in the predictable stream (E010101). For this reason, perhaps the combination of initial scarcity and unpredictable early income did not clearly trigger either control restoration or scarcity reduction motives, or had heterogenous effects on participants.

[Insert Table 1 here]

Looking at the round-by-round results gives some insight into this question. Figure 4 shows average balances by condition, and highlights how participants in the early income stream initially built up even higher balances than those in the predictable income stream. Because the early income initially seemed predictable, these participants may have initially followed a scarcity reduction approach, but with little income receipt in the later rounds, results suffered. In our next experiment, we focus on comparing the late income stream—which highlights its unpredictability sooner—to predictable income.

[Insert Figure 4 here]

Figure 5 shows the average proportion of the available balance spent in each round. Participants had to spend at least 13 pieces of gold to earn a positive score, which was a higher proportion of available funds for participants with a small initial endowment. Participants with large endowments were initially able to spend a lower proportion of their funds, leaving more of a

cushion for future rounds. However, over time those with a large endowment increased their proportional spending, particularly in the predictable income stream, likely indicating their greater confidence about the availability of resources for future rounds.

[Insert Figure 5 here]

Discussion

Our short multi-round game was played by a large community sample. As observed in previous research with a longer game, a more controlled setting, and a more homogenous sample (Feltovich and Ejebu 2014), participants smoothed consumption more effectively when they were not privy to the scores of others. Replicating this effect suggests the game is a valid approach to studying financial behavior over time in this setting and sample.

Turning to effects of scarcity, a small initial endowment impaired consumption smoothing. This effect is consistent with, and extends, the research finding that scarce resources can hurt decision-making. However, previous research generally found that scarcity reduced performance in unrelated domains, such as an intelligence test (Mani et al. 2013), while boosting performance in the use of the scarce resource (Shah et al. 2012). Our research shows that even though people may try to be careful, they do not necessarily make the best use of their scarce resources over time.

However, the interaction effect of endowment by income stream adds nuance to the main effects. In addition to the observations discussed at the end of the Results section, it is worth noting that only those participants with abundant initial resources were able to benefit from predictable income. Income is becoming increasingly unpredictable due to rises in self-employment and zero-hours contracts (CIPD 2022). Effects of income patterns can be observed using a measure of consumption smoothing, whereas they cannot really be studied with the one-shot decisions used in most previous research. An optimistic interpretation of our findings would be to say that this unpredictability doesn't further impair consumption smoothing, beyond the clear practical challenges of an experience of scarce resources.

Our investigation in the museum sample was exploratory, and the analyses were not pre-registered. We therefore looked to replicate the results, particularly the interaction effect of endowment by income stream. As noted above, we focused on the late income stream, where the unpredictability becomes evident much sooner, and dropped the group conditions to reduce the

necessary sample size. Finally, we paid participants based on their scores, so that behavior in the game was connected to an objectively measured financial outcome.

STUDY 2: PRE-REGISTERED ONLINE REPLICATION

Method

Participants. The study was approved by the authors' university research ethics committee [REC ref. 150903]. We advertised it to 1300 respondents in the United Kingdom on Prolific.co for a payment of £1 plus a bonus up to £1.91, and received 1300 submissions. There were 1306 initiations of the game, of which 12 were excluded for failing an attention check, as pre-registered, leaving an analytic sample of 1294 consisting of 728 women, 559 men, and 7 other-gendered individuals, ages 18 to 79[3] (M = 42 years, SD = 13.75). Those who reported it (96.4%) gave their net annual household income as being less than £18,500 (14.8%), £18,501-£37,000 (35.4%), £37,001-£55,500 (23.6%), £55,501-£74,000 (13.4%), £74,001-£111,000 (7.4%), and more than £111,000 (1.8%). Bonus amounts, paid to participants with a final score greater than 0 at the rate of £.01 per 10 points, ranged from £.01 to £1.86 (M = £1.00, SD = 0.47).

Design. The pre-registration is at https://aspredicted.org/432_617. The study was powered to detect the main effects of endowment and income stream. In the museum study, the adjusted marginal mean outcome (proportion of possible score) was .837 and .858 (SDs = 0.132, 0.131) for the small and large endowment conditions, respectively. The sample size calculator at https://www.stat.ubc.ca/~rollin/stats/ssize/n2.html indicated that n = 621 per condition would give 80% power to detect this effect size. Based on this, we pre-registered a sample size of 1300. Participants were randomly assigned to one cell of a 2 (initial endowment: small, large) x 2 (income schedule: predictable, late) design.

Other than revising the instructions to match the simpler design (e.g., removing reference to seeing other players' scores) and to explain the payment structure, we administered the game as in study 1. Gender, age, country of residence, and net annual household income were measured prior to the game instructions. Questionnaires administered after the game are discussed in the Online Appendix, section C.

[3] One respondent who reported an age of 0 is not included in the calculation of average age.

Results

The proportion of maximum possible points earned was again our key outcome measure. The mean was slightly higher than in study 1, and scores were less variable, probably due to the motivating effects of pay for performance (range .31 to .99, M = .88, SD = .08). There was no difference in score across the six buckets of household income we recorded, $F(6, 1287) = 1.08$, $p = .37$.

We used ANOVA to test the main effects of endowment and income stream, as well as their interaction, on scores. There was a main effect of endowment, $F(1, 1290) = 33.76$, $p < .001$, partial $\eta^2 = .026$, a main effect of income stream, $F(1, 1290) = 22.51$, $p < .001$, partial $\eta^2 = .017$, and a interaction effect of endowment x income stream, $F(1, 1290) = 9.17$, $p = .003$, partial $\eta^2 = .007$.

Estimated marginal means are shown in Figure 6. The main effects are evident in this figure: participants with a small endowment did worse, on average, and participants with predictable income did better, on average. The interaction effect shows how the effect of initial scarcity depended on income stream, with the same pattern as in the museum sample. Pairwise comparisons with Sidak adjustment for multiple comparisons indicated that participants with a small endowment performed worse than participants with a large endowment when they received late income, $p = .046$, but this difference was much larger when they received predictable income, $p < .001$. Participants with a large endowment did much better with predictable income, $p < .001$, but participants with a small endowment did not benefit from predictable income, $p = .23$.

[Insert Figure 6 here]

GENERAL DISCUSSION

We used a multi-round game to study the smoothing of consumption over time. Measures of one-shot decisions or average consumption over time say little about how people balance their spending and saving over periods of higher and lower income. Multi-round games allow consumer researchers to study a wider range of issues of both theoretical and practical importance. With a short and engaging game, in a community sample, we replicated research which found lower scores in "group" conditions when participants had information about others' performance (Feltovich and Ejebu 2014). Long games with pay for performance limit the settings and samples researchers can access; our results suggest consumer researchers need not

limit themselves to those settings and samples in order to reap the benefits of multi-round measures.

Examining behavior and outcomes over time, we are able to contribute to the understanding of effects of scarcity. Much of the research on financial scarcity focuses on non-financial outcomes, and little is known about how scarcity affects consumption smoothing. (Smoothing requires spending neither too much nor too little, so it is different from merely saving.) Recent theorizing proposes that people can respond to scarcity by focusing on acquiring or carefully consuming the scarce resource (e.g., saving, spending carefully), or by restoring feelings of control (e.g., spending, acquiring status). We thought that scarcity reduction might prevail when income was predictable, and control restoration when income was unpredictable, but it was unclear whether one or both of these effects would compensate for the practical challenges inherent with scarce resources. Our results suggest they did not.

It is worth revisiting our predictions, which were couched in a consideration of whether the population we sampled was inclined to over-save or under-save. (We speculated that the effects of scarcity might hurt in the former case and help in the latter.) Shefrin and Thaler (1988), reviewing econometric studies, noted that in practice most consumption smoothing is achieved through state-provided pensions or housing wealth. In other words, if all saving was voluntary, most people would fail to save enough to achieve a post-retirement income that was anything like their income pre-retirement (Shefrin & Thaler, 1988). Saving too little during working years is, of course, indicative of under-saving. The opposite problem, over-saving ("hyperopia" or excessive delay of gratification) is also problematic and characterizes some consumers (Kivetz & Simonson, 2002). For example, there are people who save too much money for retirement, potentially limiting the enjoyment they could have gained by spending more during their working years (Skinner, 2007). The generalizability of our results is likely to depend on similar average tendencies toward saving.

Ripe for use as a measure of change induced by manipulations? Or as a tool for learning?

Limitations and Future Directions

The gamified measure allowed us to recruit a large community sample in study 1, which represents a wide age range, including many groups of people (e.g., teenagers, older adults, less-educated adults) who are under-sampled in typical research. It is likely that these participants—

Commented [HK1]: Refer to Ballinger et al research on the game. "Allen and Carroll (2000) show that such social learning opportunities can decrease the time needed to acquire near-optimal consumption policies by more than an order of magnitude, relative to learning based solely on personal experience."
Re smoothing - Brown, Chua, Camerer (2009) find that people learn to spend optimally within four repeated life-cycles

museum visitors—were particularly interested in science and research, but the replication in study 2 suggests the findings do not rely on that interest.

The game we used necessarily simplifies decisions about spending by giving no information about prices or what one is spending on. Such information would certainly add noise to spending decisions, and given the small effects we observed, larger samples may be necessary. It is also worth noting that our results may depend in part on elements of our methodology. To give an example, our spending-to-points function implies that spending brings decreasing utility at a specific rate. Some participants might perform better with a different function. To give another example, we examined only 12 rounds (to keep the game to an engaging length). It is possible that the detrimental effects of scarcity are reduced or reversed under a longer time horizon. It is also worth noting that our measures can make it difficult to tell why participants earned higher or lower scores, although the round-by-round analyses (Figures 4 and 5) are suggestive.

However, researchers need not use our exact game to reap the benefits of studying decisions over time. The Online Appendix (section B) provides more information about how our game was built, in collaboration with a team of designers, programmers, and developers. This requires more money and time than typical online survey, but is becoming ever more accessible with advances in technology. Alternatively, researchers wishing to measure behavior over time without the gamified elements could adapt the z-tree script we used in our pre-study (Online Appendix, section A), available on our OSF page.

In sum, we suggest that multi-round games would allow consumer researchers to move beyond the traditional focus on discrete individual financial decisions like whether to save or spend, how much of a windfall to save, or which product to purchase. Examining patterns of behavior that unfold over time, such as consumption smoothing, can provide new insights into how to help people cope with real-world financial challenges like scarce resources, unpredictable income, or pressure to keep up with high-performing others.

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Figure Captions

Figure 1. Measures of consumption smoothing have in common that scores increase as a function of the amount spent in a round, but with diminishing returns, such that the highest total score comes from spending a similar and moderate amount in each round. The numbers in this figure are specific to our studies 1 and 2, where spending was in "pieces of gold" and each round represented one month.

Figure 2. Main screen of the spending game. (A) Participants earned points for each spending decision which were displayed along with an "emoji" avatar that participants had designed and named. (B) An initial message revealed a randomly assigned small or large endowment and subsequent messages stated that more gold had or had not been received according to the randomly assigned income stream. Other messages named the month, pointed out that the season was changing (to maintain engagement), and reminded participants in the final round to spend all their remaining gold. (C) Participants decided in each round or "month" how many pieces of gold to spend using a slider bar. (D) They also saw their running total of points. (E) If randomly assigned to one of the three group conditions, participants saw on a leaderboard how they compared to seven other players. In the individual (no group) condition, this section was blank.

Figure 3. Study 1: The effect of initial endowment depended on income stream. The effect of initial scarcity was pronounced with predictable income, and not evident with unpredictable income delivered mainly in the later rounds of the game. This figure shows estimated marginal mean scores, from an ANOVA with group condition as an additional factor. Error bars are one standard error of the mean. Asterisks indicate significant differences (* $p < .05$, ** $p < .01$).

Figure 4. Study 1: Average balance at the start of each round.

Figure 5. Study 1: Average proportion of available balance spent. Note that participants with a zero balance are given a proportion of 1.0 for that round.

Figure 6. Study 2: Only participants who started with a large endowment benefitted from having income delivered on a predictable schedule. This figure shows estimated marginal mean scores. Error bars are one standard error of the mean. Asterisks indicate significant differences between conditions (* $p < .05$, ** $p < .01$).