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Abstract

We investigate to what extent high-income consumers are less hyperbolic than low-income consumers using a sample of 216 bank customers and 796 undergraduates. We assess whether participants who scored lower on a test of cognitive ability were also those who tended to discount the future hyperbolically. Our problem is then to find whether lower cognitive ability translates into hyperbolic discounting. The students had higher implicit discount rates, i.e. they were more hyperbolic, for both low stakes and high stakes when long delays were involved, a result in line with the literature. The undergraduates tended to be hyperbolic regardless of stake size, whereas the bank customers tended to be hyperbolic only when high stakes were involved. This makes sense, as high-income consumers should be less sensitive to low stakes. The bank clients showed superior cognitive ability and this may explain why their System 2 could be more capable of overriding cognitive biases, such as the present bias.

JEL Classification: D03, D9

Keywords: hyperbolic discounting, cognitive ability, high-income consumers, behavioral economics

1. Introduction

In a previous study that discriminated between high-income bank customers and university students, we found indebtedness to be associated with poor cognitive ability and lack of self-control for the students, but not for the high-income clients, for whom debt was related to leverage [1]. This is a follow-up study where we gather survey evidence on the relationship between cognitive reflection and intertemporal discounting. We assemble an enlarged sample of the original high-income customers (which now totals 216 individuals) to compare with a fresh sample made up of 796 undergraduates. We aim to investigate to what extent the high-income consumers are less hyperbolic than the low-income students.

Intertemporal choice shows a tradeoff between utility across different time periods, which is captured by a subjective discount rate, or the rate by which people discount future utility as a function of the date a choice occurs. In "discounted utility theory" [2] [3], people discount all future utilities at a constant rate, which means preferences are stable over time. The simplest functional form of a discount function that declines at a constant rate is the exponential function. Yet the exponential function cannot accommodate an "instant gratification effect" because it does not decline more heavily in the short run. However, a hyperbolic function can capture the fact that today's preferences differ from tomorrow's. People may employ a higher rate when discounting in the short run [4]. Though this presents an empirical challenge to discounted utility theory [5], Laibson [6] shows how people can escape hyperbolic discounting by committing their earnings before they actually received them, such as in a retirement plan. A farsighted planner could mitigate the effects of myopic behavior in future periods. Laibson's farsighted planners implicitly imply superior cognitive ability for those escaping hyperbolic discounting. For this reason, here we directly measure the cognitive ability of our study's participants while assessing their attitudes toward intertemporal choice, as in Frederick [7] and Dohmen et al. [8].

The cognitive reflection test (CRT) is a simple test that gauges how individuals differ in cognitive ability [7] in terms of the relative powers of their Systems 1 and 2. "System 1" refers to a large set of subsystems that operate autonomously in response to their own triggering stimuli and are not under control of the analytic processing system, which is called "System 2." Individuals scoring higher on the CRT show enhanced ability for using their System 2 to override System 1. The CRT is claimed to successfully predict intertemporal choice [7].

There is a large volume of literature linking analytic processing to inhibitory control [9]-[16]. This means an individual's ability to use his or her System 2 to override System 1 can be associated with his or her self-control [17]-[19]. System 2 is in charge of self-control, and self-control problems are sometimes related to time inconsistent preferences [20] [21].

Here, we assess whether participants who scored lower on the CRT were also those who tended to discount the future hyperbolically. Our problem is then to find whether lower cognitive ability translates into hyperbolic discounting in our sample.

The rest of this paper is organized as follows. The next section presents the materials and methods used. Section 3 displays the results found. Section 4 discusses the results and Section 5 concludes this study.

2. Materials and methods

The cognitive reflection test is made up of three simple questions [7]. They are conceived to elicit automatic responses that are compelling but wrong. They are as follows.

CRT

1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?
   _____ cents

2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?
   _____ minutes

3. In a lake, there is a patch of lilypads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take the patch to cover half the lake?
   _____ days

The correct answers are 5, 5, and 47 respectively, but the intuitive (wrong) answers are, respectively, 10, 100, and 24. We requested the participants to respond to the three questions above in less than 30 seconds. This was done to make sure an automatic choice was given. We also asked whether he or she already knew one or all of the three questions. If someone reported to know at least one of the questions, then we asked him or her to answer to an alternative CRT [22] as follows.

CRT (alternative questions)

4. If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together?
   _____ days.
   [Correct answer: 4; intuitive answer: 9]

5. Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class?
   _____ students.
   [Correct answer: 29; intuitive answer: 30]

6. A man buys a pig for $60, sells it for $70, buys it back for $80 and sells it finally for $90. How much has he made?
   _____ dollars.
   [Correct answer: 20; intuitive answer: 10]

To gauge hyperbolic discounting we adapted a questionnaire from Sutter et al. [23]. Participants chose between two sure payoffs at two distinct points in time. One was an early payoff and the other was a larger, later payoff. In total, we presented the participants eight choice lists each containing 10 questions, where the early payoff remained the same and the later payoff was increased monotonically along a list (Figure 1).

The lists differed by the stake size of the early payoff (either R$100 or 250 Brazilian Real) and by the timing of the early and late payoffs. For example, Choice List 1 presented a choice between receiving a payoff today (upfront-delay of zero) and receiving a larger payoff in three weeks (delay of three weeks). Choice List 2 maintained the delay of three weeks, but shifted it into the future (upfront-delay of three weeks). List 3 required choices between a payoff today and a payoff in one year, and List 4 shifted the latter list into the future by having an upfront-delay of three weeks again. Figure 2 shows the four arrangements of these examples.

Choice list 1
[1] receive R$100,00 now ○ or ○ receive R$100,00 in 3 weeks
[2] receive R$100,00 now ○ or ○ receive R$105,00 in 3 weeks
[3] receive R$100,00 now ○ or ○ receive R$110,00 in 3 weeks
.....
[10] receive R$100,00 now ○ or ○ receive R$145,00 in 3 weeks

Choice list 2
[11] receive R$100,00 in 3 weeks ○ or ○ receive R$100,00 in 6 weeks
[12] receive R$100,00 in 3 weeks ○ or ○ receive R$105,00 in 6 weeks
[13] receive R$100,00 in 3 weeks ○ or ○ receive R$110,00 in 6 weeks
.....
[20] receive R$100,00 in 3 weeks ○ or ○ receive R$145,00 in 6 weeks

Choice list 3
[21] receive R$100,00 now ○ or ○ receive R$100,00 in 1 year
[22] receive R$100,00 now ○ or ○ receive R$105,00 in 1 year
[23] receive R$100,00 now ○ or ○ receive R$110,00 in 1 year
.....
[30] receive R$100,00 now ○ or ○ receive R$145,00 in 1 year

Choice list 4
[31] receive R$100,00 in 3 weeks ○ or ○ receive R$100,00 in 1 year and 3 weeks
[32] receive R$100,00 in 3 weeks ○ or ○ receive R$105,00 in 1 year and 3 weeks
[33] receive R$100,00 in 3 weeks ○ or ○ receive R$110,00 in 1 year and 3 weeks
.....
[40] receive R$100,00 in 3 weeks ○ or ○ receive R$145,00 in 1 year and 3 weeks

Choice list 5
[41] receive R$250,00 now ○ or ○ receive R$250,00 in 3 weeks
[42] receive R$250,00 now ○ or ○ receive R$275,00 in 3 weeks
[43] receive R$250,00 now ○ or ○ receive R$300,00 in 3 weeks
.....
[50] receive R$250,00 now ○ or ○ receive R$475,00 in 3 weeks

Choice list 6
[51] receive R$250,00 in 3 weeks ○ or ○ receive R$250,00 in 6 weeks
[52] receive R$250,00 in 3 weeks ○ or ○ receive R$275,00 in 6 weeks
[53] receive R$250,00 in 3 weeks ○ or ○ receive R$300,00 in 6 weeks
.....
[60] receive R$250,00 in 3 weeks ○ or ○ receive R$475,00 in 6 weeks

Choice list 7
[61] receive R$250,00 now ○ or ○ receive R$250,00 in 1 year
[62] receive R$250,00 now ○ or ○ receive R$275,00 in 1 year
[63] receive R$250,00 now ○ or ○ receive R$300,00 in 1 year
.....
[70] receive R$250,00 now ○ or ○ receive R$475,00 in 1 year

Choice list 8
[71] receive R$250,00 in 3 weeks ○ or ○ receive R$250,00 in 1 year and 3 weeks
[72] receive R$250,00 in 3 weeks ○ or ○ receive R$275,00 in 1 year and 3 weeks
[73] receive R$250,00 in 3 weeks ○ or ○ receive R$300,00 in 1 year and 3 weeks
.....
[80] receive R$250,00 in 3 weeks ○ or ○ receive R$475,00 in 1 year and 3 weeks

Figure 1. Gauging hyperbolic discounting using choice lists
Adapted from Sutter et al. [23]

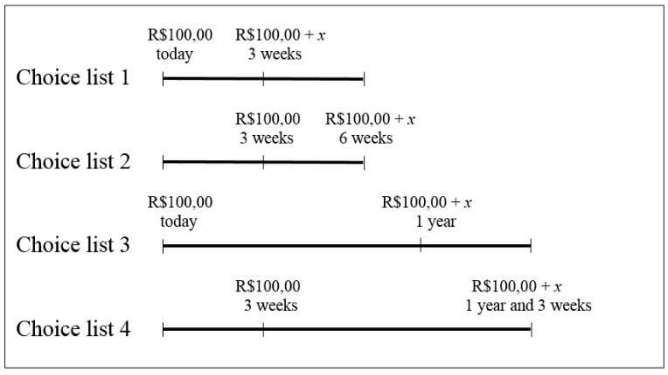

Figure 2. Combinations of early and late payoff (four choice lists for sure payoff R$100,00)
Adapted from Sutter et al. [23]

From the eight choice lists, we calculated the “future equivalent" of the (fixed) early payoff as the midpoint between the two later payoffs, where a participant switched from the earlier to the later payoff. Figure 3 illustrates the computation of the future equivalent for Choice List 1. The participant chose the payoff today twice (left-side option) and then switched to the right-side option. This means her future equivalent was R$107,50, that is, $(\text{R\$}105{,}00 + \text{R\$}110{,}00)/2$. The larger the future equivalent, the stronger the delay aversion. In other words, a larger future equivalent indicates stronger impatience.

Of note, Choice Lists 1 and 2 measure the attitude toward an identical delay (of three weeks) with an upfront-delay of zero and three weeks, respectively. Similarly, in Choice Lists 3 and 4 the delay is one year and the upfront-dalay is zero and three weeks respectively. Comparing the future equivalents between such lists allows us to learn whether discounting is constant or not [6] [24] [25]. If future equivalents are higher for Choice List 1 than for List 2 and for List 3 than for List 4, the early payoff receives more weight than the payoff in three weeks, and this provides evidence of hyperbolic discounting. Considering these four timing

combinations for both high and low stakes (as in Figure 1) allows us to control for stake size effects [23].

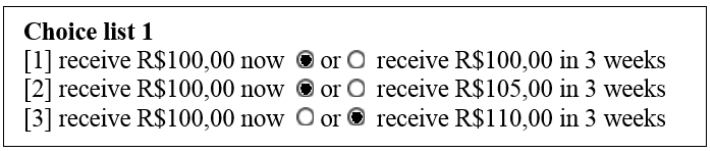

Figure 3. Example of calculation of the future equivalent for choice list 1
Adapted from Sutter et al. [23]

Participants from both sexes filled out the eight choice lists in Figure 1 in a random order and answered to the CRT. All participants were asked whether their age was below 25, or 25 or more. This is claimed to be a useful sorting of age groups from a neural perspective [26]. We intentionally assembled a non-probabilistic sample of two distinct groups according to income. The first was made up of 216 high-income bank customers from a large Brazilian bank branch located at Florianopolis, Brazil. High-income customers in Brazil usually bank at separate branches that are designated to those who individually earn R$10000 a month or more. We ended up with a sample of 147 high-income individuals (93 males and 54 females; 96 percent were 25 or older). From the original bank customers we approached, 69 either failed to answer the CRT in less than 30 seconds or made detectably sloppy choices in the intertemporal choice questionnaire. The second sample was made up of 796 undergraduates from the southern Brazilian cities of Florianopolis, Chapeco, Ibirama, Blumenau, Tubarao and Capivari De Baixo. As 334 answers to the intertemporal questionnaire were incomplete or the CRT was not answered in less than 30 seconds, in the end, the subsample of undergraduates was reduced to 462 participants (187 males and 275 females; 67.7 percent were below age 25). The students also reported their income, whether below R$1000 (35.3 percent); between R$1000 and R$10000 (64.3 percent); or above R$10000 (0.4 percent).

We capitalized on the advantages of applying the CRT and the intertemporal choice questionnaire online [27], and these were sent to the participants using the Eval&Go platform (http://www.evalandgo.com/) through e-mail, WhatsApp, Facebook or LinkedIn. Eval&Go allowed us to insert a chronometer to guarantee a CRT question flipped its screen after 30 seconds. For the first subsample of bank customers, we took advantage of the fact that author AC is also a manager at the branch where the experiment took place. Experimenter AC then collected the data from 4 April 2016 to 29 April 2016. As for the second subsample, experimenter DDF collected the data from 13 September 2016 to 31 October 2016. A higher rate of desistance from the part of the students (above 50 percent) casually suggests a higher impatience rate for this group. The final subsample was then likely to produce conservative results. Indeed, an adverse selection occurred during the sampling due to the desistance of the most impatient undergrads. However, the bank customers were likely to be more cooperative due to the very fact that their manager was asking them to participate in the experiment. The experiment was registered at Plataforma Brasil under No. 64758617.2.0000.0121, a Brazilian government organization that assesses the ethical proceedings of experiments with human beings. The dataset is available at Figshare (https://doi.org/10.6084/m9.figshare.4983392.v2).

3. Results

Most participants responded to the CRT in the first format shown earlier. Only 13 bank customers and 22 undergrads took the alternative CRT. The bank customers outperformed the students (Figure 4). Though both groups were similar in correctly answering to the three questions, the bank clients beat the students while answering one to two questions correctly. Moreover, more students than clients failed to correctly answer all three questions. The difference between the two groups was significant (p-value < 0.05, nonparametric Mann-Whitney U test $= 29673.00, Z = -2.883$). Thus, the students showed relatively poorer cognitive ability than the bank customers.

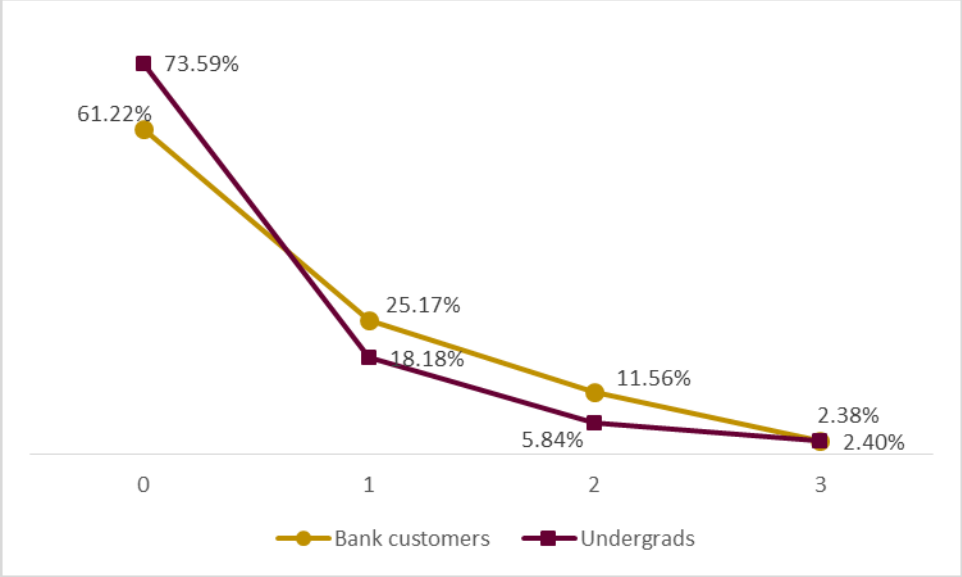

Figure 4. CRT scores: the high-income consumers beat the students

It is well established that males score higher than females do on the CRT [7] [27]. Our sample replicated this finding for both bank clients (Table 1) and undergrads (Table 2).

Table 1. Bank clients' CRT scores, by sex

	Percentage scoring 0, 1, 2 or 3			
Sex	0	1	2	3
Male_{93}	53.77_{50}	30.11_{28}	12.90_{12}	3.22_{3}
Female_{54}	74.07_{40}	16.67_{9}	9.26_{5}	0.00_{0}

Notes:
1) subscripts show the number of respondents
2) $\chi^2(3) = 6.997$, p-value $= 0.072$; Fisher's exact p-value $= 0.076$
3) Spearman's correlation $\rho = -0.19$, p-value $= 0.017$

After computing the future equivalents of each list in Figure 1, the lists were compared in pairs. Considering the delays (3 weeks or 1 year) and stakes (R$100,00 or R$250,00), four types of hyperbolic discounting could be measured, as in Table 3. For example, if a future equivalent in List 1 was greater than that in List 2, the early payoff weights more than the payoff in three

weeks, thus revealing a "present bias," in this case a hyperbolic discounting of Type 1. Comparing Lists 3 and 4 produced a gauge of Type-2 hyperbolic discounting, and so on.

Table 2. Students' CRT scores, by sex

	Percentage scoring 0, 1, 2 or 3			
Sex	0	1	2	3
Male_{187}	61.00_{114}	23.50_{44}	11.20_{21}	4.30_{8}
Female_{275}	82.20_{226}	14.50_{40}	2.20_{6}	1.10_{3}

Notes:
1) subscripts show the number of respondents
2) $\chi^2(3) = 32.093,\ p\text{-value} = 0.000$
3) Spearman's correlation $\rho = -0.25,\ p\text{-value} = 0.000$

Table 3. Four types of hyperbolic discounting measured by the future equivalents, considering delays and stakes

	Delay	
Stake	3 weeks	1 year
Low	Type-1 hyperbolic discounting	Type-2 hyperbolic discounting
High	Type-3 hyperbolic discounting	Type-4 hyperbolic discounting

Whenever a participant chose the early payoff in all the choice lists, we kept the greater future equivalent, which meant R$147,00 for Lists 1 to 4, and R$487,00 for Lists 5 to 8.

Most participants did not show hyperbolic discounting (Figure 5). This is not unexpected and is in line with literature [4]. However, for those affected by the present bias, Figure 5 suggests payoff delay mattered for the bank customers, who displayed hyperbolic discounting when high stakes were involved (Type-4 measure). Payoff delay also mattered for the students, regardless of whether stakes were low or high (Type-2 and Type-4 measures). Taking together, such results for both groups make sense, as high-income individuals are expected to be more insensitive to lower stakes.

The difference between the groups of bank customers and undergrads was not significant (Table 4). This means their attitudes toward intertemporal discounting did not differ too much (p-value > 0.05).

Next, we considered the future equivalents computed for the eight choice lists and then calculated "implicit annual discount rates" [23] as

$$i = \ln\left(\frac{\text{future equivalent}}{\text{early payoff}}\right) \tag{1}$$

for one year delay (assuming continuous discounting), and

$$i = \ln\left(\frac{\text{future equivalent}}{\text{early payoff}}\right)\frac{52}{3} \tag{2}$$

for the delays of three weeks, as a year has 52 weeks. After considering the early payoffs of R$100,00 and R$250,00, we found the median annual discount rates for the bank customers, as in Table 5. Such implicit discount rates were larger for short delays of three weeks with an upfront-delay of zero and three weeks (Choice Lists 1, 2, 5 and 6) than for long delays of one

year with upfront-delay of zero and three weeks (Choice Lists 3, 4, 7 and 8). This replicated Sutter et al. [23].

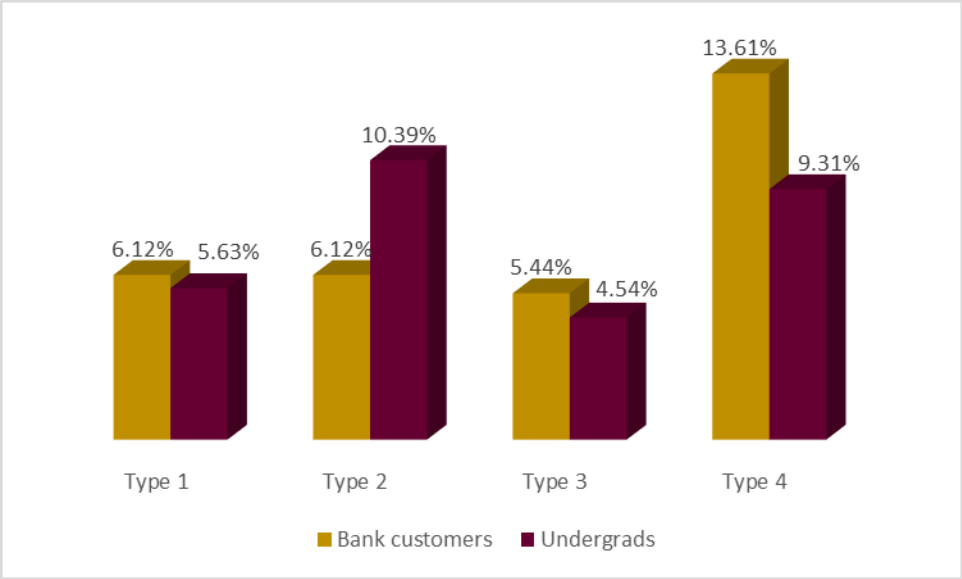

Figure 5. Incidence of hyperbolic discounting among bank customers and undergrads, by type

Table 4. Bank customers and students did not differ in their attitudes toward intertemporal choice

	Hyperbolic discounting			
	Type 1	Type 2	Type 3	Type 4
Mann-Whitney	33789.00	32508.00	33652.50	32497.50
Z	−0.224	−1.546	−0.444	−1.489
p-value	0.823	0.122	0.657	0.136

Table 5. Median annual discount rates for the bank customers, %

Delay	*3 weeks* *Upfront-delay = 0*	*3 weeks* *Upfront delay = 3 weeks*	*1 year* *Upfront-delay = 0*	*1 year* *Upfront delay = 3 weeks*
Stake				
	Choice List 1	Choice List 2	Choice List 3	Choice List 4
Low	133.39	133.39	20.70	24.68
	Choice List 5	Choice List 6	Choice List 7	Choice List 8
High	87.86	245.26	22.47	22.47

Table 6 shows the students adopted the same pattern as the bank customers did, but the students had higher implicit discount rates for both low stakes and long delays of high stakes. This is in line with literature, too, where higher rates of discount are expected for lower-income individuals [29].

We then turned to the possible relationship between cognitive ability and intertemporal discounting. As for the bank customers, Figure 6 suggests at first sight a negative correlation between cognitive ability and impatience because those individuals who scored 2 or 3 right answers escaped more from discounting the future hyperbolically. However, this was not significant for any type of present bias (*p*-value > 0.05, Pearson's χ^2 test). Importantly,

Spearman correlations between CRT and hyperbolic discounting were ambiguous and not significant for all types of discounting (p-value > 0.05).

Table 6. Median annual discount rates for the undergraduates, %

Delay	*3 weeks* *Upfront-delay = 0*	*3 weeks* *Upfront delay = 3 weeks*	*1 year* *Upfront-delay = 0*	*1 year* *Upfront delay = 3 weeks*
Stake				
	Choice List 1	Choice List 2	Choice List 3	Choice List 4
Low	196.43	272.13	35.06	38.52
	Choice List 5	Choice List 6	Choice List 7	Choice List 8
High	81.26	239.23	29.86	37.01

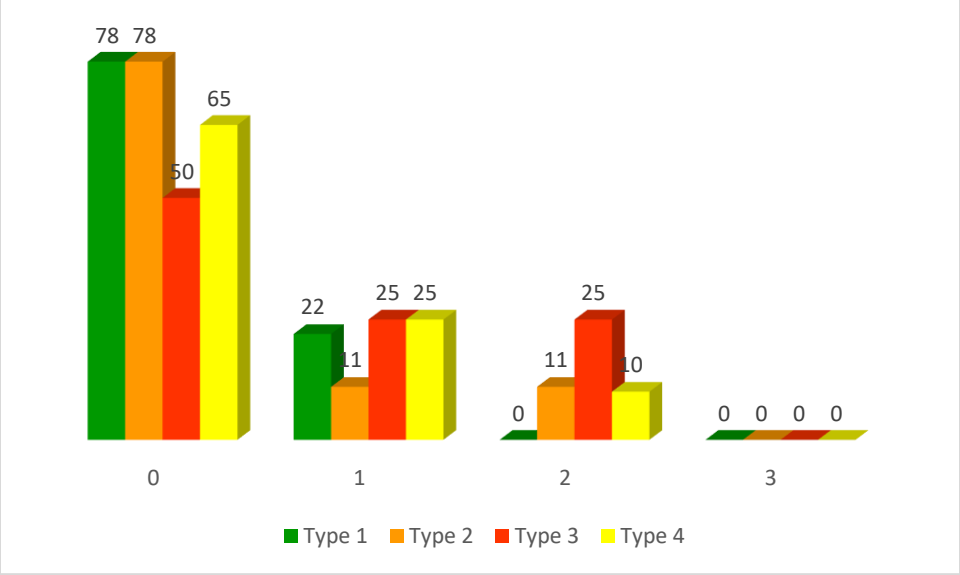

Figure 6. Percentage of bank customers showing hyperbolic discounting while scoring 0, 1, 2 or 3 on the CRT

Notes:

1) Type 1: Spearman $\rho = -0.100$, p-value = 0.229

2) Type 2: Spearman $\rho = -0.079$, p-value = 0.342

3) Type 3: Spearman $\rho = 0.065$, p-value = 0.433

4) Type 4: Spearman $\rho = 0.039$, p-value = 0.643

A different picture emerged for the undergraduates, at least as far as the hyperbolic discounting of Type 4 was concerned. The negative relationship between cognitive ability and impatience did emerge and was significant (Spearman's correlation $\rho = -0.120$, p-value < 0.05; Pearson's $\chi^2(3) = 8.226$, p-value < 0.05).

Taking together, the results for both groups suggested intertemporal choice was related to cognitive ability for the students, but not for the bank customers.

4. Discussion

The vast majority of our sample's participants of both groups did not show hyperbolic discounting. In this regard, bank customers and students did not differ too much. However, for those who did not escape hyperbolic discounting, there was a clear difference in the pattern for

the emergence of the phenomenon in high-income consumers relative to students. The undergraduates tended to be hyperbolic regardless of stake size, whereas the bank customers tended to be hyperbolic only when high stakes were involved. This makes sense as one expects high-income consumers to be less sensitive to low stakes.

The implicit discount rates were greater for short delays of three weeks (with an upfront-delay of zero and three weeks). In this regard, bank customers and students did not differ too much either. This result is usually considered as evidence of hyperbolic discounting in the literature [4]. However, it has to be said this is not unambiguous because such a finding can be accomodated by "subadditive discounting" [30]. According to this alternative theory to hyperbolic discounting, discounting occurring in short delays and long delays may differ due to the very fact that it is more finely partitioned, and not because discount rates actually declined with time.

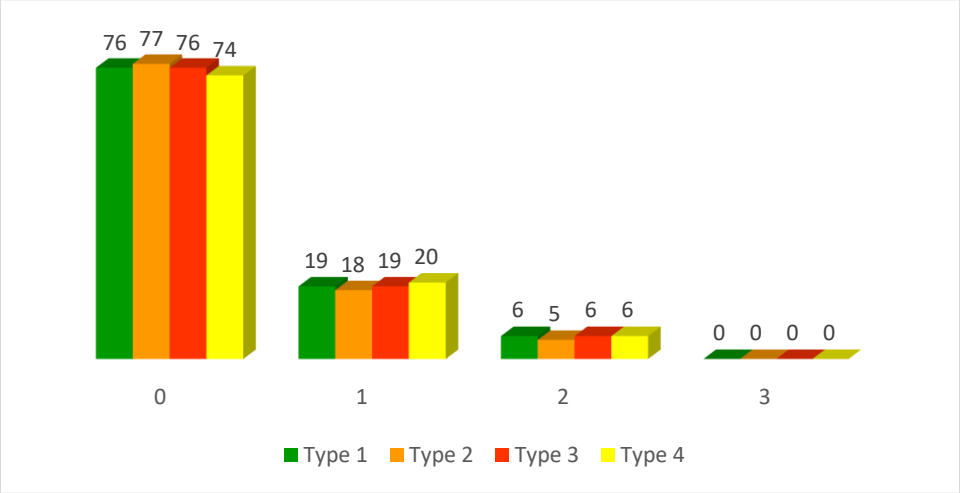

Figure 7. Percentage of students showing hyperbolic discounting while scoring 0, 1, 2 or 3 on the CRT

Notes:

1) Type 1: Spearman $\rho = 0.053$, p-value $= 0.266$

2) Type 2: Spearman $\rho = 0.104$, p-value $= 0.028$; $\chi^2(3) = 6.065$, p-value $= 0.048$

3) Type 3: Spearman $\rho = 0.013$, p-value $= 0.781$

4) Type 4: Spearman $\rho = -0.120$, p-value $= 0.010$; $\chi^2(3) = 8.226$, p-value $= 0.016$

However, regardless of the explanation for the evidence of implicit discount rates that are higher for shorter delays, our study showed a difference in pattern for each group. The students had higher implicit discount rates for both low stakes and high stakes when long delays were involved. This is in line with the literature, where higher rates of discount are expected for lower-income individuals [29].

The students showed relatively poorer cognitive ability than the bank customers did. For high stake and long delay at least, hyperbolic discounting was negatively related to cognitive ability for the group of undergraduates. This result is in line with the literature, too [7] [8] [31]. However, and importantly, intertemporal choice for the high-income individuals in our sample was not related to cognitive ability, thus suggesting other subjective mechanisms of choice were at play for the bank customers.

As for cognitive ability, the bank customers were superior to the undergrads in our sample. Individuals with higher cognitive ability may control their automatic impulse for instant

gratification and immediate payoffs [32]. This may explain why the high-income consumers where not affected by the present bias while discounting the future. Moreover, bank customers are under the influence of "nudgers" on a daily basis (their personal managers), who influence their money decisions using a "choice architecture" [33]. Such choice architects are responsible for improving the environment where these individuals make decisions. Indeed, high-income bank clients usually decide using real-time information and after considering the input provided by their personal bank managers. An extra mechanism of reinforced learning after such a nudge thus suffices to justify why bank clients were less hyperbolic in our study.

5. Conclusion

Are high-income consumers less hyperbolic when discounting the future? This study considered high-income bank customers and low-income undergraduates to partially answer to this question. And the answer is a qualified "yes." The bank customers unambiguously showed more cognitive ability than the students did on a cognitive reflection test. Moreover, those students presenting hyperbolic discounting were also those scoring lower on the cognitive reflection test. For this group, lower cognitive ability translated into hyperbolic discounting. The students had higher implicit discount rates (were more hyperbolic) for both low stakes and high stakes when long delays were involved. For high stakes and long delays at least, hyperbolic discounting was negatively related to cognitive ability for the group of undergraduates. However, while intertemporal choice was related to cognitive ability for the students, this could not be shown for the bank customers. Because the bank clients had superior cognitive ability, their System 2 was more capable of overriding the cognitive bias of hyperbolic discounting.

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