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► To cite this version:

Bernur Acikgoz, Dimitri Dubois, Sébastien Duchêne, Adrien Nguyen-Huu, Marc Willinger. Depth of reasoning in the 11-20 game differs between financial professionals and students. A lab-in-the-field experiment. *Economics Letters*, 2024, 239, pp.111754. 10.1016/j.econlet.2024.111754 . hal-04578910

HAL Id: hal-04578910

<https://hal.science/hal-04578910v1>

Submitted on 18 Nov 2024

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Depth of reasoning in the 11–20 game differs between financial professionals and students. A lab-in-the-field experiment

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ABSTRACT

We rely on Alaoui and Penta (2020)'s variant of the 11–20 game (Arad and Rubinstein, 2012), to elicit the depth of reasoning of financial professionals (FP) and students (ST). FP chose lower numbers in the 11–20 game than ST, but had similar CRT scores. We observe that ST with higher CRT scores tend to choose larger numbers. FPs' chosen numbers are positively affected by their SVO while ST's chosen numbers are positively affected by their risk-aversion.

1. Introduction

Experimental findings about the 11–20 game showed that over 50 % of the subjects choose numbers between 17 and 20 (Arad and Rubinstein, 2012; Goeree et al., 2018; Alaoui et al., 2020), which suggests a rather limited depth of reasoning. However, other reasons can explain such apparent bounded cognitive ability, including beliefs about others' cognitive limitations (Alaoui and Penta, 2016), probabilistic choice (Goeree et al., 2018; Kim and Kim, 2022) and risk aversion (Li, 2018). The same questioning arises for beauty contest games (Gill and Prowse, 2016).

We focus on subject pool effects, targeting financial professionals (FP hereafter). Little is known about the depth of reasoning in non-students subjects. Bosch-domènech et al. (2002) discovered, in newspaper beauty contest games, that non-students often pick lower numbers and more frequently opt for the Nash equilibrium. Aligned with our objective, Huber et al. (2021, 2022) and Weitzel et al. (2021) observed significantly higher CRT scores in FP than in students (ST hereafter). Weitzel et al. (2021) also noted fewer bubbles in experimental markets with FP than with ST. Alevy et al. (2007) found that FP are less prone to non-rational information cascades and Kaustia et al. (2008) found less anchoring bias. Holmén et al. (2023) reported higher Machiavellianism in FP, a trait that is closely related to cognitive ability, in particular manipulative skill (Bereczkei, 2015). However, Haigh and List (2005)

also found a greater degree of myopic loss aversion in FP than in ST. More recent studies by Rahwan et al. (2019) and Holzmeister et al. (2020) observed no discernible distinctions between FP and other populations in terms of dishonesty and risk perception, respectively (see Huber and König-Kersting, 2022, for a detailed review). The conflicting results among FP behaviors require further investigation, emphasizing the need for more data to fully comprehend these differences.

FPs play a critical role in the economy, often facing scrutiny for their involvement in financial crises and scandals, which raises questions about their integrity. Understanding their cognitive profiles and economic preferences is essential for a comprehensive understanding of the finance industry as a whole (Holmén et al., 2023).

We enhance the literature on depth of reasoning by examining choices in the 11–20 game among FP ($N_{FP} = 190$) compared to ST ($N_{ST} = 279$), controlling for differences in cognitive ability using the Cognitive Reflection Test (CRT¹) and response-time.² Despite similar CRT scores in both groups, FP participants opted for significantly lower numbers in the 11–20 game. We offer a discussion on the variances in explanatory variables across our samples.

2. Experimental set up

We utilize Alaoui and Penta's (2016, 2020) variant of the 11–20 game (instructions in Appendix 1) to gage the endogenous depth of

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¹ See Brañas-Garza et al. (2019) for a review.

² We excluded outliers: 77 ST subjects who spent less than 5 seconds on the task, and one PRO subject who spent over 1460 seconds. The corrected sample sizes are $N_{FP} = 188$ and $N_{ST} = 202$ (one missing response time for PRO).

reasoning. In the version introduced by Arad and Rubinstein (2012), players can request any integer between 11 and 20, earning the amount they request. Additionally, if a player requests exactly one unit less than their opponent, they receive a bonus of 20 units. For instance, 19 is the best response to 20, 18 to 19, and so forth, allowing for a clear association between the chosen number and depth of reasoning. However, there exists a cycle of best responses, as choosing 20 is optimal if a player believes the opponent will choose 11. To resolve this cycle, Alaoui and Penta (2020) introduced a tie-breaking rule: if both players choose the same number, the 20-point bonus is evenly divided between them. Consequently, 11 is the best response to 11.

Our participants engaged in several additional tasks: the 7-item version of the Cognitive Reflection Test (CRT) by Toplak et al. (2014) to assess cognitive ability (see Appendix 2), the Social Value Orientation (SVO) scale by Murphy et al. (2014) to measure pro-socialness (see Appendix 3). Furthermore, we elicited higher-order risk attitudes (Noussair et al., 2014) as risk preferences appear to be linked to cognitive ability (e.g., Cueva et al., 2016, and Bottasso et al., 2022). Depending on the participant’s category (FP or ST), we controlled for specific variables likely to influence their decisions: for FPs, we primarily controlled for job characteristics (type of strategy, asset category traded, and market, (see Appendix 4); for students, we controlled for age, study level, and major discipline.

3. Results

Result 1: *Students choose numbers similar to those observed in previous studies.*

Support for result 1:

We replicate Alaoui et al. (2020)’s findings about the distribution of chosen numbers in ST. We rely on their categorization, defined by the ordered variable "cat", with 1 ≡ {11, ..., 16}, 2 ≡ {17, 18, 19}, and 3 ≡ {20}. We found that 9 % of ST favored 20, similar to 8–10 % in their study. 45.5 % chose 17–19, slightly less than 50–60 % in their research, and 44.5 % chose 11–16, compared to 32–43 % in their study, varying by experimental conditions.³⁵ However, in our FP sample, while the percentage choosing 20 remains consistent with ST, the 17–19 category notably decreases to 28.7 % (see Table 1). The appendix contains ordered logit model results for "cat" or "chosen number" (Appendix tables 3–6).

Result 2: *Financial professionals choose lower numbers than students.*

Table 1
Chosen number categories by subject pool.

Cat	pro		Total
	student	professio	
11 –	90	117	207
16	44.55	62.23	53.08
17 –	92	54	146
19	45.54	28.72	37.44
20	20	17	37
	9.90	9.04	9.49
Total	202	188	390
	100.00	100.00	100.00
		Pearson chi2(2) = 13.1698	Pr = 0.001
		Fisher’s exact =	0.001

³ While our 11-20 game varies from Arad and Rubinstein’s (2012), our findings closely align: they observed 6% choosing 20, 74% favoring 17-19, and 20% selecting 11-16.

Support for result 2:

Fig. 1 compares the cdfs for different sub-samples. The median number chosen is 15 for FP and 17 for ST. The distributions of chosen numbers differ for FP and ST (KS, $p = 0.000$, rank-sum test, $p = 0.002$).

Result 3: *ST subjects with higher CRT choose higher numbers.*

Support for result 3:

Table 2 presents the frequencies, both absolute and relative, of selected numbers in the 11–20 game categorized by subject-type. Notably, an upward trend in the average CRT level is observed for the ST, progressing from 15 to 19 (in bold). There is a significant positive correlation between the chosen number and the CRT level in ST (pair-wise correlation coefficient $r = 0.1909$, $p = 0.01$).

Appendix 7 summarizes the variables influencing the chosen number category (Tables 3–4) or the chosen number (Tables 5–6). ST subjects with higher CRT levels choose higher numbers, a tendency that is absent in FP. The choice of high numbers among ST does not appear to stem from cognitive limitations; instead, it reflects their anticipation of others’ choices, suggesting that the expected payoff associated with these choices is a key driver (see Tables 4–6 in appendix 7), as discussed in detail below. We also observe that most control variables (job characteristics for FPs, study characteristics, and gender for ST⁴⁴) were insignificant. For FP participants, only SVO affects significantly the chosen number or category, in agreement with Chen et al. (2013) and Lopez et al. (2023), while for ST subjects only risk-aversion is significant, in agreement with Li et al. (2018).

4. Discussion and conclusion

Why do ST subjects with higher CRT levels choose higher numbers in the 11–20 game, contrary to expectations? Our research suggests that higher cognitive ability improves the ability to anticipate others’ choices. When players perceive cognitive limitations in their peers, they may opt for a higher number than what aligns with their own depth of reasoning (Alaoui and Penta, 2016).

Agranov et al. (2012); Georganas et al. (2015), and Alaoui & Penta (2020) demonstrated that level-k behavioral patterns not only indicate cognitive limitations but also reflect beliefs about others’ cognitive constraints (see also Jin, 2021) aligning with endogenous depth of reasoning models (Alaoui and Penta, 2016). Moreover, level-k behavior does not necessarily reflect level-k thinking. Expanding further, we introduced "epay", representing the average expected gain associated with the chosen number, conditional on the actual distribution of chosen numbers, within each sample. Integrating "epay" into the regressions results in a loss of significance for CRT (see Tables 4 and 6, appendix 7). Selecting larger numbers correlates with increased expected payoffs in both samples. This observation implies that participants in both samples accurately anticipated the distribution of chosen numbers among their peers, supporting the hypothesis of endogenous depth of reasoning (Alaoui and Penta, 2016).

Similar CRT levels were found in both FP and ST samples, contrasting with prior research on higher CRT levels in non-student populations (Huber et al., 2021, 2022; Weitzel et al., 2021), suggesting variability within the FP demographic. However, FP tended to choose lower numbers than ST, indicating a significant preference shift in the 11–20 game, setting them apart from previous findings.

We include financial experts in our studies, enhancing the generalizability of the results of the 11–20 game and addressing concerns about the external validity of experimental findings. Exploring with professionals illuminates cognitive abilities and decision-making.

⁴ We do not observe a significant difference in chosen numbers between men and women (see Appendix 5). Our findings agree with findings by those of Burnham et al. (2009), Brañas-Garza et al. (2012), about the absence of gender differences in cognitive ability and strategic sophistication.

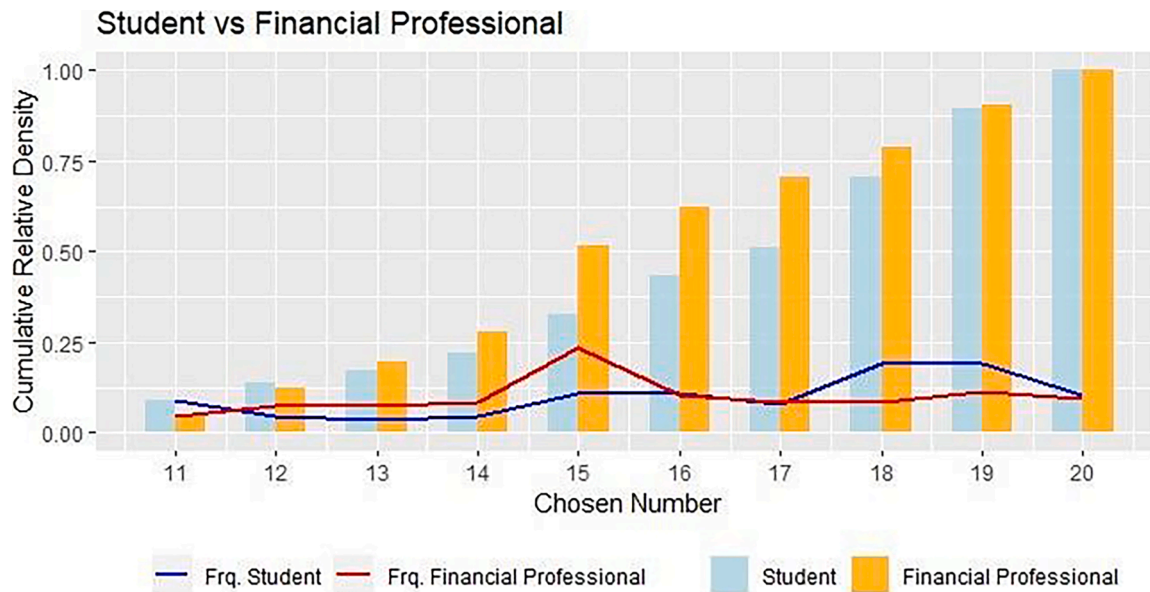


Fig. 1. Chosen numbers in the ST and FP samples (relative and cumulative densities).

Table 2
Choices in the 11–20 Game Relative to CRT Level Across Different Subject Types.

Chosen Number	Financial professionals (FP) N _{FP} = 188			Student subjects (ST) N _{ST} = 202		
	Number of Obs (%)	Average CRT	Median CRT	Number of Obs (%)	Average CRT	Median CRT
20	17 (9.04)	4.06	4	20 (9.90)	3.15	2
19	22 (11.70)	4.27	5	38 (18.81)	4.03	4
18	16 (8.51)	3.81	4	38 (18.81)	3.84	4
17	16 (8.51)	2.69	3	16 (7.92)	3.81	4.5
16	20 (10.64)	3.05	3	22 (10.89)	3.5	3
15	45 (23.94)	3.24	3	24 (11.88)	3	2
14	16 (8.51)	3.94	3	10 (4.95)	3.20	2
13	14 (7.45)	4.21	4.5	7 (3.47)	2.57	2
12	13 (6.91)	2.77	2	7 (3.47)	1.86	2
11	9 (4.79)	3.33	3	20 (9.90)	2.8	2.5

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.econlet.2024.111754](https://doi.org/10.1016/j.econlet.2024.111754).

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