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Think Twice Before Running!
Bank Runs and Cognitive Abilities

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Abstract

We assess the impact of cognitive abilities on withdrawal decisions in a bank-run game. In our setup, depositors choose sequentially between withdrawing or keeping their funds deposited in a common bank. They may observe previous decisions depending on the information structure. Theoretically, the last depositor in the sequence of decisions has a dominant strategy and should always keep the funds deposited, regardless of what she observes (if anything). Recognizing the dominant strategy, however, is not always straightforward. If there exists strategic uncertainty (e.g., the last depositor has no information about predecessors' decisions) the identification of the dominant strategy requires harder thinking than when there is not strategic uncertainty (e.g., the last depositor is informed about all previous decisions). We find that cognitive abilities, as measured by the Cognitive Reflection Test (CRT), predict withdrawals in the presence of strategic uncertainty (participants with higher abilities tend to identify the dominant strategy more easily) but the CRT does not predict behavior when there is no strategic uncertainty.

Keywords: bank runs, coordination game, observability of actions, cognitive abilities, strate-gic uncertainty

JEL classification: C91, D03, D8, G02, J16

Kétszer gondold meg, hogy érdemes-e a bankba rohanni! Bankrohamok és kognitív képességek

Kiss Hubert János – Ismael Rodriguez-Lara – Alfonso Rosa-García

Összefoglaló

A kognitív képességek hatását vizsgáljuk betétkivételi döntésekre egy bankrohamjátékban. A játékban a betétesek egymás után döntenek arról, hogy kivegyék-e pénzüket a bankból vagy bennhagyják. Az információs struktúra határozza meg, hogy a betétesek megfigyelhetik-e a korábbi döntéseket. Elméletileg, az utolsó betétesnek domináns stratégiája van, amely szerint mindig benn kell hagynia a pénzét a bankban. A domináns stratégiát azonban nem mindig egyszerű észrevenni. Ha stratégiai bizonytalanság van (például az utolsó betétes nem tudja, hogyan döntöttek a többiek), akkor több gondolkodást igényel a domináns stratégia felfedezése szemben azzal az esettel, amelyben nincs stratégiai bizonytalanság (például az utolsó betétes ismeri az összes megelőző döntést). Azt találjuk, hogy a Cognitive Reflection Test (CRT) segítségével mért kognitív képességeknek magyarázó erejük van stratégiai bizonytalanság esetén (a jobb képességűek inkább felfedezik a domináns stratégiát), de a CRT-nek nincs magyarázó ereje, amikor nincs stratégiai bizonytalanság.

Tárgyszavak: bankroham, koordinációs játék, megfigyelhetőség, kognitív képességek, stratégiai bizonytalanság

JEL kód: C91, D03, D8, G02, J16

Think Twice Before Running!
Bank Runs and Cognitive Abilities

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September 4, 2014

Abstract

We assess the impact of cognitive abilities on withdrawal decisions in a bank-run game. In our setup, depositors choose sequentially between withdrawing or keeping their funds deposited in a common bank. They may observe previous decisions depending on the information structure. Theoretically, the last depositor in the sequence of decisions has a dominant strategy and should always keep the funds deposited, regardless of what she observes (if anything). Recognizing the dominant strategy, however, is not always straightforward. If there exists strategic uncertainty (e.g., the last depositor has no information about predecessors' decisions) the identification of the dominant strategy requires harder thinking than when there is not strategic uncertainty (e.g., the last depositor is informed about all previous decisions). We find that cognitive abilities, as measured by the Cognitive Reflection Test (CRT), predict withdrawals in the presence of strategic uncertainty (participants with higher abilities tend to identify the dominant strategy more easily) but the CRT does not predict behavior when there is no strategic uncertainty.

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1 Introduction

«If the people would only leave their money in the banks instead of withdrawing it...everything would work out all right.»
J. P. Morgan in "Bankers Calm; Sky Clearing."
New York Times, October 26, 1907.

Standard economic theory assumes that agents are rational and make optimal decisions. Laboratory experiments, however, highlight that participants do frequently undertake suboptimal decisions. Eventually, this is just an illustration of real life phenomena that might have noteworthy economic consequences. The events in US housing markets that fostered the recent economic downturn, for example, were likely due in part to poor financial decision making (see Gerardi et al., 2013). These bad decisions do also take place in other financial environments. Choi et al. (2011) find that some employees forego arbitrage profits by making suboptimal investment choices to retirement plans (see also van Rooij et al., 2011). Bertrand and Morse (2011) note that some individuals may not be aware of the real costs of the loan from payday lenders, what may induce them to take up extremely expensive loans from them (despite the fact that information about alternative ways of getting money is easily available).

Since bad financial decisions may lead to severe economic losses, it is instructive to understand what factors may cause them. A straightforward answer to consider is that individuals are not as rational as the standard economic theory suppose. They may have not the cognitive abilities to overcome the potentially complex financial problems or they may act impulsively without appropriate deliberation. There is a growing literature studying how cognitive abilities affect financial decision making (see Korniotis and Kumar 2010 for a survey). In this paper, we contribute to this literature using a lab experiment in which we study participants' decisions in a bank-run game (see Kiss et al. 2014a, 2014b). As suggested by the opening sentence of J. P. Morgan, bank runs involve deciding in a setup where choosing an action (in this case, withdrawing money from the bank) may be in conflict with the rationality assumption, so it is worth analyzing the extent to which participants behave rationally.

In our game, depositors have to choose whether to withdraw their funds from a bank or keep it deposited. They decide in various informational setups that differ in the participant's position in the sequence of decision and the information that is available (both about previous depositors' decision and if subsequent depositors will observe the decision of the participant). Payoffs are such that keeping the money deposited is the dominant strategy for a depositor choosing in the last position, regardless of what is observed (if anything). However, strategic uncertainty (that is, uncertainty regarding the purposeful decision of others) makes the decision more difficult in our setup for at least two reasons. On the one hand, the computation of payoffs is easier when the depositor knows with certainty what the other participant in the lab did.[1] For instance, when a depositor in the last position observes all the previous decisions or the fact that a previous depositor have already kept the money in the bank, then she decides in a singleton information set. By comparing payoffs corresponding to the choices yields simply that keeping the money deposited is optimal. However, when a depositor in the last position observes a withdrawal or none of the previous choices, the computation of payoff is not immediate. Keeping the money deposited is still a dominant strategy but it requires harder thinking, in contrast with the straightforward comparison of payoffs in the previous case (this is because the depositor needs to think about all the possible histories of decisions and conclude that keeping the money deposited is the dominant strategy). On the other hand, and relatedly to the previous point, strategic uncertainty implies also payoff uncertainty. Because the payoff for a depositor in the last position depends on what other depositors have done, a depositor who observes nothing is uncertain about the payoff that his or her action will yield, what may cause some stress resulting in suboptimal decision-making.[2]

We use the data from a previous experiment (Kiss et al. 2014b) to investigate the depositors' behavior when the available information changes from round to round. We focus on the behavior of the last depositor in the sequence because suboptimal behavior is clearly defined in that setup. To measure cognitive abilities we use the Cognitive Reflection Test (hereafter, CRT) devised by Frederick (2005). All the three questions in the test have an answer that immediately springs to mind, but which is wrong. The test is

[1] There is a depositor who always withdraws simulated by the computer, as we will explain later in more detail.

[2] Risk preferences are indeed correlated with different measures of cognitive abilities, as it is shown in Andersson et al. (2013), Brañas-Garza et al. (2008), Burks et al. (2013), Dohmen et al. (2010) and Oechssler et al. (2009).

then intended to measure the tendency "to resist reporting the response that first comes to mind", so that it may have some predictive power in depositors' behavior as it is not just about intelligence, but also impulsiveness.[3] Given this experimental environment, we want to test if participants really play the dominant strategy. Moreover, we attempt to understand what may be behind the mistake of playing the dominated strategy. We conjecture that strategic uncertainty and cognitive abilities are two main driving forces behind suboptimal decisions. More precisely, we expect that i) participants with higher cognitive abilities (as measured by the CRT) make less mistakes, and ii) strategic uncertainty increases the likelihood of suboptimal choices. We also attempt to investigate the relationship between cognitive abilities and strategic uncertainty.

Our data show that participants tend to recognize the dominant strategy and withdraw only in 10 percent of the cases. Interestingly, we find that they incur in more mistakes when there is strategic uncertainty. In this case, however, participants with higher cognitive abilities withdraw significantly less. This is not the case when there is no strategic uncertainty, because then CRT does not have any predictive power.

The rest of the paper is as follows. In section 2, we review briefly the literature. Section 3 presents the bank-run game that we use in the experiment. Section 4 contains the experimental design, and results are in section 5. Section 6 concludes.

2 Related Literature

Our paper is related to two strands of the literature. On the one hand, it is connected to the papers that investigate how cognitive abilities affect optimal decisions and economic behavior in general, and on the other hand it belongs to the literature that studies financial mistakes and analyzes its causes.

Related to the first branch of the literature, a noteworthy aspect of our study is that there is a dominant strategy that participants should play if rational. It has been long observed, however, that experimental participants

[3]As noted by Bosch-Domènech et al. (2014) "What makes the CRT different from problem-solving or math tests is that the latter tests do not usually trigger a plausible intuitive response that must be overridden." (page 2)

do not always choose as the theory predicts. Recently, several papers attempt to explain this discordance with cognitive abilities. These studies connect individuals' cognitive abilities, as measured by standard tests, with performance in different games. Casari et al. (2007) study auctions and find that individuals with higher scores in the Scholastic Achievement Test (SAT) or the American College Test (ACT)[4] avoid the winner's curse more than the unskilled ones. It has also been observed that cognitive abilities affect the degree of strategic sophistication in the Hit-15 (Carpenter et al., 2013) in games that require the application of iterated dominance such as the beauty context (Brañas-Garza et al., 2012; Carpenter et al., 2013; Gill and Prowse, 2014; Rydval et al., 2009), as well as in some two-person 3x3 normal form games (Grimm and Mengel, 2012).[5]

We depart from these studies in that they focus on the ability of the participants for finding the equilibrium or not playing dominated strategies, whereas we investigate the effect of cognitive abilities on the choice of the dominant strategy. Although it has been observed that in some environments participants do not play the dominant strategy (Grosskopf and Nagel, 2008), the effects of CRT scores on choices has not been analyzed yet.

Related to the second strand of the literature, there is a recent but rapidly growing literature on cognitive abilities and financial decisions (see Korniotis and Kumar (2010) for a survey on this topic). These papers show that cognitive abilities correlate with bubbles (Corgnet et al., 2014), saving decisions (Ballinger et al., 2011) and behavioral biases, such as anchoring (Bergman et al, 2010) or the conjunction fallacy (Oechssler et al, 2009). A higher participation in the stock market (which is frequently used as proxy for the quality of financial decisions) has been found positively related with IQ scores (Kezdi and Willis, 2003; Christelis et al., 2010; Benjamin et al., 2013). Other papers go further and use more specific measures of decision-making. For instance, Grinblatt et al. (2012) and Korniotis and Kumar

[4]Both SAT and ACT attempt to capture academic achievement. Originally, SAT was an abbreviation of Scholastic Aptitude Test, but presently SAT does not denote a sequence of words.

[5]Grimm and Mengel (2012) investigate learning and whether play converges to Nash equilibrium. They find that the complexity of the environment affects convergence, failure to converge is attributed to higher cognitive costs. For further studies on the relationship between cognitive abilities and strategic behavior see, among others, Allred et al. (2014), Bayer and Renou (2012), Brañas-Garza et al. (2011, 2012), Burks et al. (2009), Jones (2008), Jones (2011).

(2013) use different data sets and find that the portfolios of investors with high cognitive abilities perform significantly better in various aspects (e.g. stock-picking, trade execution) than those of investors with low abilities. In some sudies, suboptimal decision-making is even clearer defined. For instance, Agarwal and Mazumder (2013) identify two instances (one related to credit card use and the other to home equity loan application) in which suboptimal decisions lead to clear financial losses. They find that consumers with higher overall test scores, and specifically those with higher math scores, are substantially less likely to make a financial mistake.[6] Gerardi et al. (2013) find that cognitive (more precisely numerical) ability affects mortgage defaults. Individuals with lower numerical ability are more likely to default on their mortgages.

Our setup resembles depositor behavior, an important kind of financial decision-making not covered by the previous studies. We use the CRT to predict the depositor's behavior, as the right answer to these questions can only be found by engaging in some cognitive reflection. Since during financial hardship people often panick and are driven by impulsive acts, this test seems appropriate to capture several aspects that may be behind suboptimal decisions. In light of the bank runs that occurred since the financial crisis erupted, it seems of first-order importance to understand how cognitive abilities may affect bank runs.

3 The sequential bank-run game

The seminal paper of Diamond and Dybvig (1983) models bank runs as a coordination problem among depositors. In their framework, decisions are made simultaneously and depositors may decide to run the bank as an equilibrium outcome. Recently, sequential decisions have received some attention in bank run literature (e.g., Gu, 2011). The experimental evidence highlights that observing what other depositors have done may affect depositors' behavior (e.g., Garratt and Keister, 2009) even if decisions in the simultaneous and in the sequential setup should not differ (Schotter and Yorulmazer, 2009). These results are in line with empirical studies that reveal the importance of observing previous decisions (e.g., Kelly and O

[6] In this study, cognitive skills were measured by the Armed Forces Qualifying Test (AFQT) score which contains information on both math and verbal ability.

Grada, 2000; Starr and Yilmaz, 2007; Iyer and Puri, 2012), and it calls for an extension of the simultaneous-move setup in Diamond and Dybvig (1983). In section 3.1 we build upon these lines and present a simple coordination game among three depositors, which we implement in the lab by allowing for observability of actions (see Kiss et al. 2012, 2014a). As we shall see in section 3.2, our game has a clear-cut prediction: the last depositor in the sequence of decision (hereafter, depositor 3) has a dominant strategy. This dominant strategy may or may not be easy to identify, depending on what depositor 3 observes. We conjecture in section 3.2 that cognitive abilities and strategic uncertainty may have some predictive power in explaining departures from the equilibrium prediction.

3.1 The setup

Consider a bank that is formed by 3 depositors. At $t = 0$, each of them deposits her initial endowment (in our experiment, 80 ECUs) in this bank that has thus initially 240 ECUs to be invested in a project. The project yields a sure high return in period $t = 2$, and the investment can be liquidated without any cost at $t = 1$, yielding no net return.

At $t = 1$ depositors choose in an exogenously determined sequence whether they want to withdraw their initial endowment or keep it deposited (that we also call waiting). Depositor i is the one that chooses in position i, where $i = 1, 2, 3$. If a depositor decides to withdraw, she immediately receives 100 ECUs as long as there is enough money in the bank to pay this amount (out of this amount, 80 ECUs correspond to the initial endowment and 20 ECUs are obtained in the form of interests). In our experiment, if depositors 1 or 2 withdraw, each of them receives 100 ECUs for sure. But if depositor 3 decides to withdraw after two withdrawals, she only receives 40 ECUs (because the first two depositors who withdrew received 100 ECUs each and the bank has only 40 ECUs to pay her). However, if depositor 3 withdraws after only one or no withdrawal, the bank pays her 100 ECUs. In sum, if one or two depositors decide to withdraw at $t = 1$, then they receive 100 ECUs. If all three depositors choose to withdraw, then the first two in the line get 100 ECUs each, while the last one receives the remaining 40 ECUs.

Depositors who decide to wait receive their payoff in period $t = 2$. The amount that depositors receive in $t = 2$ depends on the total number of waitings, which indeed determine the money that the bank has at $t = 2$. If only one depositor waits, she receives 60 ECUs.[7] If two depositors wait, then each of them gets 140 ECUs. In our model, we assume that the three depositors cannot wait and keep the money deposited in the bank. In particular, one of the depositors is hit by a liquidity shock at $t = 1$ and is forced to withdraw.[8] In line with Diamond and Dybvig (1983), there exists no aggregate uncertainty about the fundamental liquidity demand; i.e., it is common information in our setup that one of the depositors will need the money and will be forced to withdraw. Following the literature, we refer to this depositor as impatient depositor, whereas depositors who can wait or withdraw their money are called patient depositors.

The decision situation in our study is such that it pays off for patient depositors to wait if they know or believe that the other patient depositor does so as well. Our setup, however, differs from standard coordination games in that it allows for observability of actions, which is an important aspect in bank run episodes (e.g., Kelly and O Grada, 2000; Starr and Yilmaz, 2007; Iyer and Puri, 2011). More specifically, depositors may or may not observe what other depositors have done depending on the position in the line and the information structure in which depositors are set in. Information about what is observed and the position in the line is revealed to depositors before they are asked to decide in period $t = 1$. We present the sequence of events of our model in Figure 1.

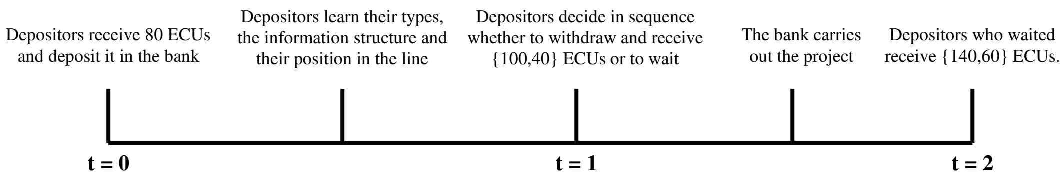

Figure 1: Timeline for the sequence of events.

As commented above, the available information about previous decisions depends on the information structure. An information structure is determined by a set of links among depositors. A link is represented by a pair

[7] After two withdrawals 40 ECUs remain in the bank at the end of $t = 1$ and this amount earns 20 ECUs of interest until $t = 2$).

[8] This is implemented in our experiment by having a depositor simulated by the computer, which is programmed to always withdraw.

of numbers ij for $i, j \in \{1, 2, 3\}$, $i < j$. The existence of the link ij implies that depositor j observes depositor i and depositor i knows that depositor j will observe her. For instance, 12 denotes that depositor 1 and depositor 2 are linked; therefore, depositor 1 knows that depositor 2 will observe her action and that depositor 2 chooses after observing depositor 1's action. Links are independent of types (patient vs. impatient), so depositors of the same type are not more likely to be linked, nor is there any relationship between types and the number of links. Position and the number of links are also independent (e.g., depositors in position 1 do not have systematically more links that subsequent depositors).

We attempt to study the depositor's behavior in all possible information structures, not only in simultaneous and completely sequential decisions (e.g., Schotter and Yorulmazer, 2009; Kiss et al. 2012). In our setup with three depositors, there are 8 possible networks: $(12, 23, 13)$, $(12, 23)$, $(12, 13)$, $(13, 23)$, (12), (13), (23), $(\emptyset)$, where $(\emptyset)$ stands for the empty network, which has no links at all, whereas the structure $(12, 23, 13)$ contains all the possible links and is called the complete network.[9] We assume that the information structure is not commonly known, information is local and thus no depositor knows whether the other two depositors are connected. The motivation for studying all these information setups is that as shown by the empirical literature cited above observing other depositors' decision seems to be crucial in the understanding of depositor behavior. However it is not clear which information structure describes best the observability of decisions, so we decided to study all possibilities in small-scale environment.

In our experiment (detailed in section 4) we vary the information structure across rounds. Suppose then that the information structure (12, 23) is randomly selected in one of the rounds, with patient depositors being randomly set in position 1 and 3. Because information is local, depositor 1 knows that depositor 2 (depositor 3) will (not) observe her decision. Depositor 1, however, does not know whether depositor 3 will observe what depositor 2 has done. In that regard, from depositor 1's point of view, she may be either in the network (12,23) or in (12,13,23). In our design, both

[9]The empty network can be interpreted as a simultaneous-move game where depositors have no information about other depositors' actions, as in Diamond and Dybvig (1983). The only difference is that positions are known in our setup but not in theirs. On the other hand, the complete network represents a fully sequential setup, meaning that depositors observe all predecessors' actions.

possibilities are equally likely. Along these lines, if the structure (12,23) is randomly selected, depositor 3 chooses after observing only what depositor 2 has done, but she has no information about whether depositor 2 observes depositor 1 or not. Important for the present study, in some rounds of the experiment depositor 3 chose after knowing what depositor 1 and 2 have done, whereas in some other rounds she had no information at all or was only informed about the decision of one of the previous depositors.[10]

As already noted earlier, one of the depositors always withdraws, increasing substantially the degree of strategic uncertainty. More precisely, in a setup in which depositor 3 observes a withdrawal, she does not know if this is due to the impatient depositor or to a patient depositor that decided to withdraw. Similarly, in a context in which nothing is observed, depositor 3 decides in presence of strategic uncertainty, not knowing what the other patient depositor has done.

3.2 Predictions

Next, we posit a clear-cut prediction of our model that we want to test with our behavioral data.[11]

PROPOSITION. *Depositor 3 has a dominant strategy and should always wait if patient, regardless of what she observes (if anything).*

PROOF. Since one of the depositors is forced to withdraw, the depositor 3's decision can be preceded by two withdrawals, or one waiting and one withdrawal. It is straightforward to show that waiting is a dominant strategy for any of these two possible history of decisions given the payoffs. We show next that the decisions that are being observed by depositor 3 may determine how difficult it is to identify this dominant strategy. If depositor 3 observes a waiting, or a waiting and a withdrawal, by waiting she receives 140 ECUs whereas withdrawal would yield 100 ECUs in these cases. Thus, it is clear that she should wait. Similarly, upon observing two withdrawals, depositor 3 knows that the other patient depositor decided to withdraw, so the best she can do is to wait and earn 60 ECUs (instead of earning 40 that a withdrawal would yield). However, if a depositor 3 observes a withdrawal,

[10]The same is true for depositor 1 and 2 (e.g., sometimes depositor 1 knows that depositor 2 will observe her choice, whereas in other setups depositor 1 knows that nobody will observe her). To see how the different information structures affect depositors' decisions, see Kiss et al. (2014a).

[11]This is part of the theoretical model in Kiss et al. (2014a)

then she cannot infer whether it was due to the other patient depositor or the impatient one. In either case, it is better for depositor 3 to wait. Note that waiting (withdrawing) after two withdrawals yields 60 ECUs (40 ECUs), whereas waiting (withdrawing) after a waiting and a withdrawal yields 140 ECUs (100 ECUs). Depositor 3 should apply the same reasoning if she observes nothing (i.e., depositor 3 should think that for any possible history of decisions it is better for her to wait).

Our objective is to study the extent to which depositor 3 follows her dominant strategy and waits. By the same token, we want to investigate how the observability of actions affects her decision. More precisely, the proof of our proposition - although simple - highlights that strategic uncertainty may play a role. We say that there is no strategic uncertainty if depositor 3 observes i) a waiting, ii) a waiting and a withdrawal, or iii) two withdrawals, as observability of actions in these cases allows depositor 3 to fully identify the action of the other patient depositor. In that context, choosing the dominant strategy should be *easy* for depositor 3, as it follows from simply comparing the payoffs of waiting (140 ECUs) and withdrawing (100 ECUs). Although waiting is also a dominant strategy in the context of strategic uncertainty (i.e., when depositor 3 observes i) nothing or ii) only a withdrawal) the computation of payoffs is not so straightforward, as the depositor needs to figure out that waiting is the best option for any possible history of decisions that is compatible with what is observed. In addition, the depositor does not know whether waiting (withdrawing) will yield 60 or 140 ECUs (40 or 100 ECUs).

Next we summarize our research questions:

1. Does depositor 3 follow her dominant strategy and wait, regardless of what is being observed?

2. Is depositor 3 more likely to wait when there is no strategic uncertainty (i.e., when the other patient depositor's action is observed) compared with the case in which there is strategic uncertainty (because nothing or only a withdrawal is observed)?

3. What is the predictive power of the Cognitive Reflection Test (CRT) in identifying the dominant strategy? Do cognitive abilities predict behavior in a context with (without) strategic uncertainty?

4 Experimental Design

Two sessions were run at the LINEEX (University of Valencia) during June 2013 using the z-Tree software (Fischbacher, 2007). A total of 60 participants having no previous experience in experiments dealing with coordination problems or financial decisions were recruited from the undergraduate population of the University. All participants in the experiment were Economics or Business students.

The experiment consisted of a total of 15 rounds following 3 trial rounds to become familiar with the software. At the beginning of each round, each participant was informed that she had been matched randomly to another participant in the lab and a third depositor (simulated by the computer) was also assigned to them so as to form a three-depositor bank. Participants played the game explained in section 3.1. They were told that they had deposited 80 ECUs in the common bank and had to decide in each round between waiting or withdrawing. Before making their decisions, participants were privately informed about their position in the sequence of decision (i=1,2,3), which was randomly and exogenously determined. Depositors were also informed about other depositors' decisions, depending on the information structure. In the experiment, we considered all the 8 possible information structures as detailed in section 3.1.[12]

It was common knowledge in our experiment that three depositors formed the bank and the computer was programmed to withdraw always (acting as the impatient depositor). In each round participants were asked to choose between waiting or withdrawing. We note that the position in the line and the information structure changed across rounds (i.e., in each round, participants were placed in a different position or faced a different environment in that their links were different). Participants were made aware of these features.

In both sessions, participants were divided into three matching groups of 10. Participants from different matching groups never interacted with each other throughout the session. At the end of the experiment, participants filled out a questionnaire that was used to collect additional information about gender, the degree of risk aversion and cognitive abilities. We elicited risk attitudes using the investment decision in Gneezy and Potters (1997).

[12]Appendix A contains the instructions.

Each participant hypothetically received 10 Euros and was asked to choose how much of it, x, (s)he wanted to invest in a risky option and how much (s)he wished to keep. The amount invested yielded a dividend equal to $2.5x$ with 1/2 probability, being lost otherwise. The money not invested in the risky option $(10 - x)$ was kept by the participant. In this situation, the expected value of investing is positive and increasing in the amount invested; therefore a risk-neutral (or risk-loving) participant should invest the 10 Euros, whereas a risk-averse participant will invest less. The amount not invested in the risky asset is a natural measure of risk aversion. The questionnaire contained also the CRT in Frederick (2005).

Each session lasted approximately 90 minutes and participants received on average 15 Euros, including the show-up fee of 3 Euros. For the payment, we used a random lottery incentive procedure by which one choice (i.e., one of the rounds) was randomly paid at the end of the experiment, with ECUs being transformed in Euros using the exchange rate 10 ECUs = 1 Euro.

5 Results

Table 1 shows the basic descriptive statistics of the sample. The socio-demographics are presented in panel *i*). This includes information about risk aversion (Gneezy and Potters, 1997), the participant's gender, and the score in the CRT. As for the behavioral data in panel *ii*), we report the frequency of choices that correspond to depositor 3 withdrawing. To assess the importance of strategic uncertainty, we define a dummy variable (I_{SU}) that takes the value 1 when there is strategic uncertainty in position 3 (i.e., I_{SU} takes the value 1 when either nothing or only a withdrawal is observed). To see the importance of the CRT, we report the frequency of withdrawal for participants with CRT equals to (larger than) 0, separately (see Brañas-Garza et al. 2012).

The behavioral data show that withdrawal rate is 10% indicating that most of the time depositors in position 3 recognize the dominant strategy and tend to wait. Panel *ii*) also reveals the role of strategic uncertainty. When depositor 3 makes her decision in the absence of strategic uncertainty, 4% of decisions correspond to withdrawal (17% if there is strategic uncertainty).[13] The relationship between cognitive abilities and the with-

[13]A simple test of proportion suggest that differences are significant at any common

Table 1: Summary of the data

	Mean	**Std.Dev.**	**Min.**	**Max.**
i) Socio-demographics				
Risk aversion	5.58	1.80	0	10
Gender (=1 if female)	0.50	0.50	0	1
Cognitive abilities (CRT)	0.57	0.98	0	3
ii) Behavioral data				
Withdrawal rate	0.10	0.31	0	1
Withdrawal rate ($I_{SU} = 0$)	0.04	0.19	0	1
Withdrawal rate ($I_{SU} = 1$)	0.17	0.38	0	1
Withdrawal rate (CRT = 0)	0.12	0.33	0	1
Withdrawal rate (CRT > 0)	0.07	0.26	0	1

drawal decision is also worth mentioning. The frequency of withdrawal for participants with CRT = 0 is almost twice as much as for participants with CRT > 0.[14] These findings highlight the importance of strategic uncertainty and cognitive abilities on withdrawal decisions (e.g., participants with higher cognitive abilities recognize the dominant strategy more easily.) One interesting question to be addressed concerns the interaction between these two variables.[15]

In order to provide some evidence in that dimension we perform an econometric analysis. We estimate a logit model in which the dependent

significance level ($z = 3.78$, $p - value = 0.0002$)

[14]Grimm and Mengel (2012) use a different division and put participants with a CRT score equal to 3 into one group (*reflective* participants) and the rest into another group. When we group the data using these categories we see that *reflective* participants (CRT=3) do never withdraw, but those with CRT < 3 do it (withdrawal rate equals 11%).

[15]Although we consider that strategic uncertainty and cognitive abilities are the leading explanations for suboptimal behaviour, one may argue that depositors rush to withdraw their money so as to behave according to what they have observed; i.e., depositor 3 may have a preference for conformity (Bikhchandani et al. 1998). If this were the case, depositor 3 would be more likely to withdraw after observing two withdrawals, compared with the case in which only one withdrawal is observed. Our data suggest that conformity cannot explain departures from equilibrium prediction as depositor 3 never withdraws upon observing two withdrawals, witht the withdrawal rate being roughly 17% when only a withdrawal is observed.

variable is the probability that depositor 3 withdraws. Because participants are asked to make decisions during 15 rounds, we follow Garratt and Keister (2009) in using History as a control variable. In our case, History is defined as the share of previous rounds in which the participant observed the other patient depositor withdrawing. We control for the socio-demographics presented in Table 1: risk, gender, and cognitive abilities (i.e., the dummy variable I_{CRT} equals 1 if CRT > 0, being 0 otherwise). We also include a dummy variable to account for strategic uncertainty (I_{SU}). The estimated standard errors in parentheses take into account matching group clustering and are corrected using the Bias Reduced Linearization (Bell and McCaffrey, 2002).[16] This analysis is summarized in Table 2.

Our estimates suggest that cognitive abilities affect the depositor's behavior, but there is an interesting link between their predictive power and strategic uncertainty, as indicated by the first regression where strategic uncertainty and its interaction with CRT are both significant. To disentangle the effect of strategic uncertainty and the CRT, we report in the last two columns the marginal effects for withdrawal decisions with and without strategic uncertainty. The importance of strategic uncertainty is clear from the observed probability, which is estimated to be close to 0% when there is no strategic uncertainty (it is roughly 15% when there is strategic uncertainty). The effect of the CRT is also evident from Table 2. When decisions are made in a context without strategic uncertainty, the dominant strategy is easy to identify and the CRT has no predictive power (p-value = 0.361). The CRT, however, predicts withdrawal decisions if there is strategic uncertainty (p-value = 0.003). Participants who obtain a positive score in the CRT are 15% less likely to withdraw.

Finally, we assess the issue of consistency of choices, which is frequently related to cognitive abilities in the context of risk decisions (Eckel, 1999), time decisions (Burks et al. 2009), and social preferences (Chen et al. 2013). Because decisions are made with and without strategic uncertainty, we can compute for each subject the difference between the frequency of withdrawing in position 3 when there is strategic uncertainty and when there is not.

[16] Our results are invariant if we do not perform this correction, although in that case the standard errors would be biased and we would be more likely to reject the null hypothesis than our p-values would suggest (see Angrist and Pischke, 2008). Our results are also robust if we use the score in the CRT instead of the dummy I_{CRT} as independent variable (see Table 3 in Appendix B for further details).

Table 2: Marginal effects for withdrawal decisions in position 3 after logit estimation.

	Pooled Data	**No Strategic Uncertainty**	**Strategic Uncertainty**
History	-0.178	-0.048	-0.229
	(0.133)	(0.044)	(0.205)
Risk aversion	-0.002	0.0002	-0.009
	(0.006)	(0.001)	(0.014)
Gender (=1 if female)	0.009	0.011	-0.040
	(0.033)	(0.013)	(0.059)
Cognitive abilities (I_{CRT})	0.126	0.032	-0.154**
	(0.033)	(0.035)	(0.051)
Strategic uncert. (I_{SU})	0.198**		
	(0.048)		
I_{CRT} x I_{SU}	-0.086**		
	(0.014)		
Obs. Probability	0.063	0.004	0.149
Wald test	3.3e05**	39.722**	7.598**
Observations	312	154	158

Notes. The set of independent variables include the share of previous rounds in which the participant observed the other patient depositor withdrawing (History), a proxy for risk aversion as measured with the investment decision in Gneezy and Potters (1997), a dummy variable for the participant's gender, a dummy variable I_{CRT} for the score in the Cognitive Reflection Test (CRT) in Frederick (2005), and a dummy variable I_{SU} for the possibility of choosing in a context with strategic uncertainty. The estimated standard errors in parentheses take into account matching group clustering and are corrected using the Bias Reduced Linearization (Bell and McCaffrey, 2002). ** p<0.01, * p<0.05

Note that the larger the difference between these frequencies, the more the subject reacts to strategic uncertainty (i.e., the less consistent decisions are). The Pearson's correlation coefficient suggest that our measure of consistency correlates negatively with the CRT ($\rho = -0.307$, $p - value = 0.032$); i.e., subjects with higher measures of cognitive abilities are less likely to vary their decisions in the presence of strategic uncertainty.

6 Concluding Remarks

This paper is a contribution to the stream of research that investigates the predictive power of cognitive abilities in decision-making. We look at the effect of the CRT on withdrawal decisions in a bank-run situation, as depositors' decisions have been frequently associated to irrational behavior. Our game relies on the seminal model by Diamond and Dybvig (1983) that we extend to allow for observability of actions. Interestingly, the last depositor in the sequence of decisions has a dominant strategy in our setup, and should always keep the money deposited if rational. One characteristic feature of our design is that depositors may observe previous choices, what may affect the degree of strategic uncertainty.

Our data show that the majority of our participants in our bank-run game follow the dominant strategy and tend to wait, with withdrawal rates being low. Observability of actions, however, is an important element at stake in that withdrawals occur more frequently when there is strategic uncertainty. In that context, the CRT has predictive power and participants with higher abilities tend to identify the dominant strategy more easily. Interestingly, the CRT does not predict behavior when there is no strategic uncertainty.

Although we cast our model in a banking environment, run-like phenomena occur in other institutions and markets as well in which investors can easily withdraw their funds or cease to roll over their investment. In such settings our analysis may be valid as well. For instance, Northern Rock, the English bank, was not first run by depositors, but by large creditors who provided short-term funding to the bank and did not renew it. Run-like episodes also occurred in money-market, hedge and pension funds (Baba, McCauley and Ramaswamy, 2009), the repo market (Gorton and Metrick, 2012) and even in bank lending (Ivashina and Scharfstein, 2010). In all these situations depositors or investors may have a dominant strategy to wait and not to act impulsively, but uncertainty about what other depositors have done can foster panicking behavior. This effect is relevant, for instance, for the optimal design of the deposit insurance, which should take into account that in these situations some depositors may run even if the insurance scheme protects them. Our results suggest that more information about previous decisions helps to reduce the probability of suboptimal decisions, a message that is potentially relevant for policymakers.

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Appendix A: Instructions [17]

Welcome to the experiment!

This is an experiment to study decision making, so we are not interested in your particular choices but in individuals' average behavior. Therefore, during the experiment, you will be treated anonymously. Neither the experimenters nor the people in this room will ever know your particular choices.

You will find the instructions on the computer screen explaining how the experiment will unfold. The instructions are the same for all participants in the laboratory and will be read aloud by experimenters. It is important for you to understand the experiment before starting, as the money that you will earn will depend on your choices. You also have a copy of the instructions on your table.

Should you have any problem during the experiment, please raise your hand and remember that you are not allowed to speak with anyone except the experimenter.

Number of rounds

This experiment has 18 rounds in total. The first 3 rounds are for you to become familiar with the software. The remaining 15 rounds will be used to determine your final payoff, so please be sure that you understand the experiment before starting the 4th round. This will help you to earn more money.

Deposits

At the beginning of each round, you will be provided a certain amount of money (80 ECUs) to be deposited in a bank. The bank in which you will invest your money will be formed by 3 depositors: one of them is you, one is someone else in this room and the third depositor is simulated by the computer. Therefore, the bank in which you deposit your money will have 240 ECUs per round in total.

[17] Instructions are originally in Spanish.

Decisions and earnings

In principle, your decision is to choose whether to withdraw your money from the common bank in the first period or to wait until the second period, taking into account that your earnings will depend not only on your choice but also on other depositors' choices. It is important that you know that the computer will always withdraw its money; thus, your earnings in each round will depend only on your choice and the choice of the other depositor in this room.

Specifically, if you both wait until the second period to withdraw your money, you will receive 140 ECUs, corresponding to your initial investment (80 ECUs) plus interest generated during the first period (during which you decided to wait).

If only one of you withdraws the money, then the one who withdraws takes 100 ECUs (which is the same amount that the computer will take in this case). The depositor who waits will receive 60 ECUs (corresponding to the remaining amount in the bank after two withdrawals – 40 ECUs plus an additional 20 ECUs interest).

Finally, it might be the case that both of you withdraw your money in the first period. As a result, your earnings will depend on the available amount of money in the bank and your position in the line. Therefore, if you are at Position 1 or Position 2 in the line and decide to withdraw, you will receive 100 ECUs, but if you are the last one in the line (Position 3), only 40 ECUs remain in the bank, and that is the amount that you will receive.

Therefore, your payoffs can be summarized in the following table:

		In you decide to wait in the first year and withdraw in the second, the…	
Number of previous withdrawals	If you withdraw the first year	If you both wait and only the computer withdraws	If, in addition to the computer, the other depositor withdraws
0	100	140	60
1	100	140	60
2	40	Not applicable	60

Please remember that the depositor simulated by the computer will always withdraw its money in the first period.

Before beginning, please consider that:

1. The person with whom you are linked will change every round. As a result, do not think that you are going to play the whole game with the same person.

2. You will always know your position in the line, but this position might change in each round. In particular, you may be located in Position 1, Position 2 or Position 3 with the same probability. The same is true for the computer.

3. In each round, you will have different information about what the other depositors at your bank have done. Therefore, in some cases, you will know what has happened before you arrived at the bank (number of waitings and withdrawals), but in some other cases, you will not. When you make your choice, you will also know whether someone else will observe your action. It may be in your interest to consider this information when making your decision. This information will appear on the left-hand side of the computer screen.

E.g.: You are at Position 1. Depositors at Position 2 and Position 3 will observe your action.

E.g.: You are at Position 2. The depositor at Position 1 has waited. The depositor at Position 3 will not observe your action.

On the right-hand side of your screen, a small graph shows with whom you are linked (that is, who do you observe and who will observe you). If there is no link between two depositors, the text on the screen indicates that the depositor who decides later cannot observe the action of the other depositor. If you see the symbol "?" , it indicates that you do not know if the other two depositors are linked or not.

Final payoff

When the experiment ends, we randomly choose one of the 15 rounds and pay you according to the earnings from that round. We convert your earnings in that round at a rate 10 ECUs = 1 Euro.

We are now going to start with the first three rounds. At the end of the three rounds, you can ask any questions to ensure that you understand the procedure. If you have any doubts after the first three rounds, please raise your hand and remain silent. You will be attended by the experimenters as soon as possible. Talking is forbidden during this experiment.

Appendix B: Econometric results

This appendix replicates the econometric results of Section 5 for the case in which the score in the CRT (instead of the dummy variable I_{CRT}) is used as independent variable.

Table 3: Marginal effects for withdrawal decisions in position 3 after logit regression

	Pooled Data	**No Strategic Uncertainty**	**Strategic Uncertainty**
History	-0.188	-0.067	-0.226
	(0.127)	(0.040)	(0.188)
Risk aversion	-0.004	-0.0003	-0.007
	(0.004)	(0.001)	(0.012)
Women	0.001	0.008	-0.036
	(0.033)	(0.014)	(0.057)
CRT	0.069	0.016	-0.336**
	(0.034)	(0.014)	(0.120)
Str. Uncert. (SU)	-0.168**		
	(0.041)		
CRT x SU	-0.228**		
	(0.067)		
Obs. Probability	0.066	0.008	0.140
Wald test	6.10 e3**	60.75**	9.54**
Observations	312	154	158

Notes. The set of independent variables include the share of previous rounds in which the participant observed the other patient depositor withdrawing (History), a proxy for risk aversion as measured with the investment decision in Gneezy and Potters (1997), a dummy variable for the participant's gender, the score in the Cognitive Reflection Test (CRT) in Frederick (2005), and a dummy variable for the possibility of choosing in a context with strategic uncertainty (SU). The estimated standard errors in parentheses take into account matching group clustering and are corrected using the Bias Reduced Linearization (Bell and McCaffrey, 2002). ** $p<0.01$, * $p<0.05$