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## Article

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## **Temptation and Retirement Accounts: A Story of Time Inconsistency and Bounded Rationality**

*By Florina Salaghe<sup>\*</sup>, Dimitra Papadovasilaki<sup>±</sup>, Federico Guerrero<sup>♣</sup>  
& James Sundali<sup>♦</sup>*

*Research shows that American workers tend to under-save for retirement. Some studies attribute the under-saving to a lack of self-control and time inconsistent saving plans, while others use the bounded rationality of retirement account holders as an alternative explanation. In this paper we ran a laboratory experiment using subjects residing in the U.S., to further explore the relationship between under-saving for retirement and investment decisions, in the context of an asset allocation game. A theoretical framework that can account for both time inconsistent (investment) behavior and boundedly rational (investment) choices is given by the “absent-minded driver’s (AMD) paradox” decision-making game of Piccione and Rubinstein (1997). The main idea of the AMD paradox is that (investment) plans that were optimal at the planning stage may no longer be optimal at decision time even if no new information and/or no change in preferences occurs. The contribution of this paper is twofold. First, our paper is the first to apply the AMD paradox to the study of asset allocation decisions in the laboratory. Second, we find that temptation and potentially boundedly rational choices seem to affect a significant number of subjects by inducing them to abandon their optimal investment plans in favor of luring potential returns offered by riskier assets. (JEL D14, D15, G11, C91)*

**Keywords:** *Absent-Mindedness, Asset Allocations, Imperfect Recall, Retirement Saving, Time Inconsistency, Temptation.*

### **Introduction**

Demographic shifts and an aging population, have led to increased social problems such as a diminishing base to fund social security payments. One of the solutions that policy makers have implemented in the U.S. is the privatization of Social Security and the shifting of the responsibility of retirement asset accumulation from the government to the individual level. However, mounting evidence suggests individuals have a difficult time accumulating enough funds in their retirement accounts, even though financial planning services are widely available and affordable, and tax incentives are in place to encourage retirement savings.

The literature attempting to explain inadequate levels of asset accumulation in

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individual retirement accounts has primarily focused on the issue of under-saving. While under-saving is certainly a critical issue, in this paper we focus on the mistakes people make regarding asset allocation between safe and risky choices. Specifically, we concentrate on the role of distractions and the inability of investors to stay on a prudent investment path in the face of risky temptations.

Drawing inspiration from the “absent-minded driver’s (AMD) paradox” introduced by Piccione and Rubinstein in 1997, this paper seeks to address the lack of a theoretical framework to explain the type of time inconsistent behavior that is observed when it comes to retirement savings. The AMD model is a single player game that studies the possibility that temptation may induce rational individuals to deviate from previously chosen optimal plans. The model provides a game-theoretic foundation to study time inconsistent behavior in asset allocation decisions. Models of time inconsistent behavior help explain the insufficient saving levels in individual retirement accounts but have not been applied to explain the inconsistent asset allocation decisions.

Our paper should be of interest to a few different audiences. First, theoreticians and scholars interested in the development of the consequences of the AMD model under pure strategies should find our experiment intriguing. Second, our paper should be of interest to behavioral scientists studying strategies to overcome time-inconsistent asset allocation decisions in saving for retirement. Third, the paper makes a methodological suggestion for the study of inter-temporal decisions in the laboratory and in that regard, should also be of interest to experimental economists and psychologists specialized in the study of inter-temporal decision-making.

## Literature Review

The burden of saving for retirement in the U.S. is shifting from a social responsibility (Social Security) to an individual responsibility. Employers in the private sector are switching from Defined Benefit Pension plans to Defined Contribution plans to shift the investment risk to their employees (Morrissey 2016). The outcome of this shift is a general decline in the participation of employees in retirement plans, especially in the new millennium. According to Morrissey (2016), the share of families participating in retirement plans has dropped from 28% in 2001 to 21% in 2013, while about half of the American workers are not given access to a retirement plan by their employers (Benartzi and Thaler 2013). Except for a relatively dated academic study (Scholz et al. 2006, using HRS (Health and Retirement Survey) primary data for the years 1992 and 1993), most of the recent studies show that Americans reach retirement age with inadequate levels of savings in their individual retirement accounts (Gale et al. 2012, Rhee 2013).

Evidence that Americans are under-saving for retirement is not limited to survey data on retirement accounts. There is indirect evidence from studies of consumption patterns that suggest a similar result. In an early contribution, Hamermesh (1984) found that consumption falls sharply as households move

into retirement. This finding was later complemented by Bernheim et al. (2001) who found that the consumption drop is sharper for households with less generous pensions and social security benefits. Furthermore, unless one assumes that American consumers are perfect inter-temporal optimizers, it is difficult to claim that this is a simple reflection of underlying preferences. Bernheim (1995) writes: “If saving reflects rational, far sighted optimization, then low saving is simply an expression of preferences. If, however, households are short-sighted, boundedly rational, dynamically inconsistent, impulsive, or prone to regret, then the adequacy of saving is a well-posed and important empirical issue”.

The literature on optimal consumption, labor effort, investment and retirement decisions is rich and well-developed (Fahri and Panageas 2007, Choi et al. 2008, Dybvig and Liu 2010, Barucci and Marazzina 2012). Barucci and Marazzina (2012) is perhaps the contribution most closely connected with the issue of underfunded individual retirement accounts at the time of retirement. In incomplete market setups in which the risky asset does not act as a hedge (i.e., the returns of the risky asset are positively correlated with labor income changes), Barucci and Marazzina (2012: 5589) have shown that labor effort and the share of the risky asset in the portfolio both decline whereas consumption goes up, as opportunities to cover against risk decline. In other words, in contexts where hedging and insurance opportunities are restricted, “agents act in a myopic way and consume a lot”.

The standard tradition of economics assumes that individuals face no problems solving their inter-temporal optimization problems. While that is a natural starting point to advance our understanding of the inter-relationships between consumption, portfolio investment and retirement decisions, there are serious reasons to start considering the problems introduced by limited rationality. As Carroll (2001: 41) bluntly puts it, “One problem is the spectacular contrast between the sophisticated mathematical apparatus required to solve the optimal consumption problem and the mathematical imbecility of most consumers”. Additionally, the evidence from both survey data (see Lusardi and Mitchell 2007, for example) and from the laboratory (Brown et al. 2009, for example) suggest that bounded rationality is indeed a large obstacle preventing individuals from adopting the optimal strategies implied by inter-temporal optimization models.

Munnell et al. (2016) investigate whether households save enough over their lifetime to maintain their pre-retirement standard of living, while trying to eliminate the restrictive behavioral assumptions of previous studies. Their findings suggest that studies that concluded that under-saving is not an issue are based on behavioral assumptions “that may not reflect real world activity or on a snapshot of consumption levels that are unsustainable in the long run”. They conclude that future retirees will be less prepared than past retirees and that more than half of the households will under-save for retirement. Munnell et al. (2014) also predict that in the coming decades a large segment of retirees will live below the poverty line. Johnson et al. (2017) find that when individuals who were born between 1976 and 1985 become 70 years old, their inflation-adjusted average annual household earnings will be less than 75% of the average wages earned from ages 50 to 54.

Another under-saving explanation is that a significant fraction of Americans are not “financially literate”. Lusardi and Mitchell (2007) show that a non-trivial percentage of Americans is unable to calculate percentages, compound interest, or division of funds. For those individuals, it is clearly far-fetched to assume that they can solve for the optimal saving policies implied in the standard models of rational consumer behavior with a buffer stock motive and habit formation (Carroll et al. 2000). Thus, part of under saving can be explained by the lack of financial literacy and the positive association with the difficulty of solving for the optimal savings rate and choosing optimal investment strategies.

The literature explaining under-saving for retirement has focused on the role played by two main behavioral assumptions: present bias (i.e., a preference for immediacy) and bounded rationality. The literature on present bias is abundant and includes models of hyperbolic discounting and quasi-hyperbolic discounting (so-called delta-beta models) à la Laibson (1997), as well as dual-self models stressing self-control (or lack thereof). The literature on the effects of bounded rationality on under-saving is also extensive. Previous experimental literature, finding evidence of under-saving and attributing it to different forms of bounded rationality, includes but it is not limited to: Hey and Dardanoni (1988), Fehr and Zych (1998), Kotlikoff (2001), Ballinger et al. (2003), Ballinger et al. (2007) and Sass and Mercado (2015).

Planning and its role in individuals’ savings, investment and wealth accumulation is a crucial piece of the puzzle in understanding why households do not develop adequate savings plans. Ameriks et al. (2003) find that financial planning is positively related to wealth for households that otherwise have very similar demographic characteristics. However, we often observe a discrepancy between planning and acting, not only when it comes to financial matters but almost all other domains such as dieting and exercise. Many psychologists and economists alike “blame” it on issues of self-control and will power that stand in the way of plans turning into actions. According to Benartzi and Thaler (2013: 1152) “self-control is easier to accept if delayed rather than immediate”. Instead, individuals deviate from their plans because of temptation. Being impatient and having myopic views on future consumption, individuals prefer present indulgence and disregard the carefully thought out planning by financial experts or themselves. Further, Benartzi and Thaler (2007) suggest that individuals spend less than one hour determining how much their savings’ rate should be. Ameriks et al. (2007) find that self-control is related to wealth accumulation, especially liquid wealth, and age, while Benartzi and Thaler (1999), suggest that the way investors think about their future decisions, such as retirement plans, depends on how the relative risk and return data are presented to them, displaying myopic loss aversion.

Sass and Mercado (2015) find that workers themselves recognize their limited discipline managing even daily finances, let alone future ones. Americans, regardless of their age or income level, are found to be shortsighted when it comes to addressing future financial issues. Sass and Mercado (2015) estimate that financial satisfaction is influenced more by current financial problems as opposed to distant ones. Current financial problems include difficulty in covering

expenses, heavy current debt burdens, unemployment, and inability to access \$2000. Distant financial problems included no medical insurance, no life insurance, no retirement plan, no college savings, and underwater mortgages. All current financial problems were found to be statistically significant predictors in reducing one's financial satisfaction, while among distant problems only not saving for college and not having medical insurance were found to have a negative and statistically significant impact on financial satisfaction. Having neither Defined Benefit nor Defined Contribution, did not seem to matter to financial satisfaction, even to those belonging to age groups that were approaching retirement. However, labor market developments such as deterioration in employment conditions, declining real wages, and increased income inequality, contributed to a short-term emphasis on consumption spending for a large fraction of the US labor force. Retirement plans seemed to be important only to those that belonged in the top income decile, suggesting that low income individuals might experience even worse economic conditions in the future and a deepening of the income inequality among retirees.

Clearly there are numerous behavioral problems that contribute to the lack of adequate financial assets in retirement. While no single theory can provide a comprehensive framework for all these problems, we believe the AMD model is rich enough to accommodate many explanations. The AMD model incorporates several of the concepts previously discussed: there is bounded rationality because the individual suffers from absent-mindedness and imperfect recall; temptation in that the object of desire (i.e. the risky asset providing high returns) becomes tempting only to the future self (the decision-maker), but not to the planner (the present self). Thus, we choose the AMD model to explain inadequate levels of funds in individuals' retirement accounts. In contrast to the existing literature on bounded rationality, the limits on rationality, in our study, are connected to the investment component of the saving for retirement process, and not with under-saving per se. That is, we do not focus on the amount saved but on how the funds for retirement are invested, to ensure an adequate level of consumption during retirement years. We next provide a review of the absent-minded driver's paradox.

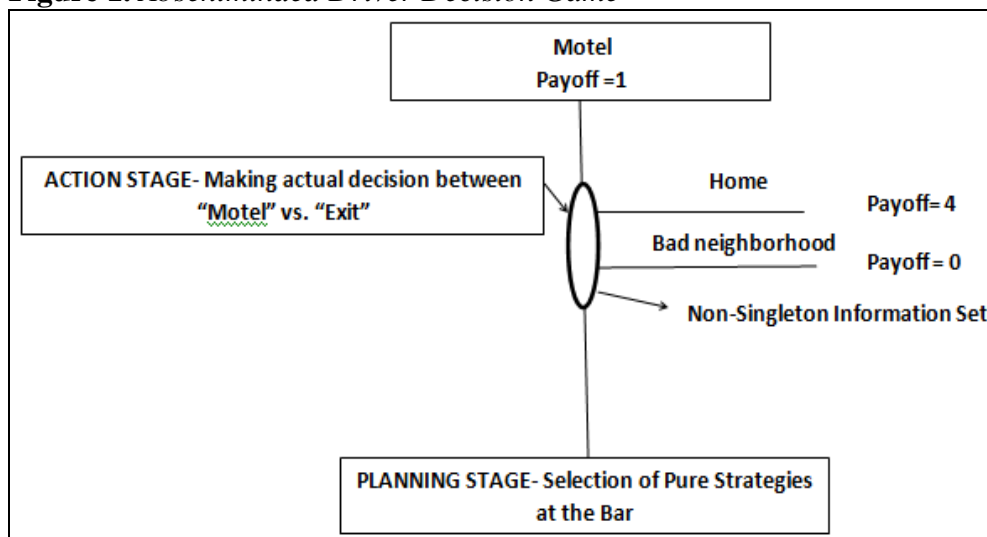
### **The Absent-Minded Driver's Paradox**

In their paper, "On the Interpretation of Decision Problems with Imperfect Recall", Piccione and Rubinstein (1997) offer a theoretical framework where time inconsistent decisions are optimal in a one person, two selves, one shot decision-making game. The simple one-person game introduced by Piccione and Rubinstein (1997) is summarized by Figure 1 below. The paradox of the absent-minded driver stems from two different ways of reasoning that lead to two conflicting equilibria between the two stages of the game: the planning stage, when the driver is sitting at the bar planning his midnight trip home; and the action stage, when he is driving down the highway. According to Piccione and Rubinstein (1997), one way of reasoning about the problem leads the driver to

stick to the plan and continue to drive down the highway when reaching an intersection. Piccione and Rubinstein (1997: 8) write: “having chosen an optimal strategy, one does not have to verify its optimality at the time of execution unless there is a change in information or in preferences”. The second way of reasoning, “which calls at each instance to maximize expected payoffs given the relevant beliefs” leads to taking the exit when reaching the intersection.

Imagine an absent-minded driver sitting in a bar planning his trip home. He knows that to get home he needs to take the highway and correctly identify and take the exit that leads home. However, if he takes the wrong exit, he ends up in a bad neighborhood and cannot return to the highway to get home. While sitting at the bar, the driver knows that he is absent-minded and will not be able to correctly identify the exit when he reaches it, so he decides his optimal strategy is to continue driving until the end of the highway and spend the night at the motel. However, when he leaves the bar to drive to the motel, although there is no change in preferences and no new information, the driver forms beliefs regarding where he is on the highway and decides to take the risk of exiting the highway rather than continuing on to the motel.

**Figure 1.** *Absentminded Driver Decision Game*



Source: Authors.

The paradox of the absent-minded driver stems from two different ways of reasoning that lead to two conflicting equilibria between the two stages of the game: the planning stage, when the driver is sitting at the bar planning his midnight trip home; and the action stage, when he is driving down the highway. According to Piccione and Rubinstein (1997), one way of reasoning about the problem leads the driver to stick to the plan and continue to drive down the highway when reaching an intersection. Piccione and Rubinstein (1997: 8) write: “having chosen an optimal strategy, one does not have to verify its optimality at the time of execution unless there is a change in information or in preferences”. The second way of reasoning, “which calls at each instance to maximize expected payoffs given the relevant beliefs” leads to taking the exit when reaching the

intersection.

In the first way of reasoning the equilibrium of the game consists of planning on going to the motel while at the bar and sticking to this strategy when the critical junction is reached on the highway. However, based on the second way of reasoning the driver forms beliefs about where he is on the highway and should take them into account when choosing whether to take the exit. Piccione and Rubinstein (1997) prove mathematically that unless the driver believes he is at the bad exit with certainty, he should choose to exit and maximize his expected payoff (accounting for his beliefs regarding the critical junction). Thus, one equilibrium dictates sticking to the original plan and driving to the motel while the second suggests it is optimal to deviate from the plan during the action stage (i.e., taking the exit). At this point, one should also note that in order to obtain the PR equilibrium, the type of thinking at the planning stage has to be deterministic, of the type “either or” (“should I plan to stay on the road or to exit”?) and of a clear normative nature (“what *should* I do for my own good?”), whereas the type of thinking at decision time becomes probabilistic and lacks a strong normative component.

### **The Absent-Minded Investor’s Game**

Adapting the absent-minded driver’s game to an absent-minded investor’s game, we used a road to retirement analogy as presented in Figure 2 below. In this game an investor chooses an investment strategy in two different stages: the planning and the action stage. In the first stage the investor can choose either a safe asset (payoff of 1) or a risky asset (payoff of 0 or 4) whose payoff is determined by chance. After choosing a strategy in the planning stage, the player then proceeds down the “investment highway” until he reaches the action stage (highway exit) where he again chooses between the safe or risky asset. The structure of the investor’s game is identical to the absent-minded driver’s game.

The intuition behind the investor’s game is the following. In the presence of absent-mindedness, that can come from either imperfect recall or bounded rationality, optimal strategies can change between the planning and the action stage without the arrival of new information and/or a change in preferences. Belief formation plays an essential part in finding the optimal strategy which led to the analogy of an uncertain investor. An investor may be uncertain about where she is in the financial cycle or, whether a new company stock is truly a “rock star” (will continue to display above average returns) or a “one hit wonder” (the stock price will plummet at some point in the near future and the company will go bankrupt)<sup>1</sup>. Since there is no way of knowing *ex ante*, investors base their decisions on beliefs they form with regards to where they are in the financial cycle or the real type of the company they are investing in. Regardless of the true type, they get tempted by the potential high returns that

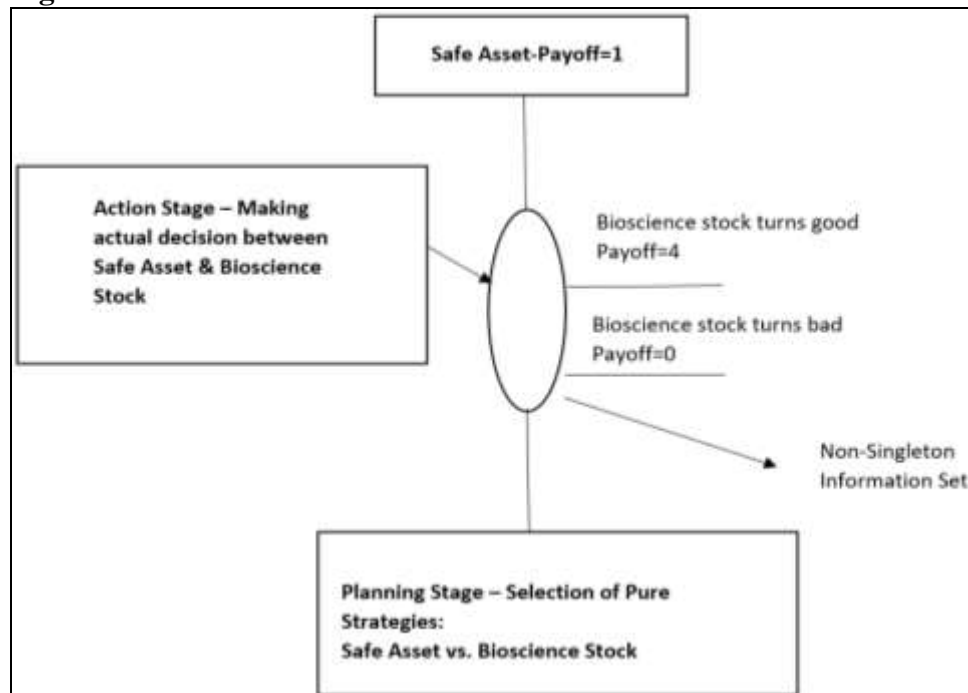
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<sup>1</sup>As an example, the reader might think of the dot-com bubble from the late 1990’s when some companies were truly innovative and survived the financial crisis, such as Amazon, while others disappeared when the bubble burst, such as Pets.com.



they don't want to miss out on, regardless of what a closer analysis might reveal.

**Figure 2.** *Absentminded Investor Decision Game*



Source: Authors.

Just as in the AMD game, the investor's game has two possible equilibria: 1. Choosing to invest in the safe asset in the planning stage and not deviating during the action stage (we refer to this equilibrium as the traditional economic theory equilibrium); 2. Planning to invest in the safe asset but choosing to switch to the risky asset in the action stage (we call this equilibrium the PR equilibrium).<sup>2</sup>

### Pilot Studies 1-5

The investment game is framed as a one-shot "retirement" asset allocation task between two assets. The safe asset is a balanced index of stocks and bonds that provides a guaranteed return of 1 unit. The risky asset is a Bioscience company stock that has a 50/50 chance of returning 0 or 4 units.

The implementation of the experiment turned out to be quite challenging methodologically since it is not a standard game for which procedures are well-known. The two features of the experiment that were particularly troublesome included correctly framing the experiment as an asset allocation retirement task and creating a true state of uncertainty at the action stage. Next, we briefly describe the results of five pilot studies conducted to test and refine the parameters of the experiment.

Subjects for the pilot studies were recruited through an advertisement sent

<sup>2</sup>A more detailed explanation of the experiment is provided in the Appendix 1.

out in the campus mail to all University of Nevada, Reno staff employees (approximately 1400), as well as through posting on SONA, an online software for human subject recruitment within the campus. The advertisement stated that a subject could earn between \$5.00 and \$21.00 depending on their performance for participating in a one-hour experiment on finance/economic decision making.

The Pilot Studies all had the same basic setup in which subjects were asked to make investment choices in the planning and action stages as shown in Figure 2 above. In Pilots Studies 1-3 we observed that a large number of subjects did not choose the optimal (pure) strategy at the planning stage (the choice of the safe asset) when the question about their plans concerning the asset to invest in was formulated as a positive statement (“What asset do you plan to choose...?”). Therefore, in Pilots 4 and 5 we reformulated the question as a normative one: “What asset should you plan to choose...?” Results from pilot studies 4 and 5 showed that the normative nature of the question enforced the selection of the pure dominant strategy at the planning stage. We believe this is a very important lesson in financial planning: when saving for retirement people need to be reminded about their long-term goal and the normative implications of their plans.

A critical component of the game is to deliver the subjects to the action stage in a state of uncertainty. To implement such uncertainty, after the action stage, and keeping a highway to retirement analogy, the subjects were given the task of counting exit signs in a video game, flashing at relatively fast speeds, as a way of identifying the “good” and “bad” exits (associated with a high and low payoff respectively). The purpose of this task was to induce absentmindedness similar to the driver from the bar in the AMD paradox. Pilot studies four and five were conducted to calibrate the speed of the flashing exit signs to induce absent-mindedness in the decision-making process. Our intent was to make the flashing exit signs impossible to count without discouraging the participants from trying. This is the equivalent of the driver not being able to distinguish with certainty the good from the bad exit, while driving down the highway. After Pilot Study 5, we identified the correct calibration for the speed of the flashing signs and were ready to proceed with a full experiment which we describe next.

## **Experiment on the Absent-Minded Investor’s Game**

### *Experimental Procedures*

The experiment took place at Lake Forest College, a liberal arts college in Illinois, U.S. Subjects were recruited through an advertisement sent out on campus email to all Lake Forest College staff employees and some students. The experiment was conducted in a computer lab in the Lake Forest College library.

Upon arrival, each subject received a copy of the human subject consent form and task instructions. The experiment began with the reading aloud of the consent form. After consent was obtained, each subject received a \$5.00 show-up fee. Since the recruitment advertisement stated that subjects would receive a minimum compensation of \$5.00, the show-up fee was given to fulfill this

promise. Subjects were then told that any further compensation in the experiment was contingent on their performance in an asset allocation task. Then, each subject filled the financial portion of DOSPERT that is used to measure relative risk attitudes.

The experiment continued with the reading aloud of the instructions<sup>3</sup>. During this process, subjects were given many opportunities to ask questions. The Principal Investigator navigated all the subjects through the experimental task simultaneously and thus all subjects completed the experimental task at a similar pace. The total duration of the experiment was about 45 minutes.

After the experimental task was completed, each subject filled out a short questionnaire regarding demographic and other questions, and a receipt documenting their earnings. Subjects then walked to the back of the room where they were paid individually and anonymously in cash for their performance, thanked, and dismissed from the laboratory.

### *The Experimental Task*

The experimental instructions explained that subjects would engage in a one-shot “retirement” asset allocation task between a safe and a risky asset. The safe asset paid 1 experimental dollar and the risky asset paid 4 experimental dollars. Subjects were then told that the experimental dollars would be converted into real dollars at the end of the experiment. For example, a payoff of 4 experimental dollars would be associated with four times more earnings compared to a payoff of 1 experimental dollar. The actual conversion rate was revealed after the asset allocation game was over and for each experimental dollar subjects received \$4-real dollars (conversion rate of 1 to 4). The decision of revealing the conversion rate after the experimental game had concluded was meant to ensure that players had relative, not absolute payoffs in mind during the game. This way, the implications of the experiment can be generalized and do not apply solely to the comparison of 4-real dollars to 16-real dollars.

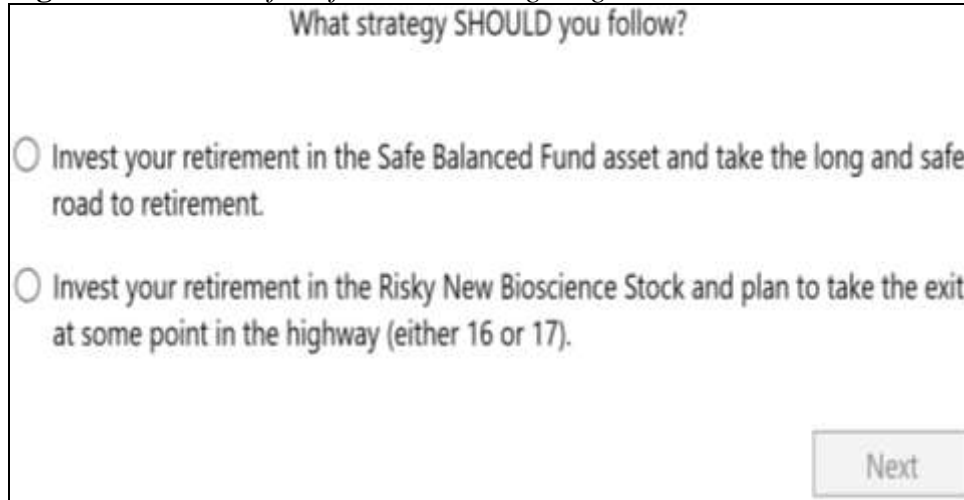
The instructions indicated that participants should frame their decision as an analogy between an absent-minded investor who is saving for retirement and is not sure whether risky assets will turn out to be good or bad, and an absent-minded driver who is driving on the highway and isn’t sure which exit to take to get home. Instructions stated the following: *“The safe option for the driver is to take the highway and drive all the way to the end where she can spend the night at a motel. The driver can get to the motel with certainty as there are no exits that she needs to take. Similarly, the investor can choose the safe road to retirement and invest her retirement savings in the safe asset. The risky option for the driver is to take an exit, knowing that she can’t get back on the highway if it is the wrong one. If she takes the wrong exit she ends up in a bad neighborhood (associated with a payoff of zero), while if she takes the exit and it turns out to be the correct one, she ends up home (associated with the highest payoff). The analogous of taking the exit for the investor is to invest in the risky stock, not knowing whether it will have a high or low payoff.”* Subjects were

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<sup>3</sup>A copy of the instructions is provided in the Appendix 1.

told that the experimental task had two stages, a planning stage and an action stage. In the planning stage subjects had to answer the question shown in Figure 3 below.

**Figure 3.** *User Interface for the Planning Stage*



What strategy SHOULD you follow?

☐ Invest your retirement in the Safe Balanced Fund asset and take the long and safe road to retirement.

☐ Invest your retirement in the Risky New Bioscience Stock and plan to take the exit at some point in the highway (either 16 or 17).

Next

Source: Authors.

The question in the planning stage was formulated as a normative question, using the word “should.” As discussed earlier, the results from Pilot Study 3 indicate that framing the question in a normative way helped subjects realize that the first stage was referring to a plan and not an action.

After subjects reported what strategy they should follow, they clicked the “Next” button. The following screen prompted them to answer, “Why did you choose this strategy?” After answering, subjects clicked “Next” and the image presented in Figure 3 appeared.

The highway shown in Figure 4 was used as an analogy between the absent-minded investor saving for retirement and the absent-minded driver that might get distracted while driving on the highway. Subjects were told that flashing exit signs would pop up on their computer screen to replicate their fictional movement along the retirement road. Their task would be to try to count the rapidly flashing Exit signs in order to identify which exit they were at. Correctly identifying the exit is akin to knowing whether the risky asset is good or bad.

Subjects were told again that it is impossible to know in advance whether the risky asset will turn out to be good or bad, and the only way to figure this out would be to try and count the rapidly flashing exit signs. Figure 5 above shows the flashing exit signs as presented to the participants.

**Figure 4.** User Interface for Road to Retirement Analogy

Source: Authors.

**Figure 5.** User Interface for Counting Flashing Exit Signs

Source: Authors.

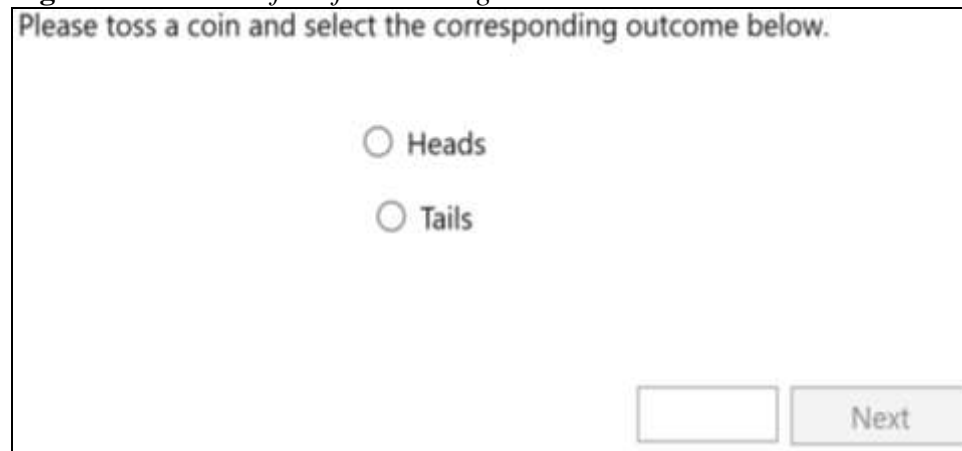
Subjects were then given the opportunity to practice “counting exits” in an uncompensated round. After the exit signs flashed on the screens, subjects were asked, “Which exit do you think you are at?” Subjects answered and received feedback as of whether they were correct or wrong.

Subjects then continued to the “action stage” of the experiment after being told that, “*the highway has a critical region comprising of Exit 16 and Exit 17. After counting the flashing exits you will arrive at the critical region. There you will have to decide if you want to continue on the highway or take an Exit. If you decide to continue on the highway, you take no risk and you will get a payoff of 1 experimental dollar, corresponding to investing in the safe asset. In other words, imagine as if you decided to invest your retirement in the balanced index of Treasury bonds and stocks of large American companies. If you decide to take the Exit then you will either get a payoff of zero experimental dollars, which is akin to having picked the wrong bioscience stock, or you will get a payoff of 4 experimental dollars, which is akin to having guessed correctly and picked the right bioscience stock.*”

Chance determined whether subjects saw 16 or 17 flashing exit signs, i.e., whether the new bioscience stock would provide the good or the bad payoff. To introduce chance in the experiment we used a coin toss. All subjects were provided with a coin that they had to toss and enter the outcome on their screen, as shown in Figure 6 below. The software was programmed such that clicking “Heads”

was the bad exit and “Tails” was the good exit.

**Figure 6.** *User Interface for Entering the Coin Toss Outcome*

The image shows a user interface window with a light gray background. At the top, there is a text prompt: "Please toss a coin and select the corresponding outcome below." Below this prompt, there are two radio button options: "Heads" and "Tails". The "Heads" option is selected, indicated by a small black dot inside the circle. At the bottom right of the window, there are two buttons: an empty rectangular input field and a button labeled "Next".

Source: Authors.

Subjects were then told that the action stage would begin next. Subjects had to count the flashing exits that popped on their screens in the next 30 seconds. The speed of the flashing signs was 0.1 seconds, and each flashing sign popped up every 0.05 seconds. The relatively high speed of the flashing exit signs was meant to ensure the impossibility of identifying the correct exit with certainty through counting, while at the same time not constituting a deterrent for subjects to at least try counting. The flashing speeds were determined by trial and error in the pilot studies. Specifically, in Pilot 1 signs were set to flash at a speed of 0.13 seconds, which, as we were to discover, turned out to be too slow, convincing subjects that identifying the “good” risky asset is not only possible, but very doable, thus denying the logic intrinsic in the Piccione and Rubinstein (1997) decision-making game. For this reason, in pilot studies 2 and 3, we speed up the rate of the flashing exit signs at 0.075 seconds. The speed turned out to be excessively fast, making the task of counting flashing exit signs humanly impossible, discouraging subjects from even trying to count the signs. Accordingly, the speed of the regular-sized flashing exit signs was set at 0.10 seconds, which is between the 0.13 seconds of pilot 1 and the 0.075 of pilot 2 and 3.

After all flashing exits popped up, subjects had to decide whether they would exit, or not. Before deciding, subjects had to answer the question shown in Figure 7 below.

**Figure 7.** User Interface for Belief Assessment at the Action Stage

Questions on Beliefs about HERE (PAPER-based)	
Question: What's your best guess that you have counted the flashing exit signs correctly and that you know where you are on the highway? Options:	
1.	Probability of having counted correctly = 1 (or 100%)
2.	Probability of having counted correctly = 0.9 (or 90%)
3.	Probability of having counted correctly = 0.8 (or 80%)
4.	Probability of having counted correctly = 0.7 (or 70%)
5.	Probability of having counted correctly = 0.6 (or 60%)
6.	Probability of having counted correctly = 0.5 (or 50%)
7.	Probability of having counted correctly = 0.4 (or 40%)
8.	Probability of having counted correctly = 0.3 (or 30%)
9.	Probability of having counted correctly = 0.2 (or 20%)
10.	Probability of having counted correctly = 0.1 (or 10%)
11.	Probability of having counted correctly = 0 (or 0%)

Source: Authors.

Subjects were then given the formula to calculate the expected value of “exiting the road”, given their guess about having counted the flashing signs correctly, as:

$$\text{Prob (correct count)} * 4 + \text{Prob (incorrect count)} * 0 = X.$$

Following, subjects compared the alternatives of staying on the road and receiving a certain payoff of 1 experimental dollar, with exiting the road and receiving the calculated expected value. Subjects made their decision in the action stage by answering the question shown in Figure 8 below.

**Figure 8.** User Interface for Choosing a Strategy in the Action Stage

Do you want to exit now?

☐ Yes

☐ No

Next

Source: Authors.

**Figure 9.** User Interface Belief Assessment Post Counting

In which exit do you think you are at?

☐ 16

☐ 17

☐ I don't know

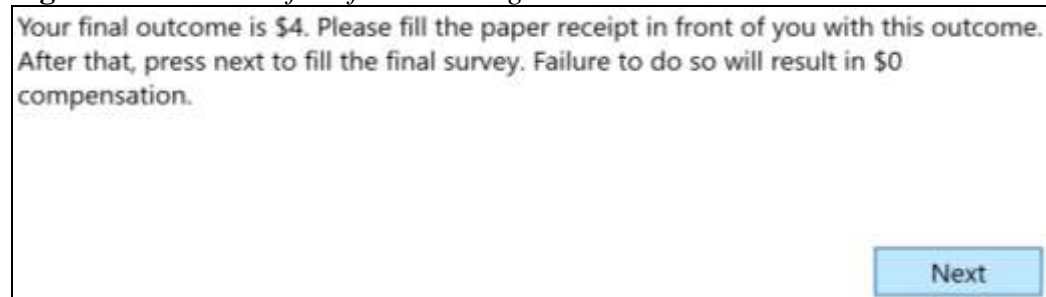
Next

After subjects chose Yes or No they clicked the “Next” button, and they were prompted on to the next screen, where they had to explain why they chose

whether to exit or not. After that, subjects reported which exit they thought they were at, as shown in Figure 9 above.

The last screen subjects saw was the outcome of their choice and the associated payoff. For example, a subject who got “Tails” in the coin toss exercise and decided to exit in the action stage, would see the message shown in Figure 10 below.

**Figure 10.** *User Interface for Revealing the Game Outcome*



Source: Authors.

### *Experiment Results*

Twenty-seven subjects participated in the experiment. The subject pool is 48% females, and 52% males. Most of the participants were college students. The average age of the participants is 21.7 years old, with 78% in the 18-22 age bracket, 20% in the 23-25 bracket, and 2% above 25 years old. In terms of investment experience, 52% reported having some, and 48% reported no investment experience. Also, 52% of the subjects claimed to have experienced a traumatic event, which might affect their subsequent risk attitudes.

In our single shot game, there are two possible equilibria as in the absent-minded driver paradox: one equilibrium that stems from traditional economic theory and suggests that once an optimal strategy has been chosen it should not be revised if there is no change in preferences and no new information (traditional economic theory equilibrium); and another that accounts for belief formation and postulates that one should always maximize expected payoffs (PR equilibrium). Playing according to traditional economic theory is equivalent to planning on investing in the safe asset and choosing the safe asset in the action stage. Playing according to the reasoning introduced by Piccione and Rubinstein (1997) is equivalent to planning on investing in the safe asset but choosing the risky asset in the action stage. Thus, we group participants based on the strategy they play in the two stages of the game as: “safe-safe” with players that plan to invest in the safe asset and choose the safe asset in the action stage (equivalent to playing the traditional economic theory equilibrium); the “safe-risky” category with players that plan to invest in the safe asset but end up deviating from their original plan in the action stage by choosing to invest in the risky asset (equivalent to playing the PR equilibrium); the “other” category with players that either planned and invested in the risky asset or planned to invest in the risky and then chose the safe option in the action stage.



As shown in Table 1 below, 88.89% (24 out of 27) of the participants played either the “safe-safe” or the “safe-risky” equilibria, while 11.11% played the “other” strategies. Out of the total participants, 60% seemed to have constant preferences and followed the “safe-safe” strategy, while 30% followed the “safe-risky” strategy. The gender distribution among participants who played each of the 3 strategies is also shown in Table 1 below.

**Table 1.** *Strategy and Gender Distribution*

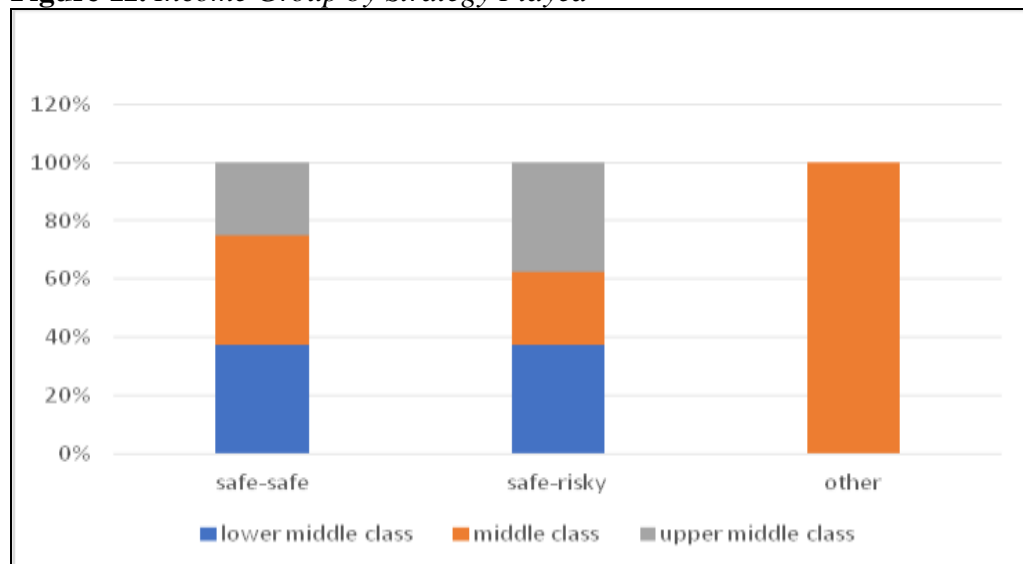
Strategy	Gender		Total
	Male	Female	
Safe-safe	8	8	16
Safe-risky	4	4	8
Other	2	1	3
Total	14	13	27

Source: Authors.

As shown in Table 1 there are no gender effects in following different strategies. The same number of males and females play either the “safe-safe” or the “safe-risky” strategy.

Figure 11 below compares the income distribution by strategy. The “other” group is composed solely of middle-class participants, while the “safe-safe” and the “safe-risky” contain all three income groups (with subjects who grew up in lower middle class, middle class, and upper middle class). Specifically, the “safe-risky” group has a slightly higher percentage of participants having grown up in the upper middle class, and slightly less participants in the middle class, compared to the “safe-safe” group.

**Figure 11.** *Income Group by Strategy Played*



Source: Authors.

A potential explanation for the income distribution across the different strategy groups is that richer families can afford to take more risk and thus, are more susceptible to temptation compared to families from lower income categories who exhibit more self-control and discipline. Indeed, individuals in the upper middle class display higher scores on the DOSPERT scale of risk seeking attitudes, providing some support to the aforementioned interpretation.

The experimental results suggest risk seeking attitudes are not likely to be the reason subjects change their initial retirement allocations to riskier assets, since the DOSPERT survey shows that only 3 out of the 27 participants were risk seeking, while the rest were risk averse. All subjects playing the “safe-risky” equilibrium are risk averse. One would perhaps expect that because these subjects are risk averse, they would follow the traditional economic theory and stick to the safe asset, but that can only be true in the absence of temptation. The fact that risk averse individuals deviate from their original (optimal) plans suggests that either temptation or bounded rationality, or both, might play a role in the decision making process.

Combining the previous observations, results suggest that temptation and absentmindedness may be causing participants to deviate at the action stage. Furthermore, participants with milder levels of risk aversion are the ones who mostly tend to deviate from their optimal plans. Given the small number of subjects in each category, these interpretations are highly conjectural and subject to potential revision by further research using significantly larger samples.

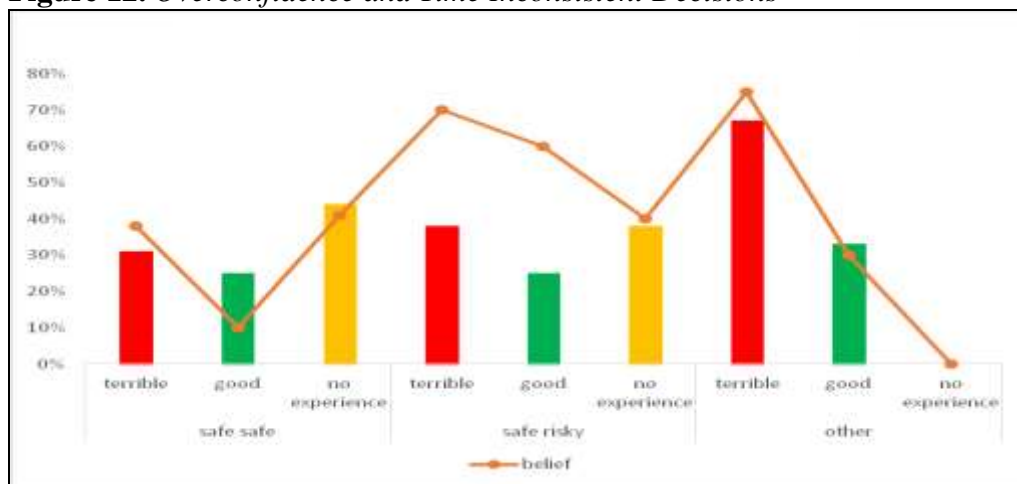
The results from our experiment indicate that most players choose the optimal strategy in the planning stage and do not deviate in the action stage, further reinforcing the idea that a large component of the under-funding of retirement accounts has to do with unsuccessful investment choices. In other words, we believe that an important issue, so far ignored by the literature, might be that individuals mismanage their savings by falling prey to temptation or distractions and thereby making poor investment decisions. Of course, we keep in mind the limitations of our study, and mainly the fact that this is a one-shot game that doesn't exactly replicate real life situations where individuals are faced with repeated decisions regarding their asset allocations using savings from their retirement account. However, there is some related evidence that individuals display bounded rationality in repeated asset allocation games as well. In a repeated asset allocation game, Papadovasilaki et al. (2018) show that investors have the tendency to change their portfolio allocation too often, even when provided with the underlying characteristics of the distribution of returns.

Our study also gives an insight into the role played by overconfidence in explaining time inconsistent behavior. To measure overconfidence, we used players' beliefs that they can correctly count the flashing exit signs, conditional on their (prior) experience playing video games. Since the task of counting rapidly flashing exit signs should be easier for those who are experienced video gamers, if a player had little experience playing video games but was fairly confident in their ability to count, we consider them overconfident. As previously explained, the speed of the flashing exit signs was chosen such that accurately counting would be impossible, without discouraging players from trying. Using results from

our five pilot studies, we found a positive association between experience playing video games and a player's ability to count flashing exit signs on a computer screen (the near misses and accurate counts of the exit signs were higher for those who frequently played video games).

Figure 12 below supports our hypothesis regarding the relationship between overconfidence and time inconsistent decisions. Given the relatively small sample of our data, we grouped players into two categories based on their self-reported performance in playing video games: terrible and good. The first group includes those who consider themselves terrible or mediocre at playing video games, while the second contains those who ranked themselves as good or very good when it comes to playing video games. Figure 12 reveals that there is a higher percentage of players who rank themselves terrible or mediocre at video games, in the "safe-risky" and "other" categories. Furthermore, players' confidence in their counting ability is relatively higher in these subgroups, compared to the same subgroup (players who have terrible or mediocre video game experience) in the "safe-safe" category. Also, within each category, players' belief that they can accurately count the flashing exit signs is higher for those with terrible or mediocre perceptions, compared to those with good or very good perceptions. Although further investigation is needed, our results are in line with previous literature and are an indication that overconfidence is associated with time inconsistency and overtrading. For example, Barber and Odean (2001: 289) find that overconfident investors trade too much which lowers their expected utility: "models that assume that market participants are overconfident yield one central prediction: overconfident investors will trade too much." Although we find no gender differences, which with our sample size could be the effect of pure randomness, we introduced a new context for measuring overconfidence and its effect on the asset allocation of retirement savings, using the absent-minded investor framework.

**Figure 12.** *Overconfidence and Time Inconsistent Decisions*



Source: Authors.

The fact that overconfidence induces subjects to deviate, and makes them more susceptible to risk, is further reinforced by the subjects' free responses on

the question as of why they decide to invest in the risky asset in the action stage. From the 8 subjects following the “safe risky” strategy, 6 claim to be very confident that they counted correctly, despite the fact that the speed of the flashing signs renders it impossible.

Although no strong conclusions can be drawn given our limited sample size and further partitioning into groups, our study gives some important insights about the role that temptation plays when it comes to asset allocation of retirement savings. Furthermore, it can be the starting point of a deeper investigation concerning the effect of overconfidence on falling prey to temptation in the context of asset allocation using the absentminded investor framework.

## **Conclusion and Future Work**

The experiment we ran, helped us discover under what set of parameters (flashing Exit signs speeds) do subjects divide into two well-populated sets, which replicate the two equilibria of the absent-minded driver paradox in a laboratory set-up. Roughly one third of subjects played the “safe-risky” time inconsistent equilibrium (PR equilibrium), and the other two thirds played the more standard, time consistent equilibrium (traditional economic theory equilibrium). Thus, our main contribution was to translate the game theoretic approach of Piccione and Rubinstein (1997) into an investment game by making an analogy between an absent-minded driver and an absent-minded investor. Just like the driver cannot distinguish the exit that leads home on the highway from the one that leads into a bad neighborhood, the investor cannot distinguish between good and bad risky assets because she doesn’t know where she is in the financial cycle. To our knowledge, this is the first laboratory study that attempts to apply the absentminded driver paradox to an asset allocation game in the laboratory.

The second contribution of this study is to reveal the importance of a normative approach in the planning stage. Not only it helped participants distinguish between the two stages of the asset allocation game, but it also taught us an important lesson in financial planning: the significance of a normative approach in inducing participants to think of their long-term retirement goals.

Finally, our experiment offers an insight into the role played by temptation and overconfidence in an asset allocation game, using retirement savings. Although specific to the way we framed our experiment, results show there is a positive association between overconfidence and time inconsistent decisions, between the planning and action stage of an asset allocation game using retirement savings.

We plan to continue our research in the following steps. First, we plan to stay within the boundaries of the present non-repeated game and explore the consequences of a few important modifications to the current setup. The first exploration has to do with varying the type of saving plans and decisions subjects are confronted with. Subjects may behave differently if for example they are told that they are saving for college rather than retirement. Re-running the experiment

with different saving conditions may shed light on the different degrees of time inconsistent asset allocations as the nature of the saving plans is altered. Another interesting and important manipulation involves replacing individual decision-making with a simulated “household-level” decision-making game, since in practice plans and decisions involving retirement saving are not made by single individuals, but by multiple person households. Prior literature has found that in the presence of social learning, saving decisions more closely resemble decisions based on models of rational behavior (Brown et al. 2009). These findings suggest another natural extension, allowing a household to learn from the decisions of the most successful households. Learning would involve a repeated game setup, to which we turn in the second stage of our research agenda.

Second, we plan to focus on the implications of the repeated decision-making game, extending the one period game to a multi-period repeated one in which subjects can plan for their retirement only once, but are given the option of making their asset allocations multiple times. The reasoning behind this implementation is that in reality one has the option to change the contribution in their benefit plans at any time. Our purpose is to understand the mechanisms that explains why individuals get short sighted when it comes to investing, in favor of satisfying shorter term needs. We propose to start with individual decision-making and then turn the setup into simulated household-level decision making with and without social learning conditions.

A third avenue includes investigating belief formation and the existence of behavioral strategies by eliciting beliefs from participants, at different stages of the game. To start with, we want to see whether participants change their beliefs regarding the probability that the risky asset is “good” or “bad” when they play repeatedly. Since in our current setup chance is the sole determinant of the risky asset being associated with a high or low payoff, playing repeatedly shouldn’t affect player’s beliefs in any way. We speculate that players will be affected by cognitive biases which will lead them to change strategies and beliefs between consecutive rounds. Specifically, we want to investigate whether participants are affected by the hot hand belief, the belief in positive autocorrelation of independent events, or gambler’s fallacy, the belief in negative autocorrelation of independent events, as found in studies such as Salaghe et al. (2016).

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## Appendix 1: Experimental Instructions

### Experiment Instructions

#### Participant Number:

The purpose of the present study is to advance our understanding of how people invest their retirement savings. To do so, we are going to play a game in two stages. The first stage is very simple and consists of answering just one question. The second stage consists of actually playing a game.

#### Experiment Overview

In this experiment we will make the analogy between an absentminded driver that gets distracted while driving and isn't sure which exit to take to get home, and an absentminded investor that is not sure whether a risky stock will be a good or bad investment. Both the absentminded driver and the absentminded investor are presented with a safe and a risky option. The safe option for the driver is to take the highway and drive all the way to the end where she can spend the night at a motel. The driver can get to the motel with certainty as there are no exits that she needs to take. Similarly, the investor can choose the safe road to retirement and invest her retirement savings in the safe asset. The risky option for the driver is to take an exit, knowing that she can't get back on the highway if it is the wrong one. If she takes the wrong exit she ends up in a bad neighborhood (associated with a payoff of zero), while if she takes the exit and it turns out to be the correct one, she ends up home (associated with the highest payoff). The analogous of taking the exit for the investor is to invest in the risky stock, not knowing whether it will have a high or low payoff.

*The experiment consists of 2 stages, a planning stage and an action stage.*

The planning stage begins by answering a question as of how you **PLAN** to prepare for retirement. Imagine you must start saving for retirement, in order to **provide for yourself during the years when you will not be able to work**. Once you have saved some money out of your paychecks, the issue will be how to invest your savings to guarantee yourself a future retirement income. You can plan to invest your retirement in either a moderately safe asset that provides relatively predictable returns, or in a risky asset that has uncertain returns. It is impossible to know in advance whether the risky asset will turn out to be good or bad. The only thing you know about the risky asset is that 50% of the time it pays a high return and the other 50% pays nothing, or 0.

In the action stage, the actual decision of investing your savings in the safe or risky asset will be made. The absentminded driver starts driving on the retirement highway and must choose the optimal strategy: to drive all the way until the end of the highway (spend the night at the motel), or to take the exit when reaching an intersection. Driving to the motel is equivalent to investing in the safe asset while taking the exit is equivalent to investing in the risky asset. At this point there is no turning back and you must face the consequences of your decision. Chance determines the nature of the risky asset and payoffs are revealed.



**Please go ahead and enter the “Participant Number”. This is the number written on the sticker on your screen.  
Continue by entering the number:**

### **Stage 1: Planning Stage**

Imagine that you will *have to* provide for yourself during the years when you will not be able to work. Once you have saved some money out of your paychecks, the issue will be how to invest the money in order to guarantee yourself future retirement income. There are two assets in which to invest your retirement savings. The first asset is a (moderately) safe asset that provides relatively predictable returns. You can think of the safe asset as a balanced index of stocks and bonds in large American companies, such as the companies in the Dow Jones Industrial Average. Investing in the Dow Jones is not likely to provide extraordinarily high returns, but is quite likely to “get the job done.” In other words, it is a secure investment with relative low risk, that will ensure your future retirement. The other asset available to invest your retirement savings is a risky asset that has uncertain returns. You can think of the risky asset as investing in some brand new bioscience company stock. There are many new bioscience companies in the market. If you pick the wrong bioscience stock then the risky asset will implode and pay nothing, but if you pick the right bioscience stock then you will end up with very high returns well in excess of the safe asset.

Knowing whether you have picked the right or wrong risky asset will be impossible. In other words, it is impossible to know in advance whether the “new” stock is a scam. The only thing you know about the risky asset is that 50% of the time it pays a high return of 4 experimental dollars, and the other 50% pays nothing, or 0 experimental dollars. When the risky asset pays zero you will be left with no income during your years in retirement. You should assume that you will not be able to rely on Social Security. On the other hand, if you decide to invest in the safe asset you will get a certain payoff of 1 experimental dollar. Please keep in mind that you will be playing the game with experimental dollars that will be converted to real money at the end of the experiment. For now just make your decisions based on relative payoffs. For example, a payoff of 4 experimental dollars will be associated with four times more earnings compared to a payoff of 1 experimental dollar.

Keep in mind that this is the PLANNING STAGE, and you will be asked to declare what you **SHOULD** invest your savings in. In other words, you are declaring what you **SHOULD** be doing with your retirement savings, not necessarily what you will do. Be mindful that this just a plan, and you can alter your plans later on, in the action stage.

You can proceed now to answer the question on your screen. ***BUT DO NOT CLICK NEXT BEFORE YOU ARE TOLD TO DO SO.***

Q: In what asset **SHOULD** you invest your savings?

- A:       a) Safe asset  
          b) Risky asset

**No go on by explaining the reason behind selecting your strategy.  
DO NOT CLICK NEXT BEFORE YOU ARE TOLD TO DO SO.**

**Stage 2: Action Stage**

There will be two basic elements on the screen you will see in a while:

- **Retirement Highway**
- **Flashing Exit Signs**

Exit signs will flash on your computer screen to try to represent your fictional movement along the retirement road. Your task will be to try to count the rapidly flashing Exit signs in order to identify which exit you are at. Correctly identifying the exit is akin to knowing whether the risky asset is good or bad. However correctly identifying the exit will only reveal the true nature of the risky asset, it will not change it (If the risky asset is bad it will continue being bad regardless of you counting correctly).

**To give you an idea as of how the highway will look like, please go ahead, enter next, and try to count the flashing signs that will appear in 30 seconds on your screen.**

**Continue by answering, which exit you think you are at by pushing next.**

**The next screen will reveal whether your counting was accurate or not.**

In the action stage, the highway has a “critical region” comprising of Exit 16 and Exit 17. After counting the flashing exits you will arrive at the “critical region.” There you will have to decide if you want to continue on the highway or take an Exit. If you decide to continue on the highway, you take no risk and you will get a payoff of 1 experimental dollar, corresponding to investing in the safe asset. In other words, imagine as if you decided to invest your retirement in the balanced index of Treasury bonds and stocks of large American companies. If you decide to take the Exit then you will either get a payoff of zero experimental dollars, which is akin to having picked the wrong bioscience stock, or you will get a payoff of 4 experimental dollars, which is akin to having guessed correctly and picked the right bioscience stock.

Only by correctly counting the flashing signs, you can identify which exits you are at, exit 16 or 17. You will only be allowed to exit at Exit 16 or 17. If you happen to exit at Exit 16, the new bioscience stock pays \$0 experimental dollars. If you happen to exit at Exit 17, the new bioscience stock pays \$4 experimental dollars. Chance, which will be implemented by a coin toss, will determine if you will see 16 or 17 flashing signs, ie whether the new bioscience stock is the good or the bad payoff.

**Coin Toss:**

**The Role of Chance in determining at what Exit you will be allowed to Exit**

This procedure determines if you see 16 or 17 flashing exit signs.

**Please toss the coin on your desk and enter on the computer screen either T for “tails” or H for “heads.”**

**The “ACTUAL” action stage will begin next. When you click on next you will start your way along to retirement and the flashing signs will appear in 30 seconds. You have to ensure that you will be able to count the flashing signs correctly.**

**Do not continue until you are being told to do so.**

**Please enter the number ----- and then click “next”.**

**Please go ahead and answer the following questions on paper.**

**Questions on Beliefs about HERE (PAPER-based)**

Question: What’s your best guess that you have counted the flashing exit signs correctly and that you know where you are on the highway? Options:

1. probability of having counted correctly = 1 (or 100%)
2. probability of having counted correctly = 0.9 (or 90%)

3. probability of having counted correctly = 0.8 (or 80%)
4. probability of having counted correctly = 0.7 (or 70%)
5. probability of having counted correctly = 0.6 (or 60%)
6. probability of having counted correctly = 0.5 (or 50%)
7. probability of having counted correctly = 0.4 (or 40%)
8. probability of having counted correctly = 0.3 (or 30%)
9. probability of having counted correctly = 0.2 (or 20%)
10. probability of having counted correctly = 0.1 (or 10%)
11. probability of having counted correctly = 0 (or 0%)

**On the next screen you will need to decide whether to exit or not.**

**Deciding whether to exit or not**

**Expected Value calculation**

Given your guess about the probability of having counted Exits correctly, the expected value of exiting the road is:

$$\text{Prob (correct count)} * 4 + \text{Prob (incorrect count)} * 0 = X \geq 1$$

**At this point you have to compare the alternatives of staying on the road and exiting the road.**

**Please enter the number ----- and then click “next”.**

To declare whether you will exit at this point of the game or not, please check the respective box on the computer screen and answer this question:

- Would you like to take this exit now?
  - i. **Yes**
  - ii. **No.**

Please go ahead and check whether you would like to exit or not.

**PLEASE CLICK ON “NEXT” answer the following questions:**

- 1. Why did you choose what you chose now?**
- 2. In which exit do you think you are at?**

**Do not continue before you are told to do so.**

### **Compensation**

You will now be paid in cash for your participation. You will receive the amount that you have earned based upon your decisions. Experimental dollars are converted into actual dollars at a rate of 1 Experimental dollar = \$4

To be compensated you need to fill out your subject payment receipt. Please do not proceed until one of the research team members checks that you have entered the correct numbers on your subject receipt. You will find the subject receipt in the documents next to your keyboard.

### **Survey**

Please click on “Survey” and fill out the questionnaire.

### **Actual payment procedure**

After you complete the survey bring the receipt to the experimenters. You will be paid individually and anonymously and no one else, other than the experimenters, will know how much you received.