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Misunderstanding Savings Growth: Implications for Retirement Savings Behavior

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Abstract

People systematically underestimate exponential growth. The current studies illustrate this phenomenon, its implications, and potential interventions in the context of saving for retirement, where savings grow exponentially over long periods of time. Experiment 1 showed that the majority of participants expected savings over 40 years to grow linearly rather than exponentially, leading them to grossly underestimate their account balance at retirement. Experiment 2 demonstrated that this misunderstanding of savings growth led to underestimating the cost of waiting to save, which makes putting off saving more attractive than it should be. Finally, Experiments 3-5 showed that highlighting the exponential growth of savings motivated both college students and real employees to save more for retirement. Making clear to employees the exponential growth of savings -- just before they make crucial decisions about how much to save -- may be a simple and effective means of increasing retirement savings.

There has been a large change in retirement plans in the US during the past 30 years. In 1979, 62% of private sector workers participated solely in defined benefit plans (i.e., pension plans). Under such plans, employers put aside money for employees, who, upon retiring, often receive a monthly paycheck for the rest of their lives. Because retirement pay is usually based on years of employment with the firm and/or pre-retirement income, little or no financial planning is required on the part of employees. That same year, only 16% of participants were solely in defined contribution plans (401(k)-type plans). With these plans, employees must decide (a) whether to participate, (b) how much of their monthly income to save for retirement, and (c) how to invest their savings. By 2005, these percentages had reversed: Only 10% of participants were in defined benefit plans and 63% were in defined contribution plans (Employee Benefits Research Institute 2007). This dramatic shift is important because a majority of private-sector employees are now responsible for saving for their retirement. In theory, defined contribution plans provide adequate income during retirement – but only if employees save enough during their working years.

Unfortunately, there is evidence that people are not saving enough for retirement. About 45% of households were “at risk” in 2004, meaning that nearly half of households were predicted to fall significantly short of having enough money at retirement to maintain their pre-retirement standard of living (Munnell, Webb, & Delorme 2006; Munnell, Webb, & Golub-Sass 2007). In fact, because so many eligible workers were not participating at all in 401(k)-type retirement plans, the Pension Protection Act was passed in 2006 in part to make it easier for US companies to automatically enroll employees in a plan (Madrian & Shea 2001; McKenzie, Liersch, & Finkelstein 2006). Exacerbating the problem is that the cost of retirement continues to increase because people are living increasingly longer, health care costs are increasing, and Social

Security benefits are decreasing. The combination of increasing retirement costs, the switch to defined-contribution plans, and a lack of retirement savings is a serious concern.

Various explanations have been offered as to why people do not save enough, including weakness of will and excessive intertemporal discounting (see, e.g., Laibson 1997; Thaler & Benartzi 2004). Such explanations, however, implicitly assume that people have a basic understanding of how savings grow over time. In this article, we show that people have a deep and fundamental misunderstanding of savings growth: Due to the compounding of interest, savings grow exponentially over time, but many, even most, undergraduate students believe that savings grow linearly, and they therefore grossly underestimate how much money can accumulate over the span of a typical career (Experiments 1 and 5). Importantly, because participants believe that savings grow linearly, they underestimate the cost of waiting to save, which makes the decision to put off saving more appealing than it ought to be (Experiment 2). However, we also show that increasing students' (Experiments 3 and 5) and real employees' (Experiment 4) awareness -- even subtly -- of the exponential growth of savings over time helps them appreciate the benefits of saving and motivates them to save more for retirement.

Calculating savings with compound interest is not simple, and estimating it is not intuitive. Imagine that you deposit $1,000 at the beginning of each year and earn 7% interest, compounded annually. After 3 years, how much money will you have? The $1,000 deposited 3 years ago has grown to $\$1,000(1.07)^3$, or $1,225; the $1,000 deposited 2 years ago has grown to $\$1,000(1.07)^2$, or $1,145; and the $1,000 deposited last year has grown to $1,000(1.07), or $1,070. The total, then, is $3,440. To calculate the total savings in one fell swoop, one can use the following equation: Annual Deposit($[(1+\text{Rate})^{\text{Years}+1}$-1]/Rate)-Annual Deposit. In the above case: $\$1,000([1.07^4-1]/.07)-\$1,000 = \$3,440$. Note that the total is almost 15% (not 7%) more than the total amount deposited because each year you earn interest on previous interest earned. After depositing $1,000 each year for 40 years at 7% annual compound interest, you will have deposited $40,000 but have savings of $213,610, or 434% more than total deposits.

People's poor understanding of exponential growth has been shown in other, non-savings domains. When presented with initial data in an exponentially increasing series and asked to estimate future values, participants' estimates are much too low. This is a highly robust phenomenon that occurs when the initial data are presented numerically, graphically, or perceptually (Jones 1979; Wagenaar & Sagaria 1975; Wagenaar & Timmers 1978, 1979).

Stango and Zinman (2009) recently provided evidence suggesting that underestimating exponential change affects real household financial outcomes, such as more borrowing, less saving, and lower net worth. They used data from surveys conducted in the 1970's and 1980's that asked (among many other questions) for an estimate of how much money respondents believed it would cost to repay a $1,000 purchase in 12 monthly installments. Repayment estimates were to include all finance and carrying charges. Respondents were subsequently asked to provide the interest rate that their estimate implied. For example, a respondent might estimate a total repayment of $1,200 and then an implied interest rate of 20%. Note, though, that given the $1,200 estimate, a 20% interest rate would be too low: Because monthly payments are being made, the principal is reduced each month, so paying $200 in finance charges implies a higher interest rate -- 35% in this case. Indeed, 98% of participants reported interest rates that were too low. Stango and Zinman used the difference between the estimated and actual implied interest rate as a measure of "payment/interest bias", which they found to be correlated with a variety of important measures (e.g., it was negatively correlated with net worth).

As interesting as these findings are, it is not obvious that payment/interest bias is the result of failing to appreciate exponential growth. The authors did show analytically that payment/interest bias is consistent with underestimating exponential change, but there are other explanations of their measure. Failing to take into account, for example, that the principal is declining each month when estimating the implied interest rate is psychologically distinct from failing to appreciate exponential change. From our perspective, the strength of Stango and Zinman's (2009) results lies in connecting the payment/interest bias to important, real world data. The two questions (repayment total and implied interest) used by Stango and Zinman provide a proxy for people's understanding of exponential change, but we are interested in examining this understanding directly in the context of saving for retirement. We probe people's understanding using a variety of independent and dependent measures, and we conduct experiments with random assignment to test potential interventions.

To our knowledge, only Eisenstein and Hoch (2007) have systematically studied people's understanding of compound interest. However, they examined understanding of growth for one-time investments rather than, as in retirement savings, recurring deposits. For example, they asked questions such as: If you deposit $1,000 today into an account earning 9% interest compounded annually, how much money would be in the account after 24 years? The authors found that the majority of participants underestimated growth and, in particular, many thought that the investment would grow linearly. For one-time investments (compared to retirement savings, in which money is deposited each month), there is a simple heuristic -- the Rule of 72 -- that one can use to estimate future dollars. Dividing 72 by the annual interest rate results in a good approximation of how many years it will take for the investment to double (8 years in the case of 9% annual return). Some participants knew the rule and used it, which reduced error. Eisenstein and Hoch taught the rule to some participants and found that this also reduced error.

Importantly, there is no simple heuristic analogous to the Rule of 72 for retirement savings (when money is regularly deposited). Furthermore, as we report in Experiment 2, participants who demonstrate an understanding of compound interest do not appreciate the exponential growth of savings any more than participants who do not understand compound interest or even know what it is. Therefore, the intervention we describe in this article is aimed not at helping people understand or calculate compound interest, but at getting people to see the implication of compound interest, namely, the exponential growth of savings. When people are shown the exponential growth, they are more motivated to save more now. Interestingly, there is a sense in which our intervention points out to participants that they will have more savings at retirement than they otherwise thought, which could conceivably leave them less motivated to save more. We show that the opposite occurs, however.

Most of our participants are undergraduate students, and readers might worry about the appropriateness of using this population in retirement studies. However, this population is nearly ideal: Many of these students will be starting their first full-time jobs within a year or two and making crucial decisions about saving for retirement. Because the benefits of compound interest are best exploited by workers early in their career, beginning workers are the perfect group for us to study. However, to increase the generalizability of our findings, we test our intervention using undergraduates (Experiments 3 and 5) and employees at a Fortune 100 company (Experiment 4).

Experiment 1

Our first experiment tested undergraduates' intuitions about retirement savings growth over 40 years. Assuming the typical college-educated worker retires in their early to mid 60's, this is about the length of a typical career during which one can put aside money each month for retirement. Previous psychological research on exponential growth has provided participants with starting values of a series, but not any information about the true underlying relationship, and then asked for predictions of future values (Jones 1979; Wagenaar & Sagaria 1975; Wagenaar & Timmers 1978, 1979). By contrast, we provided participants with all the necessary information for calculating savings (monthly deposit amount and annual rate of return) over various lengths of time and we did not provide a series of initial values. This approach eliminates any uncertainty about whether the relationship will continue over time, which could cause participants to dampen future predictions (see also Eisenstein & Hoch 2007). The approach also allowed us to investigate people's understanding of retirement savings at the very beginning of the process, when they would have few or no data points from which to extrapolate. It is just these people who stand to gain the most from exponential growth, but often fail to do so.

Method

Participants were 99 undergraduate students at UC San Diego (UCSD) who received partial credit for psychology courses. They filled out a survey in a laboratory setting in groups of up to 5, and the cover page provided the following instructions:

> It is becoming common for employees to save for their own retirement rather than have their employers pay for it. We are interested in college students' thoughts about saving for their retirement. On the following pages, you will be asked some questions about saving for retirement. We realize that you might not know a lot about this topic; we just want you to do the best you can.

Participants were randomly assigned to either the No Aid condition or the Aid condition. In the No Aid condition, the next paragraph of instructions, still on the cover page, was the following:

> When answering the questions, please provide your thoughtful best guess. In other words, it is important that you do not formally calculate your answers (e.g., by using a calculator or using this survey as scratch paper). <u>We want your best guess</u>!

The Aid group read:

> When answering the questions, please calculate your answers using the calculator and/or using the survey as scratch paper. In other words, it is important that you do not simply provide a best guess (e.g., don't respond with a number that just pops into your head). <u>We want your calculated answer</u>!

Thus, the No Aid group was explicitly forbidden from using any sort of external aid, whereas the Aid group was explicitly told to use external aids. The Aid group was provided a basic calculator that allowed them to add, subtract, multiply, and divide. This was meant to minimize simple arithmetic mistakes.

There were then two pages of questions. One page asked how much money would be in a savings account given that a fixed amount of money was deposited every month ($200 or $400), at a certain annual interest rate (5% or 10%), over different amounts of time (10, 20, 30, or 40 years). These variables were manipulated within participants, resulting in 16 questions. For example, for half of the participants, the first 4 questions were:

> Assume that you deposit $400 <u>every month</u> into a retirement savings account that earns a 10% yearly rate of interest. (You never withdraw any money.) How much money do you think you will have in your account (including interest earned):
>
> After 10 years? $____________ After 20 years? $____________
>
> After 30 years? $____________ After 40 years? $____________

The other page of questions first asked for participants' "Savings Goal": How much they thought they would need to save if they were going to retire in 40 years. They were then asked how much they would need to save each month to reach their Savings Goal in 40 years for annual return rates of 5% and of 10%, and what annual return rate they would need to reach their Savings Goal if they were saving $200 per month and if they were saving $400 per month.

The order of the two pages of savings questions was manipulated. Within each page, question order was varied so that half the participants saw the questions in one order, and half saw the questions in reverse order (with the exception of the Savings Goal question, which always came first on the page where it appeared).

On the last page of the survey, participants in the No Aid condition were asked whether they made their judgments without using a calculator or pencil and paper. If they answered "yes" to this question, they were asked whether they thought they would have given more accurate responses if they had used a calculator or pencil and paper. Those in the Aid condition were asked if they used a calculator or pencil and paper and, if so, whether they thought they would have given less accurate responses if they had not used any such aid.

Results

Figure 1 shows the median responses, along with the correct responses, for the "how much money after X years?" questions. Medians are reported because the distributions are highly positively skewed. Figure 1a shows the results for deposits of $400/mo at 10% annual compound interest for both the No Aid and the Aid group. The results for the 2 groups are essentially identical to each other and are very different from the correct responses. The median responses systematically underestimate how much money will be in the account at each point in time, and the underestimation increases with time. Note that participants' median responses increase linearly over time, whereas the correct responses increase exponentially. Because of this, the errors are quite large after 40 years, with median responses less than 10% of what they should be and an underestimation of $2.2 million.

It is also clear how most participants, especially in the Aid condition, calculated their responses. After 10 years, the modal response – 60% of Aid participants – was $52,800. This corresponds to $400 x 12 (months per year) x 10 (years) + 10%. That is, rather than calculating annual compound interest, participants merely added 10% to their 10 year total. Such a calculation leads to estimates of $105,600 after 20 years, $158,400 after 30 years, and $211,200 after 40 years, which correspond to both the median and modal responses for the Aid group. Across the 4 time periods, between 60% and 64% of the Aid participants reported exactly these values.

The results were very similar for the No Aid participants. The median (modal) response was $50,000 ($50,000) after 10 years, $109,000 ($100,000) after 20 years, $160,000 ($150,000) after 30 years, and $223,000 ($200,000) after 40 years. Across the 4 time periods, between 10% and 20% of No Aid participants reported the modal response.

Figures 1b-d show the results for the other combinations of annual rate of return and monthly deposit. The pattern of results is essentially identical for all 4 cases.

No fewer than 84% of participants underestimated the correct value in either condition for any of the 16 questions (all $\underline{p}$s < .001, 2-tailed binomial test; null hypothesis was $\underline{p} = .5$). Across conditions and questions, a mean of 90% of participants underestimated the correct value.

The other page of questions first asked participants how much money they thought they would need to save for retirement (their "Savings Goal"). The median response was $500,000 for both groups, and the interquartile range was about $250,000 to $950,000 in each case.

Participants were asked how much they would need to save each month in order to reach their savings goal with annual returns of 5% and 10%. If they do not appreciate exponential growth, they should respond with monthly deposits that are too high, especially for the 10% question. For each participant, we calculated whether their monthly deposits at the specified annual interest would exceed their savings goal. The percentages of Aid and No Aid participants who reported monthly deposits too high for the 5% return question were 88 and 80, respectively (both $ps < .001$; 2-tailed binomial test). The respective percentages for the 10% return question were 98 and 96 ($ps < .001$).

Participants were also asked what annual interest rate they would need in order to reach their retirement savings goal given they would deposit $200/mo and $400/mo. If participants fail to appreciate exponential growth, they should report interest rates that are too high. The percentages of Aid and No Aid participants who reported interest rates that were too high for the $200/mo question were 64 ($p = .065$) and 82 ($p < .001$), respectively. The percentage for the $400/mo question was 82 for both groups ($ps < .001$).

Finally, despite virtually identical results for the two groups across all measures, 100% of the Aid participants thought they would have given less accurate responses had they not used a calculator, and 88% of the No Aid participants thought they would have given more accurate responses had they used a calculator. Participants apparently have little insight into their (in)ability to calculate compound interest accurately, and the tools that will aid them in doing so.

Discussion

Participants grossly underestimated retirement savings growth: On average, 90% of the participants underestimated future savings for each of 16 questions covering different time horizons, rates of return, and monthly deposit amounts. Furthermore, extending Eisenstein and

Hoch's (2007) finding for one-time investments, we found that many participants thought that retirement savings grow linearly, rather than exponentially. The underestimation of retirement savings growth was evident not only when participants estimated future values, but also when they estimated how much they would need to deposit each month, and what annual rate of return they would need, in order to reach their retirement goal in 40 years.

A difference between our findings and those of Eisenstein and Hoch (2007) is that the latter showed that participants' estimates were often based on simple interest, which takes into account the interest rate each year, but ignores compounding. Our participants, however, did something even simpler: They applied the interest rate once to the total amount deposited, ignoring the fact that dollars invested for more years accrue more interest. This, of course, leads to even larger errors relative to calculating simple interest. It could be that the added complexity of the retirement savings scenario (with recurring deposits) led to an even simpler response strategy compared to the one-time investments used by Eisenstein and Hoch.

Experiment 2

The fact that participants underestimate retirement savings growth suggests that they may not appreciate the benefits of saving early or, equivalently, the costs of waiting to save. People might put off saving for retirement because they mistakenly assume they can easily make up for lost time later. Saving early in one's career is difficult due to relatively low starting salaries, so why not just wait and save more later when it is easier to do so? Our results thus far indicate that this reasoning is likely to be much more appealing than it should be. In Experiment 2, we probed participants' understanding of the cost of waiting to save.

Participants were also asked whether they knew what compound interest is and, if they did, to provide a brief explanation. This allowed us to determine whether those who understand compound interest perform better than those who do not.

Method

Participants were 100 UCSD students who received partial course credit for participation. The cover page of the 4-page survey provided general instructions and informed participants that they could use calculators if they wished. The calculators in this experiment were slightly more sophisticated than those in Experiment 1 in that they allowed use of exponents. Participants then answered two questions, each on a separate page. One question was the following:

> Imagine that both Alan and Bill just started working and are going to retire in 40 years. Alan deposits $100 every month into his retirement account. Bill waits 20 years to start saving, but then deposits $300 every month into his retirement account. Both accounts earn 10% interest every year, compounded annually. Neither of them withdraws any money. Who has more money at retirement?

They circled a number on a 7-pt scale, with 1 = "Alan has much more money at retirement", 4 = "equal money", and 7 = "Bill has much more money at retirement". The second question was:

> Consider again Alan and Bill, who just started working and are going to retire in 40 years. Alan deposits $100 every month into his retirement account. Bill waits 20 years before depositing money into his account. Both accounts earn 10% interest every year, compounded annually. Neither of them withdraws any money. How much money would Bill need to deposit into his account each month in order to have the same amount of money as Alan when they both retire?
>
> Bill would need to deposit $ _____________ per month.

Half the participants were assigned to a 10% annual rate of return condition and the other half to a 5% annual rate of return condition. Half the participants answered the rating question first and half answered the deposit question first. The final page asked participants whether they knew what compound interest is and, if so, to provide a brief explanation.

Results

For the rating question, the correct answer is that Alan will have more money. In the case of a 5% annual return, Alan will save $152,208 depositing $100/mo over 40 years and Bill will save $124,989 depositing $300/mo over 20 years. In the case of a 10% annual return, Alan will save $584,222 and Bill will save $226,809, less than half as much. A minority of participants, however, believed that Alan would have more money in either case. In the 5% condition, only 36% of participants provided a rating less than 4 (with 4 = “equal money” on the 7-pt scale), indicating a belief that Alan would have more money than Bill. The mean, median, and modal responses were 4.5, 5, and 6, respectively. In the 10% condition, even fewer -- 30% -- believed Alan would have more money. The mean, median, and modal responses were 5.0, 6, and 7, respectively.

We conducted a 2 (Rate) x 2 (Task Order) between-participants ANOVA on the ratings. We subtracted 4 from each rating so that 0 = “equal money”, negative values indicate that Alan will have more money, and positive values indicate that Bill will have more money. The only significant result was that the overall mean (0.8) was greater than 0 ($F(1,96) = 13.8$, $p < .001$), indicating a tendency to believe incorrectly that Bill will have more money.

We asked participants “Do you know what compound interest is?” (yes or no), and only 53% responded “yes”. Those who responded “yes” were asked to write a brief explanation of compound interest. Two independent raters judged whether each response was correct (i.e., mentioned that interest was earned on previously earned interest) and any disagreements were resolved through discussion. Sixteen of the 53 responses were judged to be incorrect. This resulted in 32 "low knowledge" participants and 18 "high knowledge" participants in the 5% condition; the respective numbers were 29 and 19 in the 10% condition. (Two participants in the 10% condition did not answer the compound interest question and were excluded from the analysis.) We conducted a 2 (Rate) x 2 (Task Order) x 2 (Knowledge) ANOVA on ratings after subtracting 4 from each rating. Although high-knowledge participants had lower (better) ratings than low-knowledge participants (0.5 vs. 0.9), the difference was not significant ($\underline{F}(1,90) = 1.2$, $\underline{p} = .28$), and the ratings were positive for both groups. The only significant effect was that the overall mean was greater than 0 ($\underline{F}(1,90) = 9.8$, $\underline{p} = .002$), as was found above.

The participants were also asked how much Bill, who is only going to save for 20 years, would have to save each month in order to have as much as Alan, who is saving $100/mo for 40 years. In the 5% condition, the correct answer is that Bill will need to save $365/mo, but participants' median and modal responses were $200/mo. Forty-five percent of these participants responded with $200/mo. In the 10% condition, the correct answer is $773/mo, but median and modal responses were again $200/mo; 52% of these participants responded with $200/mo. Since Bill will save half as long, there is a strong tendency for participants to believe that he will need to save only twice as much. The results for low- and high-knowledge participants were virtually identical.

<u>Discussion</u>

These results replicate the finding from Experiment 1 that participants view retirement savings growth as linear. More importantly, they extend the previous results by showing that this linear understanding leads participants to underweight the cost of waiting to save: They believe that it is much easier than it really is to make up for lost time, making the decision to put off saving more attractive than it should be. If participants were correct in believing that Bill could wait 20 years, deposit only twice as much as Alan each month, and have as much as Alan at retirement, putting off saving would presumably make financial sense. People typically earn relatively little money early in their careers, making saving especially difficult early on. But this line of thinking ignores the annual returns from the initial decades of saving. The higher the rate of return, the more difficult it is for Bill to make up for lost time, and participants were virtually insensitive to this variable (5% vs. 10% interest rate). Interestingly, our findings do not merely indicate a lack of understanding of compound interest. Even those who demonstrated an understanding of compound interest performed essentially identically to those who did not understand it or even know what it is.

Experiment 3

Experiments 1 and 2 showed that participants vastly underestimate retirement savings growth and the cost of waiting to save. In light of these results, what can be done to increase retirement saving? Experiment 2 indicated it is not enough simply to understand what compound interest is. We suspected that a more effective way to motivate saving would be to highlight the <u>effect</u> of compound interest: Exponential growth. In Experiment 3, we employed an intervention aimed at sensitizing participants to the exponential growth of retirement savings to see if this would increase both their understanding of the cost of waiting to save and their motivation to save more for retirement.

Interestingly, highlighting exponential growth could conceivably <u>decrease</u> motivation to save, as participants realize that they will have more retirement savings than they had otherwise expected. That is, for a given savings goal at retirement, participants will see that they could save less per month than they thought and still achieve that goal. On the other hand, seeing the effects of exponential growth will highlight the benefits of saving early and the costs of waiting to save, and these factors might be more important in influencing savings behavior.

Method

Participants were 276 UCSD students who received partial course credit for filling out a survey in a laboratory setting. They were randomly assigned to a Time, Deposit, or Control condition. After reading a page of general instructions, all participants read the following: "Imagine that you have just graduated from UCSD and have begun your first full-time job. How motivated would you be during your first year of work to start saving every month for your retirement?" They responded by circling a number on a 7-pt scale, with 1 = "not at all motivated" and 7 = "very motivated". They then answered the following: "How much do you think you would save for retirement each month during your first year of full-time work? $_________ per month."

Participants in the Time condition then turned to a third page (Appendix A). They viewed a graph tracking savings over 40 years with a 10% annual return. One curve depicted savings from monthly deposits of $100, while a second curve depicted savings from monthly deposits of $200. Participants were instructed to refer to the graph when answering several questions printed on the same page. These questions were designed to focus attention on the exponential growth of savings over time. In particular, questions (1a-c, 2a-c) targeted the fact that saving for 40 years would lead to much more than twice as much money as saving for 20 years. Question 3 probed whether participants understood from the graph that saving $100/mo for 40 years would lead to much more money than saving $200/mo for 20 years.

The Deposit condition was different only in that the questions focused on the fact that saving $200/mo always led to twice as much money as saving $100/mo (see Appendix B). In other words, the questions did not highlight exponential growth, although the graph was identical to the one in the Time condition. We simply focused participants' attention on different aspects of the graph. We tried to make Question 3 (basic comprehension of the graph) as similar as possible to that in the Time condition, but without calling attention to exponential growth.

In the Control condition, participants were not presented with this page.

At this point, participants turned in their survey to the experimenter (so that Time and Deposit participants could not consult the graph in answering subsequent questions). Participants in all conditions then received an identical survey with the two Alan-and-Bill questions from Experiment 2. Finally, they were again asked the two questions posed at the start of the experiment: How motivated they were to save for retirement during their first year of full-time employment (on a 7-pt scale) and how much they would save each month for retirement. They were told that they did not have to answer the same way they had answered earlier.

Results

Participants were asked who would have more money at retirement: Alan, who was saving $100/mo for 40 years, or Bill, who was saving $300/mo for 20 years. Both earned 10% interest every year. The correct answer is Alan, who will have more than twice as much money as Bill. Participants answered on a 7-pt scale, where 1 = "Alan has much more money at retirement", 4 = "equal money", and 7 = "Bill has much more money at retirement". Mean ratings were 3.9. 4.2, and 4.4 for the Time, Deposit, and Control conditions, respectively. Although the Time group performed better as predicted, a one-way ANOVA on ratings revealed no effect of Condition ($p = .29$). However, when we categorized responses as either "correct" (rating less than 4) or "incorrect" (rating 4 or greater), a log-linear analysis revealed a significant effect of Condition (χ^2[2, N = 275] = 6.2, p = .046). Percent correct responses were 52, 42, and 34 for the Time, Deposit, and Control conditions (Figure 2a). Contrasts revealed that percent correct differed only between the Time and Control conditions (χ^2[2, N = 183] = 6.1, p = .013).

Participants also estimated how much Bill would have to save every month in order to have as much money as Alan at retirement (the correct answer is $773). Responses were highly positively skewed, so we report only medians. For the Time, Deposit, and Control conditions, the medians were $325, $275, and $250, respectively (Figure 2b). Although there is no significant effect of Condition on these medians (Kruskall-Wallis one-way ANOVA), the pattern of responses is qualitatively consistent with that of the "who has more money?" question (above): Time participants outperformed Deposit participants, who outperformed Control participants.

The results for the questions asking how motivated the participants were to start saving for retirement during their first year of full-time employment are shown in Figure 2c. The values represent the increase in motivation (i.e., second reported motivation minus first). The Time participants showed the largest increase, followed by the Deposit and Control groups. A 3 (Condition: Time, Deposit, Control) x 2 (Period: First, Second) mixed-model ANOVA on motivation, using Period as a within-participants variable, showed a main effect of Period, with participants reporting higher motivation the second time ($F(1,271) = 84.5$, $p < .001$). (Two participants in the Time condition did not answer the second motivation question and were excluded from this analysis.) There was also an interaction ($F(2,271) = 6.0$, $p = .003$), showing that change in motivation differed across groups. Separate 2 x 2 mixed-model ANOVAs on motivation, essentially serving as contrasts, revealed no significant interaction between

Condition and Period for the Time and Deposit conditions ($p = .13$), a significant interaction for the Time and Control conditions ($p < .001$), and a marginally significant interaction for the Deposit and Control conditions ($p = .051$). Motivation to save increased significantly more for Time participants, and marginally more for Deposit participants, relative to Control participants.

Participants were also asked before and after the experiment how much money they thought they would save per month during their first year of full-time work. The distributions are highly positively skewed, so we only report medians. At the beginning of the experiment, median estimates for all 3 conditions were $100/mo. At the end, median responses were $200, $175, and $150 per month for the Time, Deposit, and Control conditions, respectively. The increases are shown in Figure 2d. Although these medians are consistent with the results for motivation, there is no significant effect of condition on the median difference between the dollar estimates before and after the experiment (Kruskall-Wallis one-way ANOVA).

Discussion

Although not always statistically reliable, the results across the 4 dependent measures were highly consistent. Participants in the Time group, who answered questions highlighting the implications of exponential growth, demonstrated greatest understanding of the cost of waiting to save: This group was most likely to answer correctly the question asking whether Alan or Bill will have more money at retirement, and they reported answers closest to the correct value when asked how much Bill needed to save each month to have as much money as Alan at retirement. This group was also the most motivated to save more for retirement: They showed the greatest increase in motivation to save for retirement, and they showed the greatest increase in terms of intended amount to save each month. The results were also consistent in that the control group showed the least understanding of the cost of waiting to save and the smallest motivation to save more, while the Deposit group fell in the middle (Figures 2a-d). We failed to find reliable differences for the two measures (Figures 2b and 2d) with skewed distributions that required non-parametric tests to be performed on medians. The overall pattern is clear, however, and is consistent across measures.

Note that our time intervention mentioned nothing about what compound interest is or how to calculate it. We simply highlighted the implications of the resulting exponential growth. Furthermore, it is of interest that highlighting exponential growth led to more, not less, motivation to save. Realizing that one will have more money than expected at retirement could conceivably make one less interested in saving more. However, it appears that the more important effect is that participants realize the benefits of saving early are surprisingly large and that it will be very difficult to make up for lost time later.

Experiment 4

Although undergraduates -- who will soon be making crucial, early decisions about saving for retirement -- form a natural population for these studies, we wanted to determine whether an intervention similar to that used in Experiment 3 would work with real employees looking at their own 401(k) information. In Experiment 3, Time and Deposit participants viewed the same graph and were merely asked different questions to highlight different aspects of the graph. This subtle manipulation was employed to see whether the effect of growth-rate information would increase when attention was directed to its exponential properties. A real-life intervention need not be so subtle. The results from Experiment 3 suggest that showing employees how much money they will have at retirement if they continue saving at their current rate will motivate them to save even more.

Method

Twenty-two percent of employees at a Fortune 100 company were sent invitations to participate in an experiment via email and told that, if they participated, they would enter a lottery to win an iPod Nano. Nine percent of those invited chose to participate in the survey, a link to which was provided in the email invitation. Of the participating employees, 250 were randomly assigned to one of two conditions included in the present experiment, either the Current Account Balance group (n = 123) or the Future Account Balance group (n = 127). (Other experimental conditions examined the effectiveness of alternative displays, such as estimated income replacement ratios, that are not of interest here.) The participating employees were 47% female with an average age and tenure of 37 and 8 years, respectively, earning a mean salary of $38,323. For the average participant, 3% of total salary was deferred to their 401(k) account annually, with a current 401(k) account balance of $31,354. There were no significant differences between the groups for any of the demographic variables.

Participants were first asked, “Are you interested in changing the amount you save for retirement?”, and they responded using a scale from 1 to 7, where “1” indicated an interest in saving much less, “4” an interest in saving the same amount, and “7” an interest in saving much more. Participants in the Current Account Balance group then saw their actual, current 401(k) balance, supplied to us by their employer. Participants in the Future Account Balance condition saw their estimated account balance at retirement. The estimate was in today’s dollars and assumed continued annual contributions at their (and their employer’s) current rates, a retirement age of 65, an annual return of 8%, and an annual inflation rate of 3%. These assumptions were made explicit (see Appendix C). The median participant in the Current Account Balance condition saw a current balance of $13,886, while the median participant in the Future Account

Balance saw a future balance of $265,100. Participants then again answered the question: Are you interested in changing the amount you save for retirement?

Results

A repeated-measures ANOVA on interest in changing saving amount, with Account Balance (Current; Future) as a between-participants variable and Period (Pre-intervention; Post-intervention) as a within-participants variable, showed only a significant main effect of Period: After seeing either account balance, employees' interest in saving more increased, $F(1, 248) = 42.2$, $p < .001$ (Ms = 5.2 vs. 5.6). There was no significant Account Balance x Period interaction ($p = .16$), although the increase in interest was greater for the Future Account Balance group than for the Current Account Balance group (Ms = .50 vs. .33). However, we were concerned that the generally high interest in increasing savings even before the intervention might be limiting our ability to detect differences in magnitude of change, so we examined whether the intervention influenced how many participants reported an increase, regardless of the magnitude. Whereas 41% of the Future Account Balance group reported an increased interest in saving more, only 27% of the Current Account Balance group did so, $\chi^2(1, N = 250) = 5.5$, $p = .02$.

Discussion

Employees who were shown the estimated account balance of their 401(k) account at retirement were more likely to increase interest in saving more compared to those merely shown their current account balance. These results conceptually replicate those found in Experiment 3 using undergraduate participants and indicate that, because people underestimate retirement savings growth, showing them how savings grow motivates them to save more. This finding may have an important practical consequence: If employees are shown estimated future account balances when making decisions about retirement savings, they may choose to save more.

Moreover, it is of interest that over two-thirds of employees were interested in saving more for retirement even before being presented with any savings information. This underscores the importance of introducing effective methods for nudging employees into savings decisions that, apparently, they already want to make (Thaler & Sunstein 2008). In addition, merely showing employees their current 401(k) account balance increased over one quarter of employees' interest in saving more, suggesting that, not only do employees want to save more, they also recognize that they are not currently saving enough. Combining these results with the fact that showing employees the implications of compounding makes them want to save more -- not less -- indicates that employees believe that they are saving too little for retirement.

Experiment 5

There were many variables we could not control or measure in Experiment 4. Indeed, it is possible that employees in the Future Account Balance condition were surprised not by how large their future account balance would be, but by how small it would be, and this could have motivated them to save more. The results of Experiments 1 and 2 cast doubt on this interpretation, given that people tend to grossly underestimate savings growth. Nonetheless, it would be useful to confirm whether, when they demonstrably exceed expectations, future account balances motivate saving. Not only would this overcome a limitation of Experiment 4, but it would address more directly an issue raised earlier: Might people be motivated to save less when they see that they will retire with more savings than they had otherwise thought?

Method

Eighty UCSD undergraduates participated and received partial course credit. They first answered the following:

Imagine that you have just started your first fulltime job and expect to retire in 40 years. You deposit $200 every month ($2,400 every year) into an account that earns 10% interest, compounded annually. You never withdraw any money. After 40 years, you will have deposited $96,000 (40 years x $2,400), but your account earns 10% interest each year. About how much money do you think you will have in your account after 40 years, including interest earned?

I estimate I will have about $_____________ in my account after 40 years.

All participants turned in this survey and received a new survey on which the experimenter had filled in the blank with the participant's estimate in case the participant wanted to refer to it: "If you deposit $200 every month and earn 10% annual compound interest, you estimated that you would have about $_____________ in your account after 40 years."

Participants randomly assigned to the Compound Interest condition (n = 40) read that, "In fact, you would have about $1,168,000 in your account." They then reported how motivated they would be to change the amount they save each month, with 1 = "very motivated to save less", 5 = "unmotivated to change", and 9 = "very motivated to save more". They were also asked how much they would like to deposit each month. The options were $0, $50, $100, $200, $300, $400, and more than $400 each month.

Participants in the No Compound Interest received the same surveys, but there was no sentence stating the correct amount they would have in their account after 40 years.

Results

Median estimates of future account balance for the Compound Interest and No Compound Interest groups were $105,800 and $106,368, respectively, so we can be sure that those in the former group found the correct amount ($1.168 million) to be surprisingly large.

(Only 2 participants estimated a value larger than the correct value.) Crucially, participants in the Compound Interest group reported being more motivated to increase saving than those in the No Compound Interest group, Ms = 8.0 vs 7.3 ($t(78) = 2.49$, $p = .015$).

The analysis of how much participants wanted to save per month was performed using a scale from 1 ($0) to 7 (more than $400), with 4 representing $200 (the current savings amount). There was no difference between groups in terms of how much per month they would save ($t < 1$). Both means were 5.6, corresponding to between $300 and $400 per month. Thus, both groups reported that they wanted to save more each month.

Discussion

Learning what their account balance would be after 40 years of saving motivated participants to save more compared to those who did not see their future account balance. We know that those who saw the future account balance were surprised by how large it was because these participants first provided estimates, and the median estimate was less than 10% of the correct value.

The present scenario provided a strong test of the effectiveness of our intervention: The correct value of $1.168 million is considerably more than most of our participants believe they need for retirement. Recall that in Experiment 1 we asked participants for their "savings goal" -- how much they thought they would need for retirement. The median response was $500,000, and 86% of participants reported values less than $1.168 million. The current finding, then, indicates that seeing the effect of compound interest motivates people to save more even when the future account balance exceeds their likely savings goal. There are undoubtedly boundary conditions, however.

We did not find a similar effect on how much participants were willing to save each month. Both groups reported similar increases in monthly deposits. It may be difficult for participants to map the motivation scale onto the dollar scale in this hypothetical scenario, with no information about, for example, income. It might also be that the two groups want to save more, but for different reasons. The Compound Interest group presumably wants to save more because they realize the surprisingly large future benefits of saving more now, but the No Compound Interest group might want to save more because their estimates of their future account balance leave them worried about not having enough money for retirement. In any event, it is clear that showing people the effect of compound interest on their future account balance is motivating.

General Discussion

Experiment 1 demonstrated that college students have a fundamental misunderstanding of savings growth. They believe it grows linearly rather than exponentially. This led to perceptions that predictably yielded gross underestimates of future value over long periods of time. When given a simple calculator to use and asked to generate the total dollars that would accumulate with monthly deposits of $400 over 40 years at 10% interest compounded annually, participants' median estimate was less than 10% of the correct value and off by more than $2 million dollars.

Importantly, linear underestimation hinders people from appreciating the cost of waiting to save (Experiment 2). They believe that it is much easier to make up for lost time than it really is. For example, in one of our scenarios, Alan saved $100/mo for a 40 year period at a 10% interest rate (compounded annually), and participants were asked how much Bill, who waits 20 years to start saving, would need to deposit each month in order to have as much money as Alan at retirement. Over half of participants judged that it would require twice Alan's savings rate, or

$200/mo, for Bill to catch up to Alan. However, Bill would actually have to save nearly eight times as much, or $773/mo. Furthermore, participants' responses were virtually identical regardless of whether they demonstrated an understanding of compound interest. These students will soon be making important decisions regarding when to begin saving for retirement, and how much to save.

It might not be terribly surprising that college students' estimates of savings growth are inaccurate. The calculations are complicated, and there are no simple heuristics for estimating future value. However, it is both interesting and important that this relatively well-educated group underestimates savings growth – and that using a calculator or demonstrating an understanding of compound interest does not help. All of this suggests that their understanding of savings growth is fundamentally mistaken. Moreover, this misunderstanding is counter to traditional economic views, where people are assumed to be capable of calculating future values and making trade-offs with present values accordingly. Our findings add to the literature showing that people tend to linearize exponential functions across domains ranging from the effects of inflation on prices to the growth of duckweed (Eisenstein & Hoch 2007; Kemp 1984; Larrick & Soll 2008; Stango & Zinman 2009; Wagenaar & Timmers 1979). In our studies, the implications of the phenomenon are clear: Failure to recognize the power of compound interest – especially over long periods of time – leads to gross underestimation of future account balances and, as a consequence, underestimation of the cost of waiting to save. The unfortunate effect is a negative impact on people's motivation to save <u>now</u>. Since the benefit of compound interest is reaped by saving over long periods of time, this lack of motivation is particularly threatening to young people's attainment of their retirement savings goals.

To address this issue, in Experiment 3 we showed participants a graphical intervention that highlighted the exponential growth of savings over time. This increased (a) awareness of the cost of waiting to save, (b) willingness to start saving early, and (c) anticipated monthly deposits. Our findings are consistent with other research showing that graphs can improve decision making by encouraging people to incorporate duration in their judgments (Liersch & McKenzie 2009). Indeed, the median student was willing to save $50 more per month after the intervention (compared to no intervention). An extra $50 per month over 40 years that earned 10% interest annually would amount to over $292,000 in additional savings.

Experiment 4 also showed -- with real employees -- that highlighting the exponential growth of savings increases motivation to save. Employees at a Fortune 100 company who viewed their estimated future 401(k) account balance at retirement were more likely to express an increased interest in saving more (relative to employees who merely viewed their current 401(k) account balance). It is notable that real workers' reactions to being presented with exponential growth were similar to our undergraduate population because employees could have developed a more sophisticated understanding of savings growth via their own retirement planning, resulting in immunity to our intervention. Alternatively, even if employees remained unsophisticated (i.e., assume that savings grow linearly), they may have felt that they were saving enough – and, seeing their (surprisingly large) future account balance could have demotivated them. Clearly, though, employees were motivated by estimates of their future account balances, presumably because it highlighted the benefit of saving now. While some researchers have argued that US households are saving enough to reach their optimal wealth targets (Sholz, Seshadri, & Khitatrakun 2006; but see Munnell et al. 2006, 2007), if the goal is for people to save according to their own preferences, then our intervention may help achieve that goal. Experiment 5 demonstrated in a more direct fashion that showing people the surprisingly steep growth of savings motivates them to save more, not less.

We are not claiming that our interventions increased knowledge of compound interest per se. Indeed, we found in Experiment 2 that understanding compound interest had no effect on behavior. Instead, our interventions in Experiments 3-5 were aimed at highlighting the effect of compound interest on saving, and any influence might very well be transient. Given that people often do not follow through even when they report an interest in increasing their savings rate (Choi, Laibson, Madrian, & Metrick 2006), we believe that it is important to introduce exponential-growth interventions immediately prior to the decision. Consider, for example, Quick Enrollment™, which allows employees to make decisions about whether to enroll in 401(k) plans without having to make a savings rate or asset allocation decision (both are pre-determined and can be altered at a later date). Including our graphical or projected account balance interventions immediately prior to the decision to enroll could substantially increase participation rates beyond what has already been demonstrated through Quick Enrollment™ (Choi, Laibson, & Madrian 2006). More generally, presenting the interventions before 1) a decision to set or increase savings rates or 2) before a decision to enroll in an automatic increase program (whereby employees can elect to automatically increase savings rates over time) may increase employees' savings rates. For example, a human resources department could provide materials to new or eligible employees with simple calculations illustrating possible future account balances (if they made particular savings decisions). This could increase participation and savings rates in a cost-effective manner. Providing people with information in combination with carefully designed decision architecture may help employees make better savings decisions (cf. Larrick 2004; Thaler & Sunstein 2008).

Although extensive financial education may lead people to save more (Bernheim, Garrett, & Maki 2001; Lusardi & Mitchell 2007), it should be kept in mind that Experiment 2 showed that understanding compound interest had no effect on behavior. The results of Experiments 3-5 indicate that people should not simply be taught what compound interest is and how to calculate it. Rather, its effect on savings growth should be more directly illustrated, especially over the 40+ years that one can save for retirement.

Even with extensive education, calculating future account balances is difficult. Assuming US workers know how to calculate future values, access to information about appropriate interest rates and risk-reward trade-offs may be limited. And calculating future account balances in today's dollars adds an additional layer of complexity because such calculations not only require additional formulas, but an additional set of assumptions. For example, understanding the impact of low or high inflation on the buying power of a future account balance requires both forward looking predictions and historical knowledge of how economic and policy shifts have influenced the purchasing power of the dollar for a particular bundle of goods (e.g., real-estate vs. commodities).

Perhaps, then, the most important implication of our graphical and projected account balance interventions is that they highlight the cost of waiting to save, and the benefit of saving now, without requiring employees to engage in complex calculations or to make decisions about appropriate assumptions (cf. Goldstein, Johnson, & Sharpe 2008). If their demonstrated effects on savings motivation translate into real savings decisions, the simple interventions explored here could substantially contribute to the welfare of retiring workers.

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Author Note

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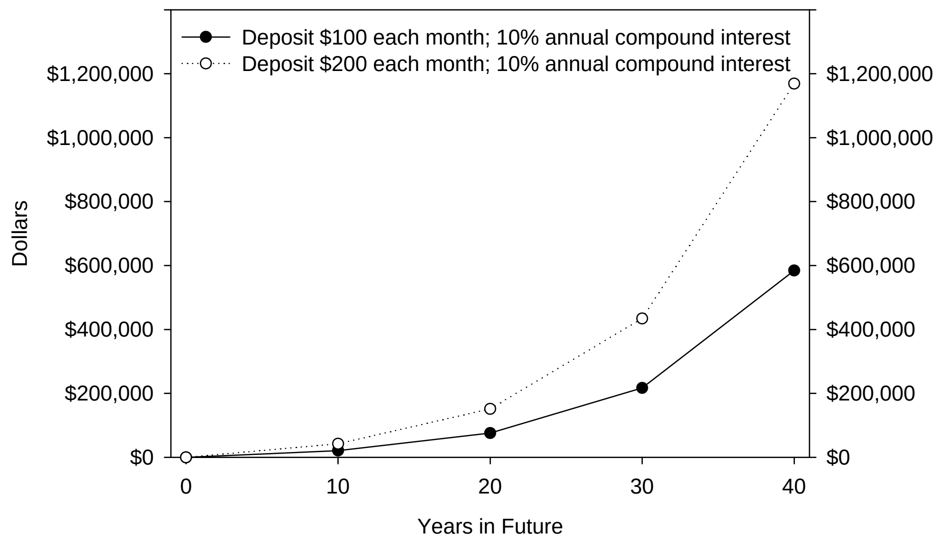
Appendix A

The graph below shows amount of money saved over time. Amount of money is on the vertical axis, and time (up to 40 years) is on the horizontal axis. The bottom line (dark circles) in the graph corresponds to depositing $100 each month. The top line (open circles) in the graph corresponds to depositing $200 each month. In both cases, the interest rate is 10%, compounded annually. *Please refer to this graph when answering the questions below* (and please write legibly!).



1a. If you deposited *$100 each month*, about how much money would you have *after 20 years*?
$ __________

1b. If you deposited *$100 each month*, about how much money would you have *after 40 years*?
$ __________

1c. If you deposited *$100 each month*, about how much <u>more</u> money would you have after 40 years compared to after 20 years?
I would have about _______ times more money.

2a. If you deposited *$200 each month*, about how much money would you have *after 20 years*?
$ __________

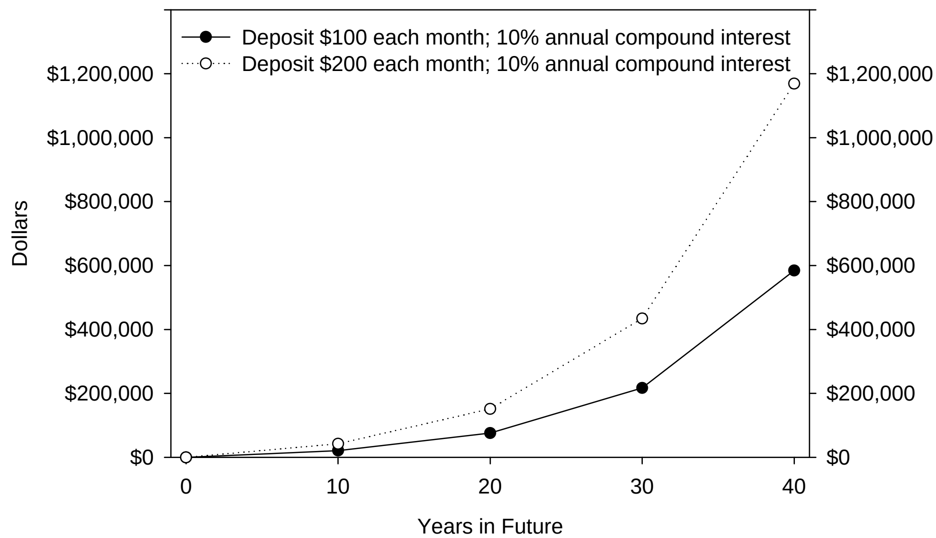
2b. If you deposited *$200 each month*, about how much money would you have *after 40 years*?
$ __________

2c. If you deposited *$200 each month*, about how much <u>more</u> money would you have after 40 years compared to after 20 years?
I would have about _______ times more money.

3. Which would lead you to have more money? (check one):
____ Depositing $200 each month for 20 years.
____ Depositing $100 each month for 40 years.

Appendix B

The graph below shows amount of money saved over time. Amount of money is on the vertical axis, and time (up to 40 years) is on the horizontal axis. The bottom line (dark circles) in the graph corresponds to depositing $100 each month. The top line (open circles) in the graph corresponds to depositing $200 each month. In both cases, the interest rate is 10%, compounded annually. *Please refer to this graph when answering the questions below* (and please write legibly!).



1a. If you deposited *$100 each month*, about how much money would you have *after 20 years*?
$ __________

1b. If you deposited *$200 each month*, about how much money would you have *after 20 years*?
$ __________

1c. *After 20 years*, about how much more money would you have if you deposited $200 each month compared to if you deposited $100 each month?
I would have about _______ times more money.

2a. If you deposited *$100 each month*, about how much money would you have *after 40 years*?
$ __________

2b. If you deposited *$200 each month*, about how much money would you have *after 40 years*?
$ __________

2c. *After 40 years*, about how much more money would you have if you deposited $200 each month compared to if you deposited $100 each month?
I would have about _______ times more money.

3. Which would lead you to have more money? (check one):
____ Depositing $200 each month for 10 years.
____ Depositing $100 each month for 30 years.

Appendix C

Condition: Current Account Balance

RETIREMENT SAVINGS: WILL YOU HAVE ENOUGH?

Based on your total account balance, are you saving enough to meet your retirement goals?

Total Account Balance $

Condition: Future Account Balance

RETIREMENT SAVINGS: WILL YOU HAVE ENOUGH?

Based on your estimated account balance when you retire, are you saving enough to meet your retirement goals?

Estimated Account Balance at Retirement $

This amount is based on your current account balance of $, continued annual contributions of $ (the amount made by you and your emp oyer over the last 12 months), and your age. Assumptions: Retirement age of 65, 8% annual return, 3% inflation rate. Estimate is in today's dollars. Taxes are due upon withdrawal. For illustrative purposes only.

Figure Captions

Figure 1. Experiment 1: Correct and estimated savings as a function of amount of monthly deposit, annual rate of return, and time. In each case, the Aid and No Aid condition medians are linear, almost identical, and far from the correct values.

Figure 2. Experiment 4: The Time group (a) was most likely to get the "who has more money?" question correct, (b) was closest to the correct answer for the "how much money does Bill need to save each month?" question, (c) showed the greatest increase in motivation to save following the intervention, and (d) indicated the greatest increase in intended monthly savings rate following the intervention.

Figure 1

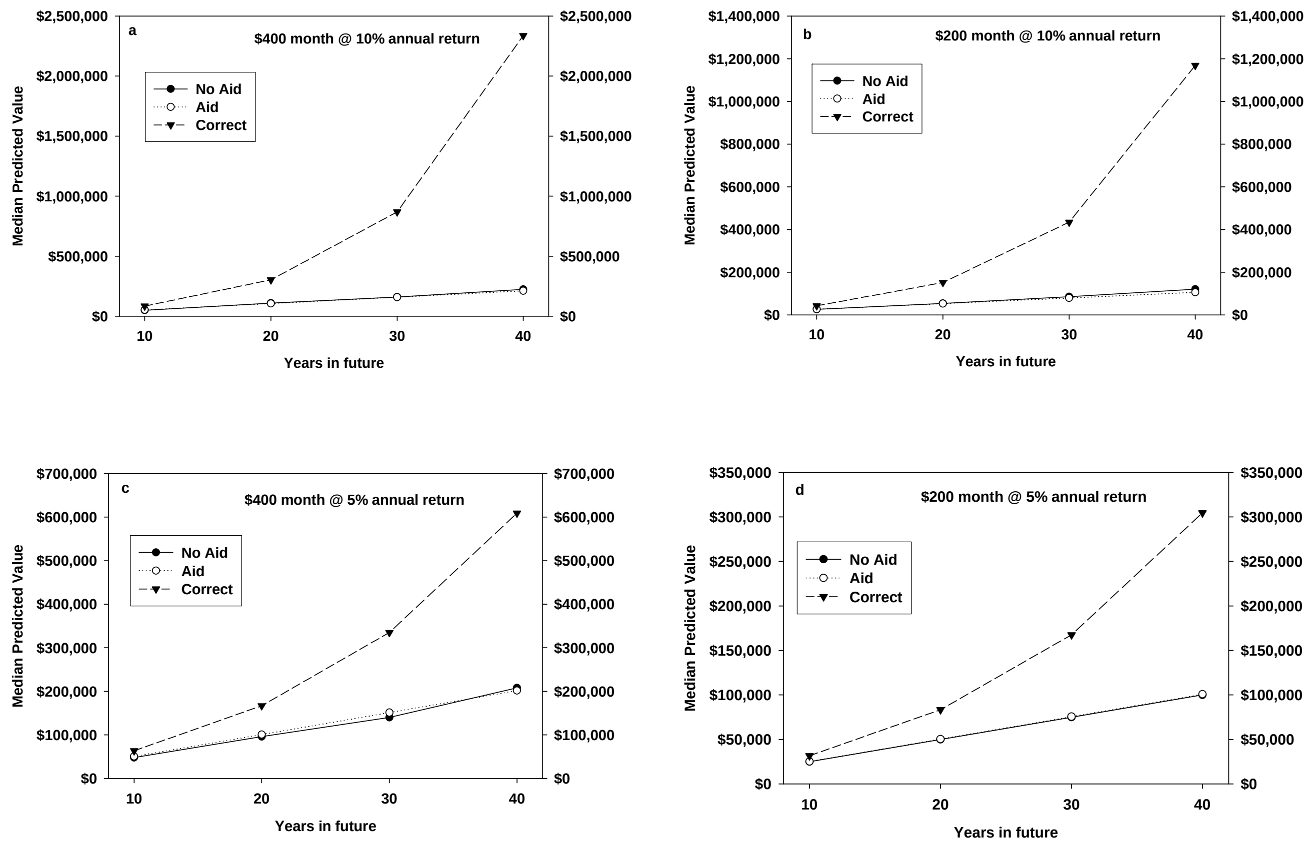
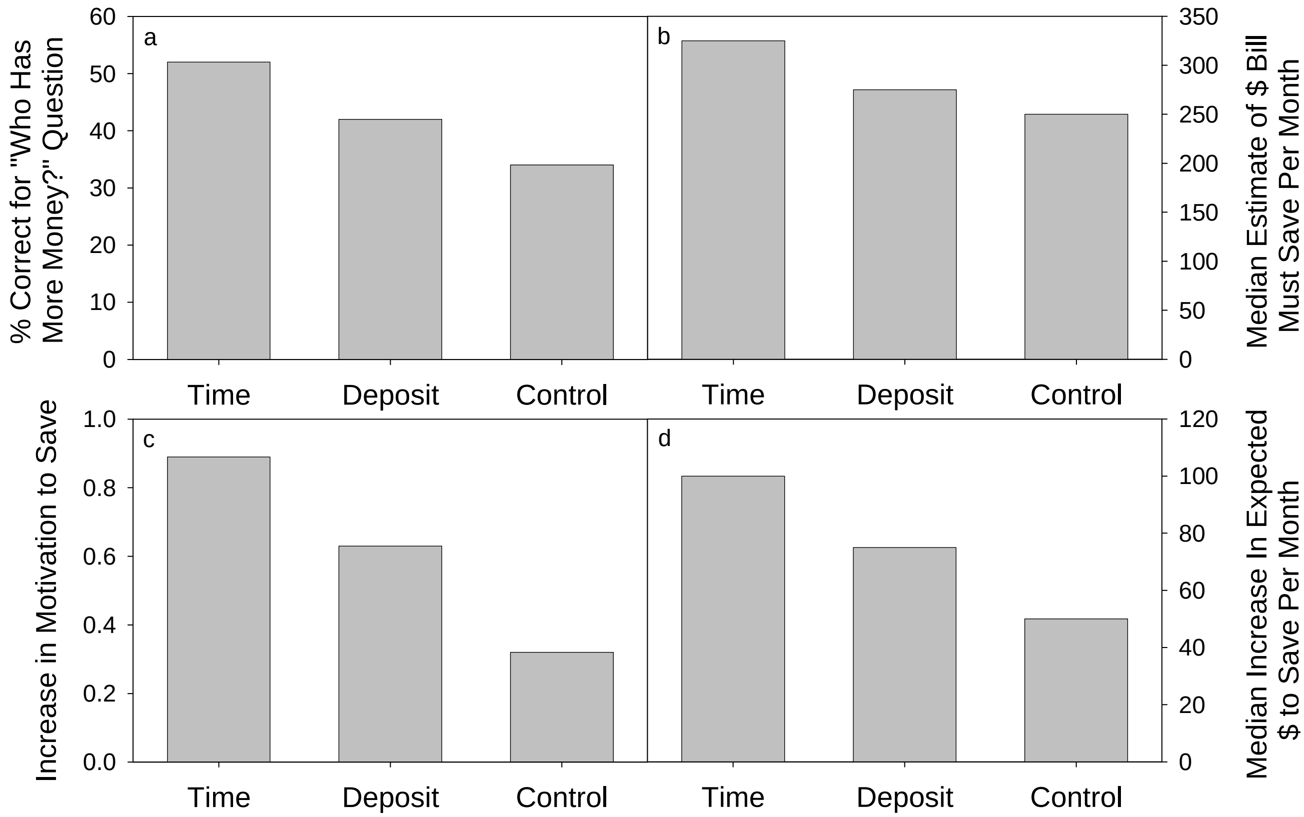

a
$400 month @ 10% annual return
No Aid
Aid
Correct
Median Predicted Value
Years in future
$0
$500,000
$1,000,000
$1,500,000
$2,000,000
$2,500,000
10
20
30
40
b
$200 month @ 10% annual return
No Aid
Aid
Correct
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
$1,200,000
$1,400,000
c
$400 month @ 5% annual return
No Aid
Aid
Correct
$0
$100,000
$200,000
$300,000
$400,000
$500,000
$600,000
$700,000
d
$200 month @ 5% annual return
No Aid
Aid
Correct
$0
$50,000
$100,000
$150,000
$200,000
$250,000
$300,000
$350,000

Figure 2



% Correct for "Who Has More Money?" Question
Median Estimate of $ Bill Must Save Per Month
Increase in Motivation to Save
Median Increase In Expected $ to Save Per Month
a
b
c
d
0
10
20
30
40
50
60
50
100
150
200
250
300
350
0.0
0.2
0.4
0.6
0.8
1.0
20
40
60
80
100
120
Time
Deposit
Control