Organizational Behavior and Human Decision Processes 153 (2019) 103–117

Contents lists available at ScienceDirect

Organizational Behavior and Human Decision Processes

journal homepage: www.elsevier.com/locate/obhdp

Easy, breezy, risky: Lay investors fail to diversify because correlated assets feel more fluent and less risky☆

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ARTICLE INFO

Keywords:
Perceived risk
Lay perception
Fluency
Diversification
Financial decision-making
Financial literacy

ABSTRACT

Why do people fail to diversify risk in their investment portfolios? We study how lay investors (people with low financial literacy) invest in financial assets whose past or expected returns are provided. Although investing in assets with negatively correlated returns reduces portfolio risk (i.e., reduces portfolio fluctuations), we find that lay investors instead prefer investing in assets with positively correlated returns, which results in less diversified and riskier investment portfolios than intended. Using a mixed-method approach, we find that lay investors rely on a lay perception of portfolio risk: assets with positively correlated returns feel more *fluent* (more familiar, simple, and predictable), and thus are erroneously perceived as less risky. We find that lay investors succeed in forming diversified, lower-risk portfolios when they are provided with aggregate portfolio returns, or when—paradoxically—they are encouraged to take more risk.

1. Introduction

With the development of employee saving plans and privatized retirement saving schemes, people with scant knowledge of finance routinely make risky decisions with a potentially dramatic impact on their future wealth. In particular, as defined contribution pension plans are replacing defined benefit plans in many countries, more workers become responsible for allocating their savings among investment products (Lusardi, 2009). Likewise, the booming FinTech industry has made it easier than ever for lay investors to buy and sell assets on their personal computer or their smartphones (Mackenzie, 2015). Choosing an optimal asset allocation is generally difficult, but there is one universally endorsed principle in portfolio management: diversification, which reduces fluctuations without sacrificing gain. For a given level of return, the overall risk (or volatility) of a portfolio can be reduced by investing in assets with uncorrelated or negatively correlated returns, since the poor performance of one asset can be offset by the good performance of another (Markowitz, 1952). Yet, investors tend to hold under-diversified portfolios (Campbell, 2006), and are largely invested in positively correlated assets such as domestic assets (Baxter & Jermann, 1997; French & Poterba, 1991), familiar assets (Huberman, 2001), or their own company's stocks (Benartzi, 2001).

Why would anybody avoid uncorrelated or negatively correlated assets and pass up a "free" opportunity to reduce their investment risk? While past research attributes such behavior to a familiarity heuristic or a home bias (Baxter & Jermann, 1997; French & Poterba, 1991; Huberman, 2001), we uncover a more fundamental psychological explanation. We show that investing in positively correlated assets may be a deliberate choice made by people with low financial literacy (referred to as *lay investors*), because they rely on a lay perception of portfolio risk: while experts evaluate portfolio risk based on the combined volatility of asset returns, lay investors' perception of portfolio risk is influenced by how *fluent* asset returns feel. Assets with highly correlated returns—i.e., returns that "move together" over time—feel more fluent, and are thus perceived as less risky.

In five multi-method studies (relying on qualitative, psychometric, and experimental approaches), we show that lay investors prefer investing in a portfolio with assets yielding positively (vs. negatively) correlated returns. Lay investors perceive such poorly diversified portfolios as simpler, more familiar, and predictable (these factors are empirically and theoretically associated with the general construct of fluency), and thus less risky. Because of this misleading lay risk perception, encouraging lay investors to take risk—ironically—makes them invest in diversified, lower-risk portfolios composed of negatively correlated assets. Providing aggregate portfolio returns (which makes portfolio fluctuations more salient) also helps lay investors to better

☆ This research was generously funded by the Social Sciences and Humanities Research Council of Canada (SSHRC), PH&N Centre for Financial Research at Sauder School of Business, and INSEAD Alumni Fund. The authors thank Ece Ikiz and Aylin Senem Pişkin for their research assistance.

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https://doi.org/10.1016/j.obhdp.2019.06.001
Received 8 September 2017; Received in revised form 27 May 2019; Accepted 4 June 2019

diversify.

We seek to contribute to research on lay diversification by drawing on psychology research on lay risk perception (Slovic, 1987). Past research suggests that lay investors neglect information on asset covariance (Hedesstrom, Svedsater, & Garling, 2006) and employ passive diversification strategies such as investing evenly across all available assets (Benartzi & Thaler, 2001; Morrin, Inman, Broniarczyk, Nenkov, & Reuter, 2012). In contrast, we propose that lay investors do not ignore covariance information so much as use it incorrectly: they prefer investing in positively correlated assets, which feel more fluent and are perceived as less risky. While financial education is one obvious remedy against such inefficient diversification, we propose and test a theory-driven solution (providing aggregate portfolio returns), that can easily be implemented on investment websites or mobile applications.

2. Conceptual development

2.1. Diversification heuristics and covariance neglect

Successful financial diversification largely relies on understanding the link between asset covariance and portfolio risk: investors should select assets not merely on their individual merits, but also on how their prices vary relative to each other (Markowitz, 1952). Indeed, for a given portfolio return, risk (or volatility) can be minimized by selecting assets with uncorrelated or negatively correlated returns.

Yet behavioral research suggests that individual investors largely neglect this prescription. For instance, when selecting assets sequentially, some investors exhibit narrow framing (Dorn & Huberman, 2010) by evaluating and selecting assets one at a time based on each individual asset's volatility. Presenting assets simultaneously (in a menu) does not seem to solve this problem – investors then tend to apply a naïve diversification strategy called the 1/n heuristic, which consists of investing evenly across all assets on the menu (Benartzi & Thaler, 2001). While investors typically do not invest in every single available asset, they tend to apply a weaker form of the 1/n heuristic whereby their allocation decision depends on how a menu of assets is partitioned (Fox, Ratner, & Lieb, 2005; Morrin et al., 2012). If the menu is mostly composed of correlated assets, the portfolio will be as well, resulting in poor diversification (Karlsson, Massa, & Simonov, 2007).

Such lack of diversification skill has been explained by "covariance neglect" (Gubaydullina & Spiwoks, 2015; Hedesstrom et al., 2006; Kroll, Levy, & Rapoport, 1988). In several studies by Hedesstrom et al. (2006), undergraduate students were shown the past returns of several funds; overall, participants made investment decisions that largely ignored covariance information, that is, they didn't take into account whether assets' past returns were positively or negatively correlated. Nonetheless, we believe that past research on covariance neglect has overlooked the way in which information on covariance between assets may affect risk perceptions across investors with low versus high financial literacy. As explained below, we propose that lay investors do not ignore covariance information so much as use it incorrectly when estimating the riskiness of a portfolio.

2.2. Lay risk perception and fluency

A wealth of research has shown that the perception of financial risk differs greatly between lay and expert investors. Risk simply means different things to different people, depending on their level of expertise (Gooding, 1975; Slovic, 1987; Slovic, Fischhoff, & Lichtenstein, 1985).

Experts think of risk as an objective, quantitative, and measurable construct. In the case of financial diversification, the risk of a portfolio is measured by the volatility (i.e., the fluctuations) of its returns; expert investors know that a portfolio is less volatile, and thus less risky, when its components have uncorrelated or negatively correlated returns. Lay investors may do well at evaluating the volatility (and thus the risk) of an individual asset (Hedesstrom et al., 2006), but evaluating the risk of a portfolio is a more challenging task because it requires knowing the objective relation between asset covariance and portfolio volatility. Since lay investors do not have this knowledge, how does portfolio covariance information (presented in the form of past or expected returns) impact lay risk perception?

Table 1
Example of table of past returns (TD Bank, 2018).

	2015	2016	2017
TD U.S. Blue Chip Equity Fund	+30.8%	−4.7%	+25.5%
TD Canadian Health Sciences Fund	+32.8%	−15.2%	+17.3%
TD Canadian Small-Cap Fund	−7.8%	+18.7%	−1.9%

While prior research has not addressed this focal question, research in other financial contexts has shown that lay people make highly subjective and feelings-based assessments of financial risk: risk is associated with feelings of fear, dread, anxiety, stress, and discomfort (Loewenstein, Weber, Hsee, & Welch, 2001; Slovic & Peters, 2006). Hence, events that feel fluent, familiar, simple, easy to control, or to predict are typically judged as less risky (Slovic et al., 1985; Slovic, 1987). In the current research, we propose that asset returns that "move together" (i.e., positively correlate) feel more fluent to lay investors, misleading them into thinking that a portfolio with positively (vs. negatively) correlated assets is less risky. Consider for instance Table 1, which displays the past calendar returns of three funds, retrieved from the consumer website of a major North-American bank (TD Bank, 2018). Based on this information, a portfolio consisting of "U.S. Blue Chip Fund" and "Canadian Health Sciences Fund" (with positively correlated returns) is objectively more volatile, thus riskier, than a portfolio consisting of "U.S. Blue Chip Fund" and "Canadian Small-Cap Fund" (with negatively correlated returns). Yet, we contend that lay investors will perceive the latter portfolio as riskier, because the negatively correlated returns feel disfluent (even after controlling for the individual characteristics of the funds).

The construct of *fluency* is generally defined as the subjective feeling of ease of processing (Alter & Oppenheimer, 2009b). In the present research, instead of using a strict conceptualization and measurement of fluency derived from the literature (e.g., Graf, Mayer, & Landwehr, 2018), we employed a mixed-method approach combining inductive and deductive methods (Creswell & Clark, 2017) in order to let the construct of fluency emerge from a qualitative analysis of lay investors' risk perceptions in the context of portfolio investment. This theory-building method generates a detailed understanding and comprehensive description of a phenomenon through documenting the perspectives of a population of interest (Mintzberg, 1979; Shah & Corley, 2006). Hence, as described in the empirical section, a qualitative, inductive exploration of lay investor thinking (Study 1) provided the necessary insights for subsequent deductive analysis with quantitative measures (Studies 2–5). This method revealed that among lay investors, perceived portfolio risk is driven by three related components: simplicity, familiarity, and predictability; lay investors perceive a portfolio with positively (vs. negatively) correlated assets as less risky, because it feels simpler, more familiar, and more predictable. In our domain of interest we find these three components to be highly inter-correlated, and statistically related to a single underlying construct that we label "fluency".

Indeed, while there are conceptual distinctions between simplicity, familiarity, and predictability, they are all associated with the general construct of fluency. Past research shows that simpler words, visually simpler fonts, and simpler syntaxes all feel more fluent (Alter, Oppenheimer, Epley, & Eyre, 2007; Lowrey, 1998; Oppenheimer, 2006). Likewise, prototypes are generally the simplest examples of a target category, and are therefore processed more fluently (Winkielman, Halberstadt, Fazendeiro, & Catty, 2006). Prototypes also

seem more fluent because they are more familiar (Rhodes, Halberstadt, & Brajkovich, 2001). Moreover, prior studies suggest a bidirectional relationship between familiarity and fluency: stimuli that are processed more fluently seem more familiar, and more familiar stimuli are processed more fluently (Koriat & Levy-Sadot, 2001; Whittlesea, Jacoby, & Girard, 1990). The relationship between predictability and fluency has been less explored in the literature, but there again it appears to be bidirectional and strong. For example, more fluent speech is judged to be more predictable, and vice versa (Goldman-Eisler, 1958). More broadly, the concept of consistency is related to both predictability and fluency: things that are consistent are easier to predict and also more fluent (Harvey, 1995; Reber, 2012; Topolinski & Strack, 2009; Winkielman, Huber, Kavanagh, & Schwarz, 2012). Of particular relevance to this research is the finding that correlated variables tend to be judged as more predictable (Tversky & Kahneman, 1974), leading to greater confidence, in spite of the fact that having correlated prediction inputs yields *worse* predictions. In sum, simplicity, familiarity, and predictability have all been demonstrated in prior research to be associated with fluency.

Turning to the connection between fluency and risk perceptions: past studies have established a solid, positive link (Alter & Oppenheimer, 2009a; Alter et al., 2007). One study found that difficult to pronounce foods and amusement park rides are judged to be less familiar, less fluent, and more risky (Song & Schwarz, 2009). Other studies demonstrated that stimuli (including financial assets) with disfluent name or description—difficult to read, to pronounce, to understand, to remember, or to recognize—are judged less risky (Alter & Oppenheimer, 2006; Long, Fernbach, & De Langhe, 2018; Mitchell & Greatorex, 1988; Novemsky, Dhar, Schwarz, & Simonson, 2007; Song & Schwarz, 2009; Weber, Siebenmorgen, & Weber, 2005). Likewise, financial assets and asset classes (e.g., bonds, stocks, gold) reported to be "easy to understand" are perceived as less risky (Long et al., 2018; Wang, Keller, & Siegrist, 2011).

We thus hypothesize that:

H1. Lay investors assess portfolio risk based on the fluency of assets' returns, while expert investors assess portfolio risk based on portfolio volatility.

Because of this difference between lay and expert risk perception, we predict that lay investors prefer investing in assets with positively correlated returns (which feel more fluent), while expert investors prefer investing in assets with less correlated or negatively correlated returns (which decrease portfolio volatility):

H2. Lay (vs. Expert) investors tend to invest in assets with more (vs. less) positively correlated returns.

Importantly, we propose that lay investors may deliberately invest in an objectively riskier portfolio, because of their misleading lay risk perception. In order to further demonstrate this misleading role of lay risk perception, we further hypothesize that encouraging (vs. discouraging) risk-seeking will ironically improve lay investors' diversification—they will no longer prefer investing in positively correlated assets:

H3. Instructing lay investors to take on more risk will improve their diversification.

As stated earlier, lay investors are able to assess the volatility (and thus the risk) of an *individual* asset based on its returns, but not the volatility of a *portfolio* of assets. We thus hypothesize that providing investors with the aggregate returns of a portfolio will improve diversification, because the portfolio volatility is directly observable and doesn't need to be estimated based on the covariance of the portfolio components:

H4. Providing aggregate portfolio returns will improve lay investors' diversification.

We ran five multi-method studies. We test our hypothesis that lay investors evaluate portfolio risk based on subjective judgments of fluency (H1) using qualitative (Study 1) and psychometric methods (Study 2). We further test our hypothesis that lay investors prefer non-diversified portfolios, i.e. portfolios with positively correlated returns (H2), based on past returns (Studies 1 through 4) or based on expected returns (Study 5). We also test our hypothesis that encouraging risk-seeking (Study 3; H3) or providing aggregate portfolio returns (Study 4; H4) improves diversification by lay investors.

3. Study 1

Study 1 adopts an inductive and qualitative approach to understand individuals' diversification decisions across different levels of financial literacy. Participants first decided whether to invest in positively or negatively correlated funds, and then they justified their investment decision in the form of brief, open-ended survey responses. Analyzing open-ended survey responses has been used in management research to provide a rich description of respondent reality at a relatively lower cost than in-depth interviews or focus groups (Sproull, 2002). The responses were analyzed with a thematic coding method (Strauss & Corbin, 1994; Weber, 1990).

In this and all subsequent studies, we used the panel of online U.S. participants provided by Amazon Mechanical Turk. These participants present a wide diversity in terms of income, education, and professional activity that does not differ fundamentally from the U.S. population (Levay, Freese, & Druckman, 2016; Paolacci, Chandler, & Ipeirotis, 2010), allowing us to capture a substantial heterogeneity in financial literacy (we return to this point in the General Discussion.)

3.1. Method

900 MTurk participants (51.9% female, mean age = 32.9) were paid $1 to participate in this study. Responses were collected in two batches (N = 400; 500). Participants first read:

Please imagine that you have invested some of your savings in one mutual fund. You are considering investing in a second fund, and you hesitate between two funds: fund Omega, and fund Epsilon. You want to invest for the long term.
Both funds Omega and Epsilon are managed by reputable firms, and in the long run, have yielded equally satisfying returns. There is however one key distinction between these two funds:
- *In the past, fund Omega has tended to perform very similarly to the fund you already have: yielding positive returns when your fund also yielded positive returns, and yielding negative returns when your fund also yielded negative returns.*
- *In contrast, fund Epsilon has tended to perform quite differently from the fund you already have: yielding positive returns when your fund yielded negative returns, and yielding negative returns when your fund yielded positive returns.*

The names of the funds were counterbalanced across participants. Hence, in the description of the results, we call the fund whose returns positively correlate with those of the fund already owned (Omega in the scenario above) the "non-diversifying fund", and the fund whose returns negatively correlate with those of the fund already owned (Epsilon in the scenario) the "diversifying fund".

Then, we asked: "Which fund would you invest in? Please remember that you want to invest for the long term." Participants chose Omega or Epsilon.

On the next page, participants were shown the scenario again, were reminded of their choice, and were asked: "Please try to explain your

choice in a few sentences." Participants needed to answer using a minimum of 200 characters.

Then, we measured financial literacy with 19 multiple-choice questions presented in random order (see Appendix A). These questions varied across levels of difficulty, and were selected from several sources (Fernandes, Lynch, & Netemeyer, 2014; Lusardi & Mitchell, 2011; Mandell, 2008; Volpe, Kotel, & Chen, 2002). None of the questions addressed financial diversification. Embedded in the financial literacy test was one question designed to verify participants' attention and seriousness: "Which activity is the riskiest?"; possible answers were "Leaving all your money in a savings account", "Investing your money in trusted mutual funds", "Gambling all your money at a casino" (the correct answer), and "I don't know".

In the second batch of responses, there were also exploratory close-ended questions placed *after* the open-ended question. We do not discuss them here (see full survey in Appendix C, and analyses in Appendix D).

3.2. Results

3.2.1. Data exclusion

Among the 900 MTurk participants, 87 participants (9.7%) failed the attention check embedded in the financial literacy questionnaire. A large majority of these participants also provided nonsensical open-ended responses (e.g., unrelated copy-pasted text), indicating that they are likely to be "bots"–automated programs mimicking human behavior–or non-English speaking participants. We excluded these participants from analysis, yielding a total of 813 participants. In all subsequent studies, the exclusion rate was much lower (around 3–4%) due to using the "Turkprime" platform (Litman, Robinson, & Abberbock, 2017), which has been shown to improve the data collection quality. In Appendix H, we report the analyses of investment choices across all studies, with and without data exclusion (overall, the level of significance of the effects was not altered by data exclusion).

3.2.2. Fund choice

We coded the choice of the diversifying fund as 1, and the choice of the non-diversifying fund as 0. We conducted a logistic regression of this binary variable on the financial literacy score. We found that a higher financial literacy score predicted a higher likelihood to choose the diversifying fund ($z = 5.44$, $p < .001$).

To better understand fund choices across high and low financial literacy individuals, we proceeded to a quartile analysis (see Fig. 1). Among participants in the top quartile of financial literacy (N = 185, the relative "expert investors"), 62.16% chose the diversifying fund. This proportion was significantly different from chance level, as shown in a two-sided binomial test ($p = .001$). In contrast, among participants

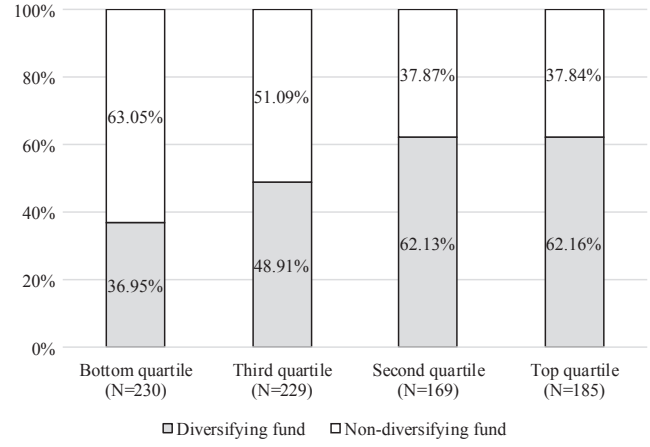

Fig. 1. Study 1 – Fund choice across financial literacy quartiles.

Table 2
Study 1 – Thematic coding of open-ended responses.

		Financial literacy:			
		Bottom quartile	Third quartile	Second quartile	Top quartile
Reasons for choosing the non-diversifying fund					
Total number of participants		***145***	***117***	***64***	***70***
Low risk	Choosing this fund is less risky, safer; it feels "less like a gamble". Would feel less stressed, less nervous, more confident.	61	53	24	22
Simplicity	Funds would be easier to track, monitor, or manage; it would be less confusing and simpler.	16	12	12	4
Predictability	Returns are more consistent, thus more predictable and less surprising; easier to plan for the future.	58	55	32	21
Familiarity	Funds would become more familiar, easier to gain knowledge and understand how they work.	27	28	12	8
Total "Lay" risk perception	**Low risk/simplicity/predictability/familiarity**	**97**	**85**	**47**	**38**
High profit	Choosing this fund would make the overall investment more profitable (making a "double win"), especially if timing the market.	18	21	16	28
Indifference	Indifferent; the choice is inconsequential.	2	1	1	0
Other/No reason	No clear reason; paraphrase of the scenario; additional assumptions not included in the scenario.	26	18	2	8
Reasons for choosing the diversifying fund					
Total number of participants		***85***	***112***	***105***	***115***
"Expert" risk perception	**Choosing this fund would reduce portfolio risk/volatility/fluctuations; the profit of one fund would compensate for the loss of the other fund.**	**56**	**87**	**92**	**111**
Variety-seeking	Want something different, for the sake of variety.	3	8	1	2
High risk	It would be risky, but willing to take this risk.	3	2	1	0
Indifference	Indifferent; the choice is inconsequential	3	3	0	0
Other/No reason	No clear reason; paraphrase of the scenario; additional assumptions not included in the scenario.	21	13	12	2

in the bottom quartile of financial literacy (N = 230, the relative "lay investors"), only 36.95% chose the diversifying fund, also significantly different from chance level ($p < .001$). The fund choices in the two other quartiles were in-between, as shown in Fig. 1.

3.2.3. Thematic coding of open-ended responses

Two trained coders were provided a spreadsheet with all 813 open-ended responses, associated with each respondent's investment decision. The coders were not aware of our research hypotheses, not informed of participants' financial literacy level, and not given any pre-established theme. We first instructed the coders to list all recurring themes in the responses. The two coders generated their themes list independently. Then, one author of this manuscript met with the two coders, and together they constructed a unique list of recurring themes and established a code book. Finally, one of the two coders was instructed to code each opened-ended response, based on whether the theme was present. Each participant response could be classified under more than one theme.

Table 2 provides a list of all the themes that the participants provided to justify their fund choice, along with the number of participants who evoked each theme, in each quartile of financial literacy.

As shown in Table 2, among participants justifying a decision to invest in the non-diversifying fund, we identified three themes. The first was *simplicity*: correlated assets are simpler to track, monitor, or manage (e.g., #32 "It would be easier to track its performance and use the same strategies I use with my current fund. I like the idea of a fund similar to my own.") The second was *familiarity:* it would be easier to gain knowledge and understand how correlated assets "work" (e.g., #215 "Because it works the same as my current account. I'm familiar with it and feel safe to have another one just like the current one.") The third was *predictability*: returns of correlated assets are consistent thus easier to predict (e.g., #119 "Because it performs similar to the investment I already have. It makes me feel comfortable and more at ease knowing what to expect with my investments. It gives me peace of mind because I can plan and expect my returns to be a certain amount.") We noted much overlap across these three themes, providing initial evidence that they represent an overarching construct related to fluency. We also noted that many participants who evoked these themes also explicitly mentioned that their investment decision would be less risky (*low risk*), especially participants with low financial literacy (e.g., #74 "I am a creature of habit. I am more comfortable investing into something similar. If it is producing the same way as my other fund, I would be more comfortable with that. I am not a person willing to take too many risks.") Among the 145 participants in the bottom quartile of financial literacy who chose the non-diversifying (correlated) fund, 97 evoked themes related to this "lay" risk perception (i.e., explicitly mentioned low risk and/or themes related to fluency).

Additionally, we identified a *high profit* theme*:* some participants justified their decision to invest in the non-diversifying fund by saying that owning correlated assets would be more profitable, especially on the short term (e.g. #10 "I chose it because it they are both doing well I can sell them at the same time cash out and make money.") We found this theme especially prevalent among participants in the top quartile of financial literacy (38 out of 70). Importantly, this short-term strategy was inconsistent with the scenario that required making a long-term investment. We explore the role of profit perceptions (vs risk perceptions) in more detail in studies 2 and 3.

Among participants justifying a decision to invest in the diversifying fund, most participants identified the correct ("expert") reason: uncorrelated assets reduce portfolio volatility, and thus portfolio risk. This was especially prevalent among participants in the top quartile of financial literacy (111 out of 115). However, among the bottom quartile participants who chose the diversifying fund, a majority (56 out of 85) had a close enough intuition (e.g., #467 "I would not have low points and high points. It would be steady income. One fund would offset the other fund. Like if I had two jobs that pay bi-weekly I would want my checks on opposite weeks.")

3.3. Discussion

In line with Hypotheses 1 and 2, in Study 1, participants with high financial literacy preferred investing in a diversifying fund; most of them explained that uncorrelated assets reduce portfolio volatility, which is the normative (or "expert") driver of portfolio risk. On the other hand, participants with low financial literacy preferred investing in a non-diversifying fund, erroneously thinking that it would be less risky. We identified three broad themes (all related to fluency) and driving this lay risk perception: (1) correlated assets are simpler to track and manage, (2) correlated assets are easy to get familiar with, and (3) correlated performances are easier to predict.

There are limitations to Study 1. First, the scenario endowed participants with a fund, so their decision to invest in a second, identical fund may be explained by a status-quo bias; it is already established that people like to be consistent in sequential gambles, which can lead to "doubling down" on risk (Markle & Rottenstreich, 2018), generating a pattern similar to what we observed in Study 1. In the next study, we extend our research to a situation where investors choose two funds simultaneously. Second, we did not provide numeric information about the funds, and some participants drew inferences about the individual profitability of the funds. We address this limitation in the next study by providing a numeric summary of past returns, and controlling for the individual profitability and volatility of the funds.

4. Study 2

Study 2 aims to replicate Study 1 results with simultaneous (in addition to sequential) investment decisions, and to collect process evidence with psychometric methods. We measured the "lay" themes identified in Study 1 (simplicity, familiarity, and predictability) with similar wording as used by participants, and tested whether these themes represent a common, underlying construct (fluency). Study 2 also aims to show that lay versus expert investment decisions derive from divergent portfolio risk perceptions: *lay* risk perception is driven by fluency (explaining why correlated assets are judged less risky), while *expert* risk perception is driven by portfolio volatility (explaining why negatively correlated assets are judged less risky).

4.1. Method

395 MTurk participants (60.3% female, mean age = 34.7) were paid $1 to participate in this study. In this and all subsequent studies, we used the "TurkPrime" platform. Using this platform not only allowed collecting quality responses, but also ensured that we did not use respondents from other studies included in this manuscript. Participants were randomly assigned to one of two experimental conditions: sequential choice or simultaneous choice. All participants first read a scenario. In the "sequential choice" condition, the scenario was very similar to the one presented in Study 1: participants were told that they already owned fund Gamma, and that they could choose to invest in a second fund, either Epsilon (that has reportedly performed very similarly to Gamma in the past) or Sigma (that has reportedly performed quite differently from Gamma in the past). Information about asset covariance was also provided in the form of a table of past returns over 7 years, as shown in Fig. 2: Gamma's returns were positively correlated with Epsilon's returns, and negatively correlated with Sigma's returns. The individual variance and the 7-year performance of the funds were identical. The 7-year performance was provided in the table. We created two versions of the table (randomized across participants) to control for any potential effect of the sequence of returns (see Appendix B). For instance, in the first (second) version of the table, the 2016 returns of Gamma and Epsilon were negative (positive) while the 2016 return of Sigma was positive (negative).

Calendar Returns

	2011	2012	2013	2014	2015	2016	2017	Overall performance (7 years)
Gamma	5.5%	-5.1%	13.8%	-4.6%	13.6%	-1.4%	5.2%	**+28%**
Epsilon	5.7%	-4.9%	13.9%	-4.8%	13.8%	-1.6%	4.9%	**+28%**
Sigma	-1.5%	13.9%	-4.8%	13.5%	-4.9%	5.6%	4.9%	**+28%**

Fig. 2. Study 2 – Example of table of past returns.

In the "simultaneous choice" condition, participants read a similar scenario and were shown the same table, although they were not told that they already owned Gamma.

In both conditions, participants were reminded that they were investing for the long term. They indicated whether they preferred investing in Gamma & Epsilon (which we call here the "non-diversified portfolio") or in Gamma & Sigma (which we call here the "diversified portfolio"), on a 5-point scale ranging from −2 (labelled "definitely Gamma & Epsilon") to +2 (labelled "definitely Gamma & Sigma") with a middle point 0 (labelled "I'm indifferent").

Then, we asked a series of questions presented in random order (with the table of past returns shown to participants in order to help them answer the questions).

4.1.1. Risk

We measured risk perception with three items, using wording similar to what Study 1 participants used: "Which portfolio seems riskier?"; "Which portfolio seems safer?"; "and "Which portfolio seems more dangerous?". We measured each answer on a 5-point scale ranging from −2 (labelled "definitely Gamma & Epsilon") to +2 (labelled "definitely Gamma & Sigma") with a middle point 0 (labelled "Both portfolios equally"). The same 5-point scale was used for all questions listed below.

4.1.2. Volatility (driver of "expert" risk perception)

We measured volatility perception with a single item, using wording that could be understood by all participants: "Which portfolio is likely to fluctuate more over time (meaning sharply moving up and down)?".

4.1.3. Fluency (driver of "lay" risk perception)

While volatility is an objective, statistic construct that is measured by a single item, fluency is a more complex and highly context-dependent construct. In line with our inductive-deductive approach, we measured fluency with three subscales composed of three items each, measuring the themes uncovered in Study 1. All questions were largely inspired by the wording of the open-ended responses collected in Study 1. The first 3-item subscale measured simplicity: "Which portfolio would be easier to track?"; "Which portfolio would be more complicated to track?" and "Which portfolio would be more confusing?". The second 3-item subscale measured familiarity—we worded the questions so that they could apply to both sequential and simultaneous investment decisions: "Which portfolio would it be easier to get familiar with?"; "Which portfolio would it be easier to get used to?"; and "Which portfolio would it be easier to get accustomed to?". The third 3-item subscale measured predictability: "Which portfolio would have more predictable future performances?"; "With which portfolio would you know better what to expect about future performances?"; and "Which portfolio makes you feel more certain about future performances?".

4.1.4. Profit and loss

We also measured perceived long-term profitability ("Which portfolio is more likely to be profitable in the long run?") and loss ("Which portfolio is more likely to lose money in the long run?").

Finally, we measured financial literacy with the same 19 questions as in Study 1.

4.2. Results

4.2.1. Data exclusion

12 participants (3.0% of the total number of participants) failed the attention check embedded in the financial literacy questionnaire, and were excluded from analysis.

4.2.2. Scale construction

The three-item risk perception scale was highly reliable ($\alpha = 0.93$).

We ran a factor analysis (PCA) of the 9 items measuring the drivers of lay risk perception: simplicity, familiarity, and predictability (3 subscales of 3 items). The first factor had an eigenvalue of 4.50, and the factor loadings of the 9 items ranged between |0.54| and |0.86|. The second factor had a much smaller eigenvalue (1.05), with a maximum factor loading of |0.52|. We concluded that the scale measuring the drivers of lay risk perception was unidimensional. We thus created a unique 9-item scale, which was highly reliable ($\alpha = 0.89$), and which we used for the subsequent analyses. Hence, while there are theoretical differences between simplicity, familiarity, and predictability, our data (in the context that we study) suggests that they reflect a single underlying construct in the minds of participants. Following our inductive-deductive approach and due to the high reliability of this construct, we label this construct "fluency" in our subsequent analyses.

4.2.3. Portfolio choice

We regressed portfolio choice onto the mean-centered financial literacy score, a binary variable capturing the effect of the simultaneous vs. sequential decision manipulation (coded −1 for sequential, and +1 for simultaneous), and their interaction. Neither the main effect of the simultaneous vs. sequential decision manipulation, nor the interaction effect between the manipulation and financial literacy significantly impacted investment decisions (p's > 0.65). In contrast, financial literacy significantly predicted investment decisions ($t(379) = 8.61$, $p < .001$). The sequential vs. simultaneous manipulation had no significant impact on any of the collected measures; we thus collapsed the two experimental conditions in the subsequent analyses, and do not discuss them further.

We then proceeded to quartile analyses (see Fig. 3). Consistent with Study 1, participants in the top quartile of financial literacy largely invested in the diversified portfolio, i.e. Gamma-Sigma. The mean answer was 0.95 (SD = 1.12), on the 5-point scale ranging from −2 (Definitely Gamma-Epsilon) to +2 (Definitely Gamma-Sigma). This was significantly different from zero, the indifference point ($t(94) = 8.22$, $p < .001$). Consistent with Study 1, participants in the bottom quartile of financial literacy invested in the *non*-diversified portfolio, i.e. Gamma Epsilon (M = −0.46, SD = 1.10; significantly different from zero: $t(90) = -4.00$, $p < .001$). The results in the other two quartiles were "in-between".

Risk Perception, Volatility and Fluency. We then proceeded to analyze risk perception and its potential drivers: perceived volatility and perceived fluency.

As shown in Fig. 3, participants in the top quartile of financial literacy considered the non-diversified portfolio riskier than the diversified one (M = −0.64, SD = 0.90; significantly different from zero: $t(94) = -6.94$, $p < .001$), more volatile (M = −0.67, SD = 1.18; $t(94) = -5.56$, $p < .001$), but also more fluent (M = −0.38, SD = 0.64; $t(94) = -5.76$, $p < .001$). In fact, all four quartiles found

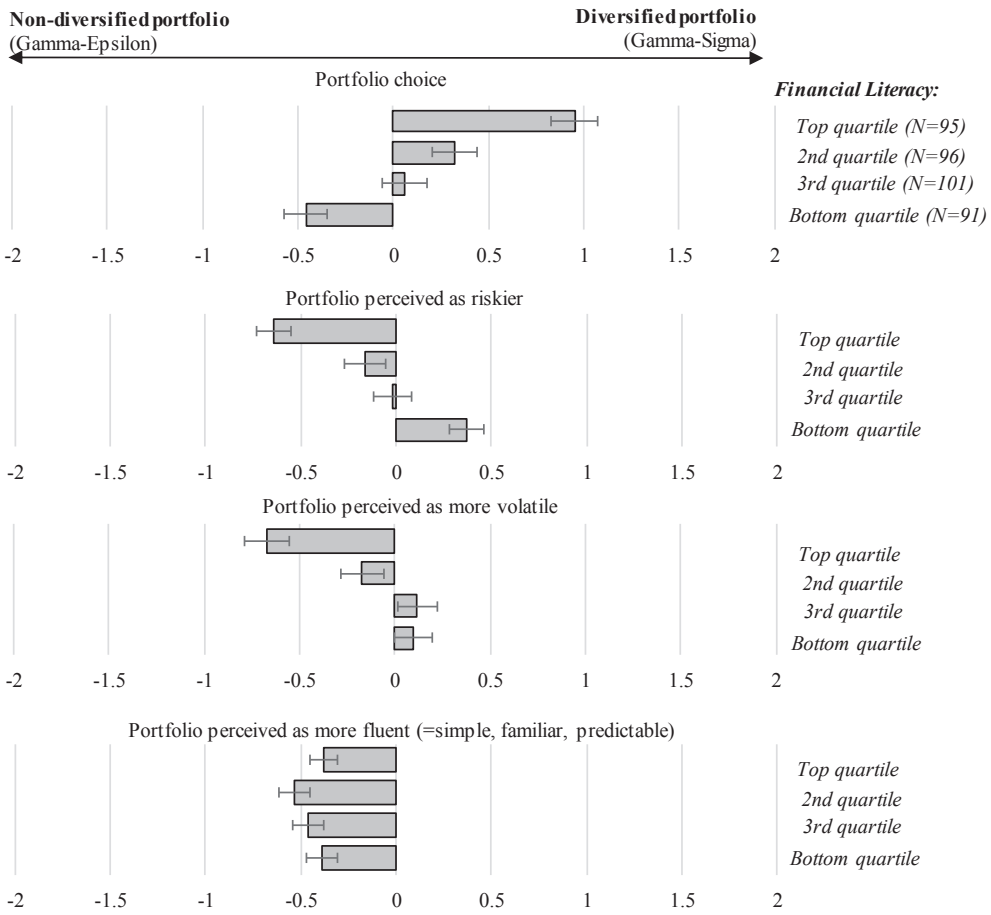

Fig. 3. Study 2 – Mean portfolio choice, and mean risk, volatility, and fluency perceptions across financial literacy quartiles. Note. Error bars indicate standard error of the mean.

the non-diversified portfolio more "fluent", although this does not necessarily predict investment decisions, as the following mediation analyses show.

Participants in the bottom quartile of financial literacy considered the non-diversified portfolio less risky than the diversified one ($M = 0.37$, $SD = 0.89$; significantly different from zero: $t(90) = 3.92$, $p < .001$), and also more "fluent" ($M = -0.39$, $SD = 0.81$; $t(90) = -4.65$, $p < .001$). They did not consider a portfolio more volatile than the other ($M = 0.10$, $SD = 0.94$; $t(90) = 1.00$, $p = .32$), consistent with past research suggesting that lay investors ignore the relation between asset covariance and portfolio volatility.

The results in the other two quartiles were consistently "in-between".

4.2.4. Mediation analyses

In the following analyses, we investigate how volatility perception and fluency perception influence risk perception and portfolio choice across the four quartiles.

We built a structural equation model, with volatility and fluency as independent variables, risk perception as a mediator, and portfolio investment choice as the dependent variable. Hence, two paths (Volatility → Risk → Investment, and Fluency → Risk → Investment) were estimated simultaneously. Table 3 displays the coefficients and the 95% confidence intervals of the total effects of the IVs on the DV, the indirect effects (i.e., mediation through risk perception), and the residual direct effects for each of the four quartiles of investment literacy. The 95% confidence intervals were all obtained with the bootstrapping method (5000 replications), which is an estimation option available on STATA for Structural Equation Modeling.

As shown in Table 3, in the top quartile of financial literacy, perceived fluency did not play any significant role, while perceived volatility played a key role. The perceived lower volatility of the diversified portfolio significantly predicted investment in that portfolio (total effect: $\beta = -0.25$; 95% CI = $[-0.47, -0.04]$), and this effect was fully mediated by risk perception (indirect effect: $\beta = -0.18$; 95% CI = $[-0.29, -0.08]$); the residual direct effect was non-significant. In other words, as hypothesized, these expert investors relied on the "expert" driver of risk (volatility), explaining their investment in the diversified portfolio.

In the bottom quartile, perceived volatility did *not* play any significant role, while perceived fluency played a major role. The perceived fluency of the non-diversified portfolio significantly predicted investment in that portfolio (total effect: $\beta = 0.57$; 95% CI = [0.29,0.85]), and this effect was fully mediated by risk perception (indirect effect: $\beta = 0.39$; 95% CI = [0.11,0.66]); the residual direct effect was non-significant. In other words, as hypothesized, these lay investors relied on a "lay" driver of risk (fluency), leading them to invest in the non-diversified portfolio.

4.2.5. Risk vs. profit and loss

Thus far, the analyses showed that differences in risk perception explain why portfolio choices drastically differ across participants with different levels of financial literacy. Arguably, the differences in portfolio choices could also be driven by differences in profit or loss perception.

However, participants in the bottom quartile of financial literacy found the diversified portfolio only marginally more prone to loss ($M = 0.16$, $SD = 0.87$; $t(90) = 1.80$, $p = .07$), and just as profitable as

Table 3
Study 2 – structural equation model.

Financial literacy	Structural Equation Model (Volatility & Fluency → Risk → Investment)					
	Volatility → Risk → Investment			Fluency → Risk → Investment		
	Total Effect	Indirect Effect	Residual Direct Effect	Total Effect	Indirect Effect	Residual Direct Effect
Top quartile (N = 95)	β = −0.25 [−0.47,−0.04]*	β = −0.18 [−0.29,−0.08]*	β = −0.07 [−0.27,0.13]	β = 0.33 [−0.03,0.68]	β = 0.13 [−0.05,0.30]	β = 0.20 [−0.12,52]
2nd quartile (N = 96)	β = −0.10 [−0.37,0.16]	β = −0.11 [−0.23,0.01]†	β = 0.00 [−0.25,0.26]	β = 0.06 [−0.29,0.41]	β = 0.20 [−0.01,0.42]†	β = −0.15 [−0.48,0.19]
3rd quartile (N = 101)	β = 0.00 [−0.22,0.23]	β = −0.03 [−0.14,0.08]	β = 0.03 [−0.18,0.24]	β = 0.47 [0.17,0.77]*	β = 0.30 [0.14,0.47]*	β = 0.16 [−0.11,0.43]
Bottom quartile (N = 91)	β = 0.12 [−0.15,0.39]	β = −0.07 [−0.17,0.03]	β = 0.19 [−0.10,0.48]	β = 0.57 [0.29,0.85]*	β = 0.39 [0.11,0.66]*	β = 0.18 [−0.21,0.58]

Note. Coefficients and 95% confidence intervals. Confidence intervals obtained with bootstrapping (5000 reps) for all total effects, indirect effects, and residuals direct effects.
* Indicates significant effects (based on 95% confidence intervals).
† Indicates marginally significant effects (based on 90% confidence intervals).

the non-diversified portfolio (M = 0.00, SD = 0.86), providing evidence that profitability could not explain investment decisions among these participants. Participants in the top quartile found the non-diversified portfolio less profitable (M = 0.19, SD = 0.72; t(94) = 2.57, p = .01) and more prone to loss (M = −0.22, SD = 0.77; t(94) = −2.78, p = .01), although these effects were small compared with those of risk perception (M = −0.64) or volatility perception (M = −0.67). Furthermore, risk perception strongly predicted investment decisions, even when controlling for profit and loss perceptions in the bottom (p = .01) and top quartiles ($p < .001$) of financial literacy.

To further test these alternative explanations, we estimated a multiple-mediation model, with financial literacy as the independent variable, portfolio choice as the dependent variable, and risk perception, profit perception, and loss perception as three potential mediators. Only risk perception was a significant mediator (indirect effect through risk perception: β = 0.035, 95% CI = [0.019,0.051]). The indirect effects through loss perception and profit perception were non-significant (respectively, β = 0.002, 95% CI = [−0.006,0.010]; β = 0.006, 95% CI = [−0.002,0.014]).

4.3. Discussion

Study 2 confirmed the findings of Study 1 with psychometric methods. In line with Hypotheses 1 and 2, lay investors perceived the non-diversified portfolio as less risky, because it felt more fluent: simpler, more familiar, and more predictable. Therefore they diversified poorly. Expert investors perceived the diversified portfolio as less risky, because it was perceived as less volatile; therefore they diversified effectively.

5. Study 3

Study 3 aims to provide further experimental evidence that the different diversification strategies of lay and expert investors are driven by divergent perceptions of risk. Rather than measuring risk perception, we manipulated investment goals and encouraged participants to either seek or avoid risk in their investment decision. We hypothesize (H3) that encouraging risk-seeking will have opposite consequences across lay and expert investors: it will effectively decrease expert investors' tendency to diversify, while it will ironically *increase* lay investors' tendency to diversify. Importantly, in the instructions in this study, the term "risk" was always left to participants' own interpretation. We also collected additional evidence suggesting that lay and expert diversification decisions are driven by risk, rather than long-term profitability perceptions, in the context of the scenarios we employ (in which past profitability is held constant).

5.1. Method

615 MTurk participants (60.2% female, mean age = 33.8) were paid $1 to participate in this study. We assigned participants to one of two between-subject conditions, "risk-avoiding" and "risk-seeking". Participants first read the same "simultaneous choice" scenario as in Study 2, requiring them to choose between a non-diversified portfolio (Gamma & Epsilon, with positively correlated returns), or a diversified portfolio (Gamma & Sigma, with negatively correlated returns).

In addition, in the risk-avoiding condition, the scenario ended with: "This is important: when choosing between "Gamma & Epsilon" and "Gamma & Sigma", you want to make a low-risk investment. You don't care about trying to make huge returns, you only care about making a safe, low-risk investment." In the risk-seeking condition, the scenario ended with: "This is important: when choosing between "Gamma & Epsilon" and "Gamma & Sigma", you want to make an investment with high returns. You don't care if your investment is risky or unsafe, you only care about making a high-return investment." Participants made their investment decision on a 5-point scale ranging from −2

("definitely Gamma & Epsilon") to +2 ("definitely Gamma & Sigma") with a middle point 0 ("I'm indifferent").

Then, we measured risk, volatility, profit, and loss perception; the results were highly consistent with Study 2, and the risk manipulation did not significantly impact these perceptual measures (we provide the analyses in Appendix E.)

Finally, we measured financial literacy with the same test as in previous studies.

5.2. Results and discussion

5.2.1. Data exclusion

19 participants (3.1% of all participants) failed the attention check embedded in the financial literacy questionnaire, and were excluded from analysis.

5.2.2. Portfolio choice

We regressed portfolio choice on the mean-centered financial literacy score, a binary variable capturing the effect of the manipulation (coded −1 for risk-seeking and +1 for risk-avoiding), and their interaction. We found a significant main effect of financial literacy ($t(5\,9\,2) = 4.41$, $p < .001$) and a significant interaction effect ($t(5\,9\,2) = 3.22$, $p = .001$). The main effect of the manipulation was not significant ($t < 1$).

We then proceeded to a quartile analysis. As shown on Fig. 4, the mean choices in the risk-avoiding condition were very similar to Study 2: participants in the top quartile of financial literacy largely invested in the diversified portfolio (M = 0.82, SD = 1.21; significantly different from zero, $t(65) = 5.47$, $p < .001$), and participants in the bottom quartile invested in the non-diversified portfolio (M = −0.51, SD = 1.16; $t(60) = -3.41$, $p = .001$).

Consistent with Hypothesis 3, encouraging participants to take risk had an opposite effect among participants with different financial literacy. Encouraging risk-seeking significantly *decreased* top quartile participants' investment in the diversified portfolio (M = 0.25, SD = 1.27; effect of the risk manipulation: $t(1\,3\,1) = 2.59$, $p = .01$), and *increased* bottom quartile participants' investment in the diversified portfolio (M = 0.10, SD = 1.21; effect of the risk manipulation: $t(1\,2\,7) = -2.92$, $p = .004$). That is, they ironically made a *less* risky investment. This shows that lay and expert investment decisions are driven by different perceptions of portfolio risk.

5.2.3. Risk perception versus profit and loss perception

Like in Study 2, participants in the bottom quartile of financial literacy perceived the diversified portfolio as riskier than the non-diversified one (M = 0.26, SD = 0.94; significantly different from zero: $t(1\,2\,7) = 3.07$, $p = .003$), and—to as smaller extent—more prone to loss (M = 0.15, SD = 0.86; $t(1\,2\,7) = 2.10$, $p = .05$). However, both portfolios were judged equally profitable (M = −0.07, SD = 0.96; not significantly different from zero: $t(1\,2\,7) = -0.83$, $p = .41$), providing additional evidence that profitability could not explain investment decisions among these participants.

Like in Study 2, participants in the top quartile perceived the diversified portfolio as less risky than the non-diversified one (M = −0.43, SD = 1.21; significantly different from zero: $t(1\,3\,1) = -4.09$, $p < .001$), and—to a smaller extent—more profitable (M = 0.17, SD = 0.86; $t(1\,3\,1) = 2.32$, $p = .02$) and less prone to loss (M = 0.16, SD = 0.80; $t(1\,3\,1) = -2.29$, $p = .02$). Risk perception largely predicted investment decisions, even when controlling for profit and loss perceptions in the bottom ($p < .001$) and top quartiles ($p = .002$) of financial literacy.

5.3. Discussion

Study 3 provides experimental evidence that lay and expert investors employ different diversification strategies because of divergent perceptions of risk. As hypothesized (H3) encouraging risk-seeking effectively decreased expert investors' tendency to diversify, and ironically *increased* lay investors' diversification. As encouraging risk-seeking is understandably not a practical solution to improve diversification, we investigate a more viable intervention in the next study.

6. Study 4

Past research suggests that lay investors are able to assess the volatility (and thus the risk) of an individual asset based on its returns, but not the volatility of a portfolio of assets, because it requires them to understand the relationship between asset covariance and risk. Our previous studies show that lay investors do not have this knowledge, and instead, they misleadingly rely on how fluently they perceive assets' returns. In Study 4, we test whether providing aggregate portfolio returns can help lay investors diversify more effectively (Hypothesis 4). This would suggest that lay investors are potentially sensitive to portfolio volatility, although they need to observe it directly. This aggregation intervention complements previous literature on Myopic Loss Aversion (MLA; Benartzi & Thaler, 1999; Haigh & List, 2005; Looney & Hardin, 2009; Webb & Shu, 2017). Research on MLA has found that aggregating investment returns over time ("broad bracketing", Read, Loewenstein, & Rabin, 1999) helps investors visualize or understand cumulative performance over *time*. Similarly, aggregating investment returns across the *portfolio* should help lay investors better understand portfolio performance (and volatility), leading to a preference for a

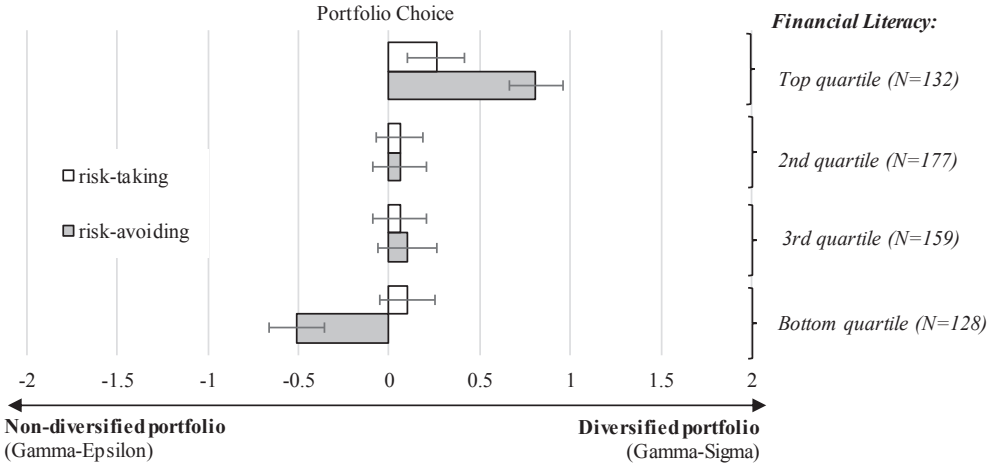

Fig. 4. Study 3 – Mean portfolio choice per financial literacy quartile and risk condition. Note. Error bars indicate standard error of the mean.

portfolio with a more attractive risk profile.

We also address a limitation of Studies 2 and 3: one of the three possible funds (Gamma) was by default always included in participants' fund choices; this could potentially have a normative effect. In Study 4, we eliminate this potential confound by asking participants to choose among two portfolios, with two distinct funds in each of them.

Also, Study 4 includes a financial incentive: participants were paid a bonus equivalent to a randomly-picked one-year return of their chosen portfolio (where 1% = 1 cent). This feature directly measured participants' capacity to understand how covariance relates to risk, insofar as choosing the diversified portfolio ensured the payment of a bonus. One limitation of this financial incentive is that it could induce participants to focus on past single year's performance, instead of trying to estimate the best portfolio as a long-term investment. In order to address this limitation, we ran a close replication of Study 4 without any financial incentive; the results were consistent and reported in Appendix G.

6.1. Method

603 MTurk participants (59.4% female, mean age = 33.8) were paid $1 to participate in this study (plus a bonus, as described below). We assigned participants to either a control condition or a "portfolio returns" condition.

In the control condition, participants first read a scenario in which one trusted bank was offering a portfolio composed of two funds with visibly correlated returns shown in a table (Gamma & Epsilon, which we call here the "non-diversified portfolio"), while another trusted bank was offering a portfolio composed of two other funds with visibly negatively correlated returns (Omega & Sigma, the "diversified portfolio"). As in the previous studies, there were two versions of each table, to control for the sequence of returns (see Appendix B).

In the "portfolio returns" condition, the scenario was identical, with the exception that we also provided aggregate portfolio returns in the tables. It was thus salient that the diversified portfolio had less volatile returns than the non-diversified portfolio (see Fig. 5).

Next, we explained the financial incentive to participants:

In order to motivate you to make a choice that you think is best for you, your bonus payment will be determined by your portfolio choice. You will start with a bonus of 10 cents. Then, we will randomly determine one year of returns (it could be 2011, or 2012, or 2013, etc.) and add or subtract the overall return of the chosen portfolio of two funds on that year, where 1% = 1 cent.

We provided some examples to make sure that the financial incentive was understood (see full script in Appendix C). Then, participants chose either Portfolio Gamma-Epsilon or Portfolio Omega-Sigma.

We measured the risk perception and the volatility perception of the portfolios as manipulation checks. Finally, we measured financial literacy with the same test as in the previous studies.

6.2. Results

6.2.1. Data exclusion

21 participants (3.5% of all participants) failed the attention check and were excluded from analysis.

6.2.2. Manipulation checks

In the control condition, risk and volatility perceptions were similar to what we found in Study 2. In contrast, in the "portfolio returns" condition, all participants perceived the diversified portfolio as significantly less risky and less volatile (see analyses in Appendix F).

6.2.3. Portfolio choice

We performed a logistic regression of the portfolio choice (coded 0 for the non-diversified portfolio, and 1 for the diversified portfolio) on mean-centered financial literacy, a binary variable capturing the effect of the manipulation (coded −1 for control and +1 for portfolio returns), and their interaction. We found significant main effects of financial literacy ($z = 3.22$, $p < .001$) and of the manipulation ($z = 2.02$, $p = .04$), as well as a significant interaction effect with a negative sign ($z = -4.31$, $p < .001$), indicating that the "portfolio returns" manipulation had a stronger effect among participants with low financial literacy, as confirmed below.

We performed a quartile analysis based on financial literacy (see Fig. 6). In the control condition, a majority of top quartile participants

Calendar Returns

	2011	2012	2013	2014	2015	2016	2017	Overall performance (7 years)
Gamma	18%	-7%	15%	-12%	12%	-9%	16%	**+32%**
Epsilon	14%	-13%	17%	-8%	20%	-11%	16%	**+32%**

	2011	2012	2013	2014	2015	2016	2017	Overall performance (7 years)
Omega	-8%	16%	-14%	14%	-9%	19%	16%	**+32%**
Sigma	14%	-10%	20%	-8%	15%	-13%	16%	**+32%**

Calendar Returns

	2011	2012	2013	2014	2015	2016	2017	Overall performance (7 years)
Gamma	18%	-7%	15%	-12%	12%	-9%	16%	**+32%**
Epsilon	14%	-13%	17%	-8%	20%	-11%	16%	**+32%**
Overall portfolio	**16%**	**-10%**	**16%**	**-10%**	**16%**	**-10%**	**16%**	**+32%**

	2011	2012	2013	2014	2015	2016	2017	Overall performance (7 years)
Omega	-8%	16%	-14%	14%	-9%	19%	16%	**+32%**
Sigma	14%	-10%	20%	-8%	15%	-13%	16%	**+32%**
Overall portfolio	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**16%**	**+32%**

Fig. 5. Study 4 – Examples of tables of past returns in the control condition (top) and "portfolio returns" condition (bottom).

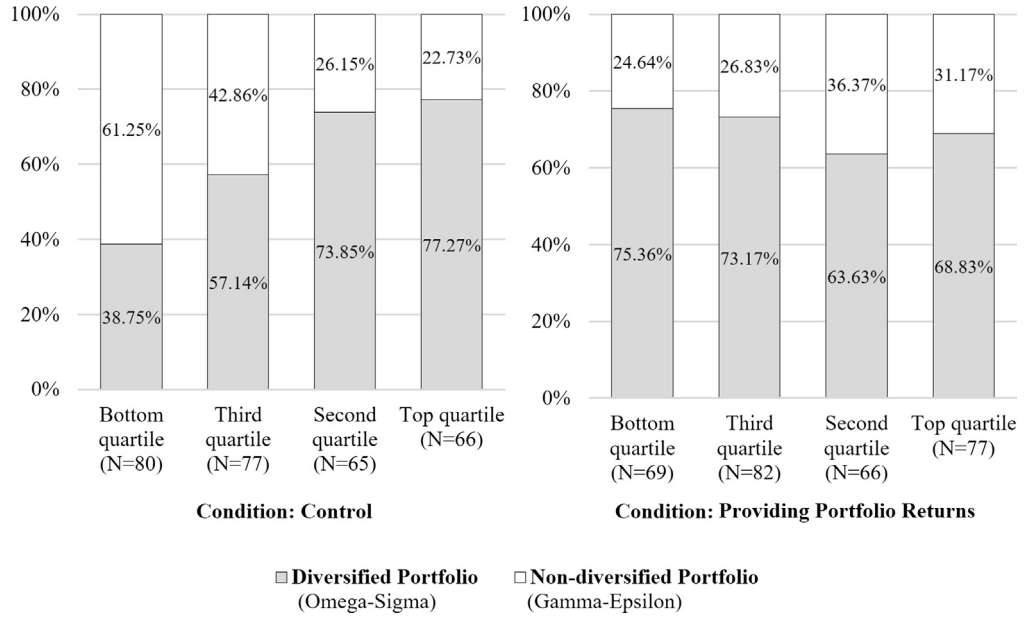

Fig. 6. Study 4 – Portfolio choice per financial literacy quartile and information condition.

invested in the diversified portfolio (77.27%; significantly different from chance-level based on a two-tailed binomial test, $p < .001$), while a *minority* of bottom quartile participants invested in the diversified portfolio (38.75%; marginally significantly different from chance level, $p = .06$). Note that the latter test was fully significant when using a one-tailed test, or when using a two-tailed test among participants in the bottom *quintile* of financial literacy.

Conversely, providing portfolio returns made a majority of bottom quartile participants invest in the diversified portfolio (75.36%; significantly different from chance level, $p < .001$).

6.3. Discussion

As hypothesized (H4), informing lay investors (participants with low financial literacy) of aggregate portfolio returns improved diversification. This shows that lay investors are potentially influenced by portfolio volatility, although they cannot infer it from the past returns of individual funds. Note that, because of the financial incentive, investing in the non-diversified portfolio was not necessarily suboptimal like it was in the previous studies: risk-seeking participants could have actually preferred this option, which offered approximately a 50% chance to obtain a 26-cent bonus, while choosing the diversified portfolio offered a 100% chance to obtain a 13-cent bonus. Still, when providing clearer information about bonus payment (i.e., when providing portfolio returns), we found that a majority of participants, in all four quartiles of literacy, preferred the safer, diversified portfolio. Hence, bottom quartile participants' choice of the riskier, non-diversified portfolio in the control condition was a deviation from their risk preference.

Furthermore, while participants in previous studies were instructed to invest for the long term, participants in this study were incentivized according to their performance in the short term. We replicated our key findings, demonstrating robustness to incentives and time-frame.

7. Study 5

Study 5 aims to replicate the effect of financial literacy on diversification decisions (H2) when participants are provided with *expected* returns across hypothetical future scenarios. Further, as demonstrated in the previous studies, lay investors ignore the objective relation between asset covariance and portfolio risk, because this relation is not intuitive. However, in the previous studies, we did not provide any reason why assets co-vary, which may make it especially difficult to intuit or visualize that investing in negatively correlated assets reduces risk. Thus Study 5 aims to test the generalizability of Hypothesis 2 in situations where individuals are given a concrete, logical reason for why assets co-vary the way they do. In other words, we test whether knowing the underlying causal structure of asset covariance helps lay investors diversify. This is plausible based on findings from prior research (Cosmides & Tooby, 1992) showing that people can more easily solve logical reasoning problems when the abstract rule to test (e.g., "If a person has a 'D' rating, then his documents must be marked code '3'") is reframed as an everyday situation (e.g., "If a person is drinking beer, then he must be over 20 years old").

7.1. Method

408 MTurk participants (68% female, mean age = 33.7) were paid $1 to participate in this study. We assigned them to either an "abstract" or a "concrete" scenario condition.

In the abstract condition, participants read the following scenario:

Imagine that you want to invest in two of the following three company stocks: Omega, Gamma, and Epsilon. All companies are profitable, but the expected returns of the stocks depend on the future economic situations. You can expect two kinds of economic situations: Situation A or Situation B. These situations are equally likely to occur in the future.

- *If Situation A occurs, then Omega and Gamma are expected to yield +30% positive returns, whereas Epsilon is expected to yield a −10% negative return.*
- *If Situation B occurs, then Omega and Gamma are expected to yield −10% negative returns, whereas Epsilon is expected to yield a +30% positive return*

In the concrete condition, participants read:

Imagine that you want to invest in two of the following three videogame company stocks: Omega Games, Gamma Games, and Epsilon Games. All companies are profitable, but the expected returns of the stocks depend on the future success of videogame consoles.
Omega and Gamma both have an exclusivity deal with the videogame console "GameStation", while Epsilon has an exclusivity deal with the

videogame console "GameBox". Usually, only one videogame console is successful and wins the market. You can expect two kinds of situations: GameStation wins the market, or GameBox wins the market. These situations are equally likely to occur in the future.

- *If GameStation wins the market, then Omega and Gamma (which produce games for GameStation) are expected to yield +30% positive returns, whereas Epsilon (which does NOT produce games for GameStation) is expected to yield a −10% negative return.*
- *If GameBox wins the market, then Omega and Gamma (which do NOT produce games for GameBox) are expected to yield −10% negative returns, whereas Epsilon (which produces games for GameBox) is expected to yield a +30% positive return.*

In both conditions, we provided a table that summarized this information (see full script in Appendix C). Participants were asked whether they preferred investing in Omega & Gamma (which we call here the "non-diversified portfolio") or Omega & Epsilon (which we call here the "diversified portfolio"), on a 5-point scale ranging from −2 (labelled "Strongly prefer Omega & Gamma) to +2 ("Strongly prefer Omega & Epsilon") with a middle point 0 ("I'm indifferent").

We measured financial literacy with the same test as in the previous studies.

Like in Study 4, choosing the non-diversified portfolio was not necessarily a mistake—it depended on one's attitude toward risk. Hence, at the very end of the survey we measured each participant's risk tolerance (using a method similar to Kahneman & Tversky, 1979), by asking their preference between two options whose risk and payoff were identical to the portfolios. Option A (whose payoff mimicked the non-diversified portfolio) had "50% chance of yielding a +30% return, and 50% chance of yielding a −10% negative return". Option B (whose payoff mimicked the diversified portfolio) had "100% chance of yielding a +10% return". Participants answered on a 5-point scale ranging from −2 (labelled "Strongly prefer A") to +2 ("Strongly prefer B") with a middle point 0 ("I'm indifferent").

7.2. Results

7.2.1. Data exclusion

18 participants (4.4% of all participants) failed the attention check and were excluded from analysis.

7.2.2. Portfolio choice

We regressed portfolio choice on the mean-centered financial literacy score, a binary variable capturing the effect of the abstract vs. concrete manipulation (coded −1 for abstract, and +1 for concrete), and their interaction. We found a significant main effect of financial literacy ($t(3\,8\,6) = 4.87$, $p < .001$), but neither the main effect of the manipulation nor the interaction effect were statistically significant (respectively, $t(3\,8\,6) = -1.28$, $p = .20$; ($t(3\,8\,6) = 0.81$, $p = .42$). We therefore collapsed the two experimental conditions (abstract vs. concrete) in the subsequent analyses, and do not discuss them further.

We then proceeded to quartile analyses (see Fig. 7). Consistent with Hypothesis 2 and as shown in Fig. 7, participants in the top quartile of financial literacy preferred investing in the diversified portfolio ($M = 0.54$, $SD = 1.40$; significantly different from the midpoint zero: $t(77) = 3.39$, $p = .001$), while participants in the bottom quartile preferred investing in the non-diversified portfolio ($M = -0.54$, $SD = 1.29$; significantly different from zero: $t(1\,1\,0) = -4.41$, $p < .001$).

7.2.3. Comparison with risk attitude

As shown in Fig. 7, participants in all four quartiles of financial literacy were risk-averse (they preferred the safe option, the one that mimicked the payoff of the diversified portfolio). Participants with high financial literacy were well calibrated and chose a diversified, low-risk portfolio corresponding to their risk tolerance, while participants with low financial literacy chose a non-diversified, high-risk portfolio despite being risk-averse.

7.3. Discussion

As hypothesized (H2), participants with low financial literacy invested in a non-diversified portfolio based on expected returns, taking more risk than they would seem to want (based on a separate but equivalent measure of risk attitude). Furthermore, providing a concrete, logical reason why assets co-vary did not improve diversification.

8. General discussion

We find that lay investors (i.e., those low in financial literacy) perceive portfolio risk differently than expert investors (i.e., those high in financial literacy). Expert investors base their judgments of risk on portfolio *volatility*; they know that portfolios with negatively correlated assets are less volatile, thus less risky. In contrast, lay investors base their judgments of risk on *fluency*; they view portfolios with positively correlated assets as simpler, more familiar, and more predictable (which are empirically and theoretically associated with the overarching construct of fluency), and erroneously perceive such non-diversified portfolios as less risky. Hence, providing covariance information can have perverse consequences: lay investors will deliberately avoid negatively correlated, and choose high-risk, high-volatility, non-diversified portfolios due to these portfolios feeling more fluent. This pattern emerges consistently across both sequential and simultaneous investment allocation tasks, regardless of whether covariance information is presented with verbally or numerically described past returns, or expected future returns. Across all studies, we excluded participants who failed an attention check embedded in the financial literacy questionnaire, but the results were similar—if not slightly stronger—when including inattentive participants, as seen in Appendix H.

Building on these insights, we identify two interventions that "nudge" lay investors (Thaler & Sustein, 2003) to choose diversified portfolios. The first intervention is—ironically—to encourage lay investors to take more risk. Because lay investors perceive negatively correlated assets as riskier, encouraging risk-seeking results in choosing such assets and forming less volatile, better diversified portfolios. However, this nudge has the opposite effect on expert investors: because they base their judgments of risk on volatility, they choose relatively less diversified portfolios when encouraged to take risk. Of course, this intervention is deceptive and could backfire in some cases (e.g., if investor literacy is incorrectly assessed). A second, less deceptive and more practical intervention is to pre-calculate and display aggregate portfolio returns (rather than only the individual returns of each asset). In this case, it becomes very salient that diversified portfolios (with negatively correlated assets) are less volatile, increasing their attractiveness even among lay investors. This intervention complements previous literatures on Myopic Loss Aversion (Benartzi & Thaler, 1999; Haigh & List, 2005; Looney & Hardin, 2009; Webb & Shu, 2017) and choice bracketing (Read et al., 1999). Note, however, that in the current research, we held investment time horizon and average profitability constant across portfolios, such that the less risky portfolio always provided a more attractive risk-return profile; while research on MLA focuses on situations where a higher return-higher risk investment is more attractive. Future research could vary these factors independently to see if they moderate our findings.

We tested a possible third intervention: providing concrete, causal reasons why assets co-vary the way they do. This intervention relies on research showing that people can more easily solve logical reasoning problems when an abstract rule is reframed as a concrete one (Cosmides & Tooby, 1992). However, this intervention did not have a significant impact on lay investors' diversification, suggesting that the relation between asset covariance and risk is particularly difficult to intuit or

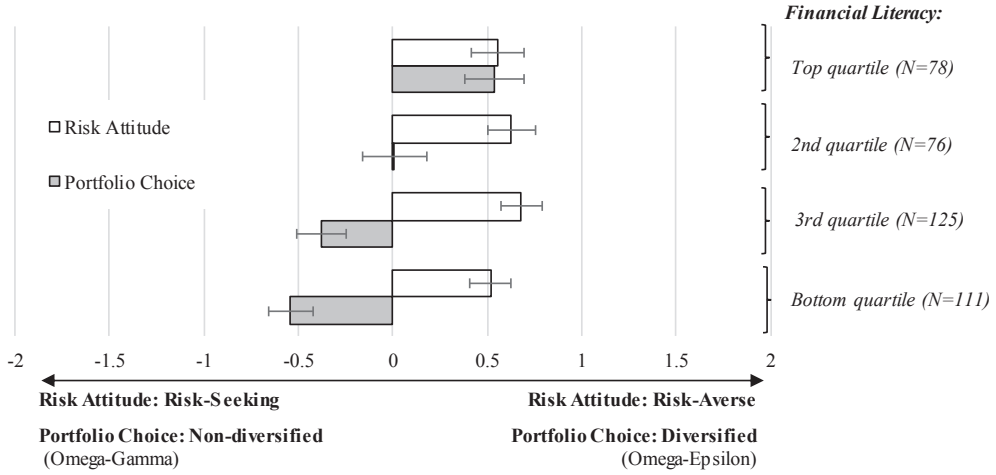

Fig. 7. Study 5 – Mean portfolio choice and risk attitude per financial literacy quartile. Note. Error bars indicate standard error of the mean.

visualize. Future research could investigate how to make this relation more intuitive to lay investors.

A fourth intervention would be investor education. We found that investors with high financial literacy had the correct views of risk and made the recommended choices for portfolio diversification. It is unclear, however, how much education and training would be required to change investor risk and diversification beliefs. This should be explored in future research.

Across all studies, we measured financial literacy with a 19-question test that included a blend of easier and harder questions. We always used the same population, Amazon Mechanical Turk participants, who are fairly representative of the U.S. population in terms of income, education, and professional activity (Levay et al., 2016; Paolacci et al., 2010), hence we could take advantage of heterogeneous, and fairly representative financial literacy. While we included a study where portfolio choice was financially incentivized, a potential concern is that participants had no extrinsic incentive for the financial literacy test. What if, rather than distinguishing high from low financial literacy, this test is instead a measure of attention or intrinsic motivation? In other words, what if the supposed "low financial literacy" participants are merely random responders? We believe that random responses had a very marginal impact on the results. First, in Studies 2 through 5 (where we used the TurkPrime platform), only 3–4% of participants failed the attention check embedded in the financial literacy test, and these participants were excluded from analysis. Second, a participant who answered randomly to all 19 questions of the financial literacy test (and somehow managed to pass the attention check) would have, on average, a financial literacy score of 4.55 out of 19, situating her in the bottom quartile of financial literacy (score between 0 and 7). Yet, across all studies, bottom quartile participants preferred investing in correlated assets; the effect was always significantly different from chance level. Again, this suggests that inattentive participants had only a marginal (if any) impact on the results, otherwise we would have failed to find this significant difference from chance level.

We have also examined how well MTurk participants performed on the financial literacy test. Across all studies (N = 2763), Mturk participants correctly answered on average more than half of the 19 multiple-choice questions (M = 9.64, SD = 3.55), with each question presenting 3–6 possible answers. As a comparison, we distributed a selection of 7 difficult questions from the test to 710 undergraduate students from a major U.S. Business School (Mean age = 19.67; 56% Female); 688 of them passed the same attention check as the one used with the MTurk participants. Among them, there were 211 students in a Finance concentration, and 477 students in a non-Finance concentration (although all of them took at least an Introduction to Finance course). On average, MTurk participants correctly answered 2.25 of these difficult questions (SD = 1.43); this was significantly less than the Finance students (M = 2.70, SD = 1.47; $p < .001$), but significantly more than the non-Finance students (M = 1.64, SD = 1.34; $p < .001$). Therefore, it appears that the overall financial literacy of the MTurk population is reasonable.

In this paper, we have used the terms "lay investor" and "low financial literacy" interchangeably. While these dimensions are undoubtedly correlated, there are lay investors who are high in financial literacy, and many supposedly expert investors who are low in financial literacy. Future research could disentangle the effect of financial literacy from the effect of financial experience.

Another limitation of this research is that we mainly compared highly positively correlated funds with highly negatively correlated funds (although in Appendix G, we report a study with more modest negative vs positive correlations and find the same pattern of results). Examining the fluency and risk perceptions of perfectly uncorrelated funds ($r = 0$) remains a topic for future research, but our theory and findings thus far strongly suggest that the same pattern of results would be observed.

Our findings make several theoretical contributions. First, we contribute to the literature on "risk as feelings" (Alter & Oppenheimer, 2006; Loewenstein et al., 2001; Slovic & Peters, 2006), demonstrating fluency as an important driver of heuristic perceptions of financial risk, and showing differential reliance of lay (vs relatively expert) investors on this heuristic process. This suggests a novel contributing factor for well-established investment biases, such as the home bias (Cooper & Kaplanis, 1994; Coval & Moskowitz, 1999). For instance, in addition to having familiar names, "home" investments also have correlated returns, which may feel more fluent to lay investors, further explaining why individuals' portfolios are over-invested in domestic assets. Furthermore, people's preference to "double down" on background positions in financial gambles (Markle & Rottenstreich, 2018) may be driven, in part, by the greater subjective fluency of holding consistent positions.

Our findings also contribute to the literature on financial diversification, which has two components: "passive diversification" (investing in multiple assets) and "diversification skill" (choosing imperfectly correlated assets) (Goetzmann & Kumar, 2008). Previous research on diversification biases has primarily focused on the former component, passive diversification, finding that lay investors tend to invest evenly across available financial assets (Benartzi & Thaler, 2001) and neglect covariance (Hedesstrom et al., 2006). In contrast, our research focuses on the latter component, diversification skill. We show that lay investors do not neglect covariance, but rather they use it incorrectly to assess financial risk. Our findings can be reconciled with research on covariance neglect: overall, covariance information does not seem to

influence diversification decisions. However, financial literacy strongly moderates this seemingly null effect, insofar as covariance information has opposite consequences among individuals with low versus high financial literacy.

From a practical perspective, our findings provide solutions to improve financial diversification. For instance, past research has suggested that employers should limit the number of assets offered in a 401(k) investment menu because too much choice may be overwhelming (Iyengar, Huberman, & Jiang, 2004; Morrin et al., 2012). In addition, our results suggest that financial institutions, or employers who offer contribution plans, should propose online tools that allow individuals to observe the aggregate returns of the different assets they wish to invest in. For example, prospective new assets could be integrated with the existing portfolio to show the aggregate fluctuation. Such features should nudge lay investors to form well-diversified portfolios, while having little effect on expert investors; a "just-in-time" financial education (Fernandes et al., 2014).

Financial illiteracy across individual investors remains widespread, even in such developed financial markets as the United States, Western Europe, and Japan (Van Rooij, Lusardi, & Alessie, 2011). At the same time, as defined contribution pension plans gain popularity among employers and FinTech applications gain popularity among consumers, individuals often find themselves in charge of their own financial security, while simultaneously being confronted with an assortment of sophisticated financial instruments. The need for robust solutions to help people to make better investment decisions has never being greater. Through an improved understanding of the risk perceptions of lay investors, we can build better financial tools to bridge the gap and nudge lay investors to allocate like expert investors.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.obhdp.2019.06.001.

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