Designing Investing Apps to Promote Healthier Trading Habits in Retail Investors

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Abstract

Retail investors often make poor investing decisions due to behavioral factors. In recent years, smartphone apps such as Robinhood that promise to "democratize investing" have risen in popularity. These apps have allowed retail investors to trade stocks, options, and other securities easily and inexpensively, often commission-free. It seems plausible that the design patterns of these new apps may significantly influence trading behaviors of their users. For instance, since underperformance is caused by behavioral, rather than informational, factors, making trading easier or increasing access to information can be counterproductive. But so far, there is little formal design guidance on how such apps should be designed. This thesis starts to fill this gap in design guidance by making two overarching contributions. First, it introduces a set of design guidelines for trading platforms based on fundamental results from related fields that may encourage healthier investing behaviors. Second, it presents a prototype for *Robinhood's Forest*, an "interpassive" trading application based on these principles. The thesis also discusses design implications and opportunities for future design.

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Chapter 1

Introduction

In recent years, smartphone-based trading applications that promise to "democratize investing" have shifted the stock market from being territory exclusive to institutional and wealthy investors and opened it up to less privileged individuals [69]. This expansion of access is exemplifed by apps such as Robinhood, Webull, and Public that have become popular in recent years [103, 102]. Unlike traditional brokerage firms, these apps require no minimum amount to be invested. Furthermore, while traditional brokerages charged investors every time they bought or sold an investment, newer apps do not charge commissions for most kinds of securities. Together, this makes these apps more attractive to less wealthy investors, who seek to avoid the expenses of investing. So attractive are these offerings that even traditional brokerages are eliminating fees and investment minimums in order to remain competitive [113, 28]. Overall, these trends potentially open up investing to less wealthy people, specifically to retail investors, defined as those who invest their own money and have no professional training in investing.

I argue that this transition from a traditional, high cost, and high barrier to entry interaction with financial market to a disruptive, zero-commission, and nearly effortless experience [10] for retail investing constitutes a fundamental shift in investing, one of the most consequential human behaviors. It is thus worthy of close study by the design community.

Not only has easy and free access to trading lured millions of people, especially first-time retail investors, to these platforms [84, 108], these apps also afford novice investors one-click access to invest in riskier securities such as cryptocurrencies and options [101]. Some evidence suggests that during the COVID-19 pandemic, people confined to their home repurposed the money they could no longer spend on recreation to speculation on these apps which were just a download away [64]. As recent episodes with companies like GameStop demonstrate, these apps have also allowed inexperienced investors to adopt riskier strategies such as "short squeezing" [90]. Some estimates suggest that more than a quarter of Americans bought "meme" stocks in 2021 and a majority faced a loss [106]. For some, devastating losses have had catastrophic results [89, 84, 9]. In short, the rise of zero-commission trading apps has both vastly expanded the reach of investing and qualitatively changed its nature.

Given this background, it is easy to see the role that design might play in shaping investing behavior. Through its design, a trading platform can determine which actions and behaviors are easily available to users, and thus encouraged [73]. It could also discourage certain actions. To make an analogy, consider

social networking apps. With its focus on ephemeral content and gesture-heavy user interface, Snapchat has a very different appeal compared to other platforms like Facebook and Reddit and encourages different kinds of content to be posted, even in a narrowly defined topic such as national elections [14]. Similarly, one could expect design decisions made by trading platforms to affect investing behavior.

More specifically, investing apps can be considered as technical and social choice architectures that influence investing behavior. Extending research on digital choice architectures [46], one can expect that the design, structure, and features of investing apps can also enable and constrain specific behaviors in users. Certain design decisions can encourage investors to act on their instincts and possibly be less rational, while other alternative decisions might encourage systematic deliberation [91, 13]. For instance, absence of commissions for each trade in most popular investing apps can encourage more people to trade more frequently. Similarly, the use of "golden tickets", confetti, and free stocks, as seen in Robinhood's interface in Figure 1.1 may blur the lines between an investing app and one for lotteries and gambling [108, 41]. In sum, the design of smartphone trading platforms may prevent or encourage investors in making fully informed decisions [69].

Figure 1.1: Robinhood offers its users a free stock when joining the platform or referring a friend. This flow uses a lottery scratchcard interface. Such design patterns may lead users to conflate the idea of investing with gambling. Image from Tory Hobson/Pinch Pull Press (`https://link.medium.com/uxXrSIPuCdb`).

Despite the large impact that design patterns can have on investing behaviors, research on this topic is unfortunately lacking. This thesis starts to fill this gap of design guidance by making two overarching contributions. First, it introduces a set of design guidelines for trading platforms based on fundamental results from related fields that may encourage more successful investing behaviors. Second, it presents a prototype for *Robinhood's Forest*, an "interpassive" trading application based on these principles. The thesis also discusses design implications and opportunities for future design.

Chapter 2

Design Guidelines for Trading Apps

2.1 Introduction

There is a long history of research in the design community on how individuals, especially from vulnerable populations, make budgeting decisions [51] and how design can induce healthier habits in them [11, 29]. However, this prior literature does not always apply to investing because of three critical differences between budgeting and saving activities and investing in stocks and other risky instruments. First, saving and budgeting behaviors are strongly embedded in culture. For instance, immigrants to the United States in the early 20th century repurposed empty soup cans to earmark savings for different goals [110]. This practice is not altogether different from contemporary practices of spending and saving through different credits cards and bank accounts [51]. These cultural norms both offer a guide for what is reasonable behavior and discourage behavior that is economically sound but socially irresponsible, such as raiding children's piggy banks to pay for an unexpected expense [110]. Unfortunately, barring discouraging speculation, there are few cultural practices around successful investing [24]. Second, successful saving and budgeting behaviors are often straightforward and intuitive to adults, but successful investing requires counterintuitive thinking. For instance, it is intuitive to most adults that it is better to save more in times of economic stability for a rainy day. It is less clear whether it is similarly better to purchase more stocks in a booming economy when stock prices may be inflated [12]. Third, and perhaps most important, investing is inherently risky. While saving money in a bank account guarantees a risk-free return, investors also stand the chance to lose their capital and suffer ruinous losses. As such, the heuristics investors use to evaluate the trade-off between risks and potential rewards can play a big role in their success [9]. These critical differences between saving and investing suggest that design implications from studies on budgeting behaviors are unlikely to be sufficient to inform the design of investing interfaces.

In trying to fill this gap, I take inspiration from methods for creating design guidance in other fields without thick cultural practices, a need for counterintuitive thinking, and inherently uncertain outcomes. In particular, I looked at guidelines for designing interfaces for artificial intelligence (AI) applications that are based on fundamental findings from related domains such as psychology and law. Design guidelines for AI applications, while new, follow a decades-long intellectual tradition from human-computer interaction community. From Neilsen's heuristics for user interfaces [72] to Norman's principles of designs of everyday

objects [74], guidelines have aided practitioners in designing interfaces and sparked future research.

This chapter offers similar design guidelines for investing apps to encourage healthier trading habits over market speculation. In this chapter, I offer similar design guidelines for investing platforms that might encourage healthier trading habits over market speculation. First, I demonstrate how trading how trading apps might encourage certain kinds of trading habits based on fundamental insights from three bodies of related work: 1) findings from finance and economics literature on healthy investing, 2) the dual process theory from behavioral sciences, and 3) design metaphors used in interfaces with uncertain rewards. Second, I cluster these disparate insights into eight actionable guidelines that can help encourage more successful investing behaviors among the users of these platforms. I validate the guidelines by using them to analyse two popular US trading apps, Robinhood and E-Trade. The chapter ends by discussing design implications and opportunities for future design.

2.2 Related Work

2.2.1 Behavior of Retail Investors

In practice, most retail investors underperform their professional counterparts, such as banks and hedge funds, even when they have the same information. Researchers have attributed this underperformance primarily to behavioral factors. Overconfidence in their investing decisions, poor risk evaluation [9, 38], overreacting to news events [63], and believing they can predict the market [55, 56] lead retail investors to realize fewer gains.

Because underperformance is caused by behavioral, rather than informational, factors, making trading easier or increasing access to information backfires. Indeed, it encourages investors to trade more actively and perform even worse [75, 10]. Some popular media accounts also contend that easier app-initiated trading nudges retail investors to take bigger risks [108, 83, 107, 84]. However, outside of accounts in popular media, research on how these apps influence investing behaviors is still lacking. Overall, the empirical research on retail investor outcomes suggests that the design of my guidelines should be informed by behavioral findings on financial decision making.

2.2.2 Heuristic Evaluation Processes

Many studies have shown that decision making under uncertainty, such as in financial markets, involves heuristic processing [82, 96]. Unlike systematic processing that involves careful and deliberate processing of the message, heuristic processing reduces cognitive effort by using simple decision rules to quickly analyze situations. While these simplifications, such as buying stocks based on a friend's recommendation, are often valuable in uncertain environments, they are also susceptible to predictable biases. For instance heuristic decisions are prone to persuasive techniques such as framing, anchoring, and social proof [25, 39, 98, 97, 61, 96, 65]. These effects are further intensified in digital settings [22, 111, 60]. Overall, this research suggests that design metaphors and decisions that affect heuristic processing can be leveraged to improve trading habits and thus outcomes for investors. Next let us focus our attention on such design metaphors.

2.2.3 Design Metaphors

User interface choices such as what elements are first visible, which stimuli are salient (e.g. choice of colors), and which settings are chosen as defaults, influence the heuristic decisions made by users [59]. Similarly, researchers have studied how design metaphors can make messages more persuasive [36, 65]. Others note that certain design patterns (dark patterns) can encourage heuristic processing and result in more instinctive decision making [13].

Most closely related to my work, Tanakaa and Kawabatab found the interface predictability can impact the kinds of bets people make [95]. To my knowledge, no prior work has directly studied how design metaphors influence trading habits. However, other researchers have studied the impact of design metaphors in contexts such as filing taxes [47], social lending [109], and voting [49]. This chapter leverages these findings taken together in developing my guidelines.

2.2.4 Guidelines for Designing Human-Centered Technology

For several decades, the human-computer interaction community has proposed guidelines for ethical design of technology across many domains. For instance, Norman applied principles of designs from everyday objects to technology products [74]. Höök's concept of soma design shifted the perspective on interactive design to focus more on fundamental human values [42]. Horvitz's formative work on mixed-initiative systems [43], Brown's work on human-computer interfaces [19], and Amershi et al.'s work on human-AI interaction guidelines [5] are some example of sets of guidelines that serve as a useful resource for practioners working with consumer-focused technology. There is also a growing body of research on how and why to improve the fairness and explanability of AI systems [86, 58, 54, 100]. Several notable organizations such as Google [1], McKinsey [21], and Partnership on AI [2] have also laid down their own principles for responsibly building AI products. Further, there has also been work on how to best operationalize these guidelines in industry [62, 68].

The development of design guidelines generally follows a four-step process that I adopt in my own work: 1) a review of findings from fundamental research to suggest possible design decisions or metaphors, 2) clustering of related decisions and abstracting higher-level guidelines, 3) evaluation of guidelines to ensure they apply to practical design artifacts, and 4) refinement based on evaluation.

While guidelines are meant to distill theoretical rigor into practical suggestions, they are not meant to be rigid rules. Also, given the effort and time required to design new interfaces, it remains difficult in practice to evaluate if designers' decisions based on guidelines empirically improve user outcomes. Indeed, some of the most impactful guidelines such as Neilsen's heuristic evaluation method [72] or Amershi et al's guidelines for human-AI interaction [5] lacked such evaluation when they were first introduced. My work has the same limitation.

Finally, I note that a theory-based approach is not the only feasible way to discover design guidelines. For instance, a service design approach has also been successfully used in the area of financial literacy [112] and it is possible such an approach might unearth new service expectations. Elsewhere, Odom et al. offer deep design guidance on "slow technology" using a research through design approach [76, 77]. It is easy to see how such an approach might also be valuable around investing. Further afield, Irani and others

take an ethnographic approach that critically examines power structures [45]. While my work is largely complementary to these methodologies, this prior work also highlights my methodological limitations. For instance, I do not seek to question or reframe the goals of retail investing or to investigate the power structures inherent in app-initiated investing.

2.3 Methods

The guidelines in Table 2.2 were developed using a four-phase process. In Phase 1, I reviewed fundamental literature from behavioral finance, psychology, and design relevant to financial decision making and tried to extract recommendations that are actionable through interaction design interventions. In Phase 2, these insights were consolidated to propose an initial list of design guidelines for investing apps. In Phase 3, I applied these guidelines to one trading app (Robinhood) and one traditional online brokerage (E-Trade) to evaluate their applicability, violations, and blindspots and asked other researchers in my organization with no prior experience designing investing interfaces to independently review the guidelines and their applications. These reviews led to improvements to enhance the clarity and scope of the guidelines in Phase 4.

2.4 Phase 1: Review of Fundamental Theory

2.4.1 Investing, Uncertainty, and Diversification

Investing is the act of putting aside money with the hope of gaining more, while acknowledging that they also stand to lose their capital. This inherent risk associated with investing sets it apart from saving, which could be practically "risk-free" [32]. The expected returns on investments are generally understood to be determined by three factors: asset allocation (the kinds of things or assets that are invested in, such as stocks, real estate, etc.), security selection (the particular assets or securities chosen, such as specific companies, plots of land, etc.), and time horizon (the timeline of when these securities are bought and sold) [35]. The expected return from particular allocations, securities, and timing are subject to risk. Risk is generally classified as either systematic or specific. Systematic risks such as recessions, interest rate changes, pandemics, etc. broadly affect all investing (e.g. most investments do poorly in a shrinking economy). Specific risks are related to a particular security or industry.

Diversification

Diversification is the process of investing in multiple kinds of assets and securities and with varying timing to reduce the specific risk assumed [70]. Investing and portfolio theory emphasizes diversification, but empirically there is a large gap between these theoretical recommendations and how retail investors actually invest [34, 9]. While adequate diversification is possible even with 30 securities [92], retail investors typically only invest in 4 [9]. In addition, many retail investors trade speculatively rather than systematically and so increase risks related to timing. As a result of these actions, an average retail in-

vestor underperforms institutional investors such as university endowments by 4 to 8% every year [57], and even the market as a whole by approximately 1.5%.

Security Selection

While portfolio theory suggests choosing securities based on expectations of future earnings and growth potential, other factors are empirically more predictive of retail security selection. In particular, retail investors choose securities with a local bias and overweight past performance.

Local bias is the tendency of investors to invest in stocks of businesses that they are psychologically or physically nearby, such as a local construction company, the industry that employs them, or a favorite chain restaurant. However, the increased familiarity with the selected securities does not predict increased future performance [34, 56]. Such concentrated portfolios can sometimes perform better than diverse portfolios but also carry more specific risk, and underperform over the long term [9].

Kumar and Dhar found that a large number retail investors are sensitive to past price trends [55], such as focusing on stocks that are "rising" or a "steal" at current prices. Retail investors with high trend-tracking behavior were correlated with having portfolios with lower levels of diversification [34].

Market News and Timing

While news releases and earning events have some significance for future returns of an investment, retail investors tend to overreact to these events, believing they fundamentally change the value of their investments more than they actually do [63]. Barbera and Odean found that stocks that retail investors bought tend to earn strong returns in the subsequent two weeks of the trade but underperform in the longer run. This behavioral anomaly of selling investments that are doing well while holding on to their losing investments is called the disposition effect [9]. I outline potential reasons for this bias in Section 2.4.2.

Sensation Seeking

Investing money in the stock market can result in a thrilling sensations akin to gambling. This is evidenced by the fact in periods with high lottery jackpots, the volume of trades is lower [38]. However, high-turnover in portfolios, whether caused by an overreaction to market news or sensation-seeking, decreases investing returns over time. Active retail investors underperform the market by 6.5% every year, as compared to 1.5% for investors who buy and hold [9].

Transaction Costs

While transaction costs such as brokerage commissions, taxes, and fees reduce the returns earned by investors, there is evidence that retail investors earn below market returns even before these costs are accounted for [9]. Smartphone-based trading apps and new brokerages typically charge no commissions, and instead earn money through margin fees, cash balance interest, and compensation by other wholesaler firms that buy and sell securities [101]. As a result, investors now can trade securities for free. Such free

trades have increased trading frequency [101]. And since underperformance of retail investors is caused by behavioral, rather than informational, factors, more frequent trading tends to exacerbate the problem.

2.4.2 Heuristic Evaluation Processes

The heuristic-systematic model of information processing is a dual-process theory that suggests that human beings can process messages systematically and/or heuristically [23]. Systematic processing involves careful and deliberate processing of the message, whereas heuristic processing reduces cognitive effort by using simplifying decision rules to quickly analyze the message. For instance, heuristic processing might skip the complete processing of the content of the message and instead uses indicators such as credibility and expertise the person who is sending the message or endorsing it. This can occasionally lead to cognitive biases in the decision making process [96].

Investment decisions are made in the presence of heuristic processing [82]. Due to imperfect information in financial markets, inherent uncertainties, and volatility, investors can only rely on a handful of data points when making decisions. Heuristics, such as past performance of a stock or analysts rankings, simplify and speed up the decision making process. Studies suggest that even financially literate investors are driven by behavioral factors and tend to trust their intuition while building their portfolios [33]. However, relying on some heuristics over others can result in biased judgments and poor financial decisions [3]. For instance, the level of under-diversification is affected by factors such as overconfidence, trend-tracking behavior, and local bias of the investor [34].

The two most important determinants of which processing route is used when processing a information are motivation and ability [81]. People are more likely to engage systematically with a persuasive message if they are more motivated to do so. This in turns depends on the personal relevance and response involvement of the message. Similarly, people's tendency to choose heuristic processing is higher when availability of cognitive resources is low. This includes lack of time, focus, or requisite knowledge or the presence of stress and other distractions [33]. Below, I discuss specific heuristics most relevant to investing, and how they affect financial decisions.

Representativeness Heuristic

Under uncertainty, such as while investing in stocks, people tend to rely on representativeness to make decisions. For instance, trend-tracking investors believe that a stock with a good returns in the past will continue to perform well in the future [15, 8]. This leads investors to make generalized judgments about the potential of stock after observing its performance for a short period of time. These analyses are prone to be incorrect since the expected price of a company's stock is based on expectations of its future earnings and not necessarily based on past prices.

Availability Heuristic

People assess the likelihood of events with the salience of the event, i.e. the ease at which similar instances can be brought to mind. Investment decisions can be biased by more vivid and memorable movements

in stock prices, what other investors are purchasing, and similar salient events rather than less salient information such as the history of dividends paid by the company. The availability heuristic also causes investors to blindly trust analysts' market recommendation revisions, even when they are not sound investments [53].

Hot Hand Fallacy and Gambler's Fallacy

The hot hand fallacy and gambler's fallacy are two widely studied cognitive biases that causes people to misinterpret sequences of essentially random market prices and affects their investment decision. The hot hand fallacy is the expectation that price trends will persist indefinitely, i.e. rising stocks will continue to rise and falling stocks will continue to fall. This leads to buying stocks that show an increasing trend and selling stocks that show a decreasing trend, together increasing the cost of investing. The gambler's fallacy is the expectation that investments will always revert to their previous price, without regard to fundamental changes such as technological innovation or obsolescence. This leads to people holding onto losing investments for too long and selling winning investments too soon. Huber et al. found that people who rely on the recommendations of experts were prone to the hot hand fallacy and people who acted individually were prone to the gambler's fallacy [44].

This disposition effect stems from the prospect theory, which posits that humans tend to be risk-averse when dealing with gains but risk-seeking when dealing with losses [48]. Factors such as involvement, choice, and familiarity can also lead investors to develop an illusion of control and lead them to implicitly believe that they can control the outcome of chance situations [56].

Anchoring Heuristic

The anchoring heuristic is a behavioral bias in which, when under uncertainty, people estimate quantities using an initial benchmark and then adjust it to make judgments [96]. One consequence of this is that people can anchor their estimates of what an investment is worth to the price they purchased it for rather than to present market conditions. This can cause them to hold onto poor investments for too long [71, 82].

Confirmation Bias

Confirmation bias leads people to seek information that is consonant with their prior beliefs. It lead to investors maintaining unrealistically high expectations of performance of their current investments, and lower expectations of alternative investments, leading to lower overall returns [79]. Moreover, focusing too narrowly on ones current portfolio can also expose investors to high levels of specific risk.

2.4.3 Design Metaphors

Beyond fundamental psychological biases, decision making is also influenced by design metaphors and decisions. Specifically, certain design decisions can prompt System 1 thinking processes, which are undemanding, instinctive, and possibly less rational than System 2 thinking processes as suggested by dual process theories [91, 13]. Some relevant decisions are outlined below.

Jackpot Metaphors and Ignoring Probabilities

Few investors make investment decisions after accounting for factors such as implied volatility or adjusting returns for risk [66]. However, when deciding whether to invest in what is perceived as a "jackpot", decision making is dominated by the magnitude of the potential winning rather than its probability [37]. To the extent that trading apps highlight the massive returns of penny stocks and some options contracts or use explicit visual imagery of jackpots or lotteries (Figure 1.1) they may encourage investment gains to be perceived as jackpots.

Commitment Leading to Entrapment

Entrapment is the tendency of people to commit to a goal that has not been realized beyond an economically rational point [18, 93]. Argyris found that cutting one's losses, in gambling and trading, is interpreted as embarrassing and also giving up on potential returns [7]. To the extent that apps and platforms allow users to share information about their trade, such as on a social feed, they may increase commitment, in turn leading to entrapment, despite mounting losses [105].

Gratification Delays, Reinforcement Schedules, and Habit Formation

While latency in interfaces is generally detrimental [6], immediate payback of risky bets encourages more frequent plays and the tendency to regamble any winnings with little rational financial consideration [37]. For instance, when playing with scratchcards and slot machines, there is only a few seconds between the initial gamble and the payback. Instant settlement on trading apps can also potentially result in similar behavior.

How frequently and regularly rewards are obtained can play a significant role in engendering behaviors and habit formation. A variable-ratio reinforcement schedule, where rewards result after a varying number of attempts, such as with slot machines, leads to stronger habit formation [30]. Unfortunately, frequent trading, especially with little financial consideration, results in rewards with varying frequency, further reinforcing the risky habit.

2.5   Phase 2: Clustering of Guidelines

From the literature review phase, I came up with a list of 25 factors that play a role in determining investors' success. Of these, 20 factors can be affected through design decisions. For instance, even though overconfidence works to the detriment of retail investors, reducing overconfidence is hard to do through interface design. I labeled these relevant factors as either visual, behavioral, or financial, depending on the community where the underlying research was conducted.

Next, I generated an initial set of design guidelines that operationalized these factors. The candidate factors were clustered using affinity diagramming, such that factors that were related in possible implementations and effect were clustered together. I limited cluster sizes so that guidelines did not become too abstract and applications and violations of the guidelines was easy to identify.

Table 2.1: Initial clusters of design guidelines for investing apps. Guidelines are inspired by research done by visual design (V), behavioral sciences (B), and finance (F) communities.

Factor	Guideline
[F] Diversification [F] Security Selection	Encourage Diversification
[B] Representativeness Heuristic [B] Anchoring Heuristic [B] Commitment Leading to Entrapment [F] Market Timing	Focus on the Long-Term Future
[B] Hot Hand Fallacy [B] Gambler's Fallacy [B] Confirmation Bias [B] Illusion of Control	Do Not Encourage Predicting Random Numbers
[V] Gratification Delays [V] Habit Formation [F] Sensation Seeking	Discourage Active Trading
[V] Jackpot Metaphors [V] Ignoring Probability [B] Availability Heuristic [F] Market News	Do Not Make Trading a Popularity Contest
[V] Reinforcement Schedules [B] Heuristic Processing	Encourage Thoughtful Trading
[F] Transaction Costs	Minimize Roundtrip Costs

This clustered set of guidelines went through multiple stages of iteration. This involved reclustering, rephrasing, and dropping some guidelines. For instance, I realized that frequency and thoughtful trading were not necessarily correlated, so I split the "Encourage Infrequent and Thoughtful Trading" guideline into two. I also noticed that the "Do Not Charge Commissions" guideline emphasized a particular business decision rather than a design decision. I rephrased this guideline to "Minimize Roundtrip Costs" to improve its applicability and flexibility. Other guidelines were rephrased to improve clarity. Still other guidelines were dropped entirely if they did not relate specifically to investment or trading, for instance the "Use Clear Verbiage" guideline.

Some of harder to resolve conflicts come from inconsistencies across the different domains. As one notable example, though finance literature suggests transaction costs significantly bite into an investor's returns, behavioral finance literature suggests that the lack of commissions can encourage investors to trade more frequently. In this case, I decided to keep both the, potentially conflicting, guidelines. This was in recognition of the fact that technology design can involve difficult trade-offs. My set of guidelines helps designers evaluate their design choices, and consider how problematic effects could be mitigated creatively. A list of the clusters and corresponding guidelines towards the end of this phase is shown in Table 2.1.

2.6   Phase 3: Evaluation

In this phase, I evaluated my set of guidelines with five other researchers and designers to identify its applications, violations, and blind spots. Two of the evaluators had not used any trading app in the past. All of them are members of the Human-Computer Interaction Institute at Carnegie Mellon University and are my frequent collaborators. Protocol for the study was approved by the Carnegie Mellon University Institutional Review Board.

The study was inspired by the modified heuristic evaluation done by Amershi et al. while devising their list of guidelines for human-AI interaction [5]. Amershi et al. asked evaluators to use their guidelines to assess existing interfaces and identify applications and violations of their guidelines. I extended their method and also asked evaluators to also provide feedback on any potential blind spots of the guidelines themselves. This helped me identify potential ways in which my guidelines could be extended to be more applicable.

For the evaluation, I decided to study the design patterns in two different trading platforms: Robinhood, one of the most popular zero-commission trading apps, and E-Trade, one of the "big four" brokerages in the United States. Between them, these platforms handle more than 5 million daily average revenue trades [88]. Moreover, these two platforms use significantly differently modalities (smartphone and website, respectively) and target investors with different amounts of investable capital, allowing me to inspect how my guidelines evaluated them differently. If an evaluator did not have an account on the platform, I provided them a comprehensive list of screenshots and flows from the application as shown in Figure 2.1. Evaluators provided verbal feedback on how each platform compared against my set of guidelines and how easy and intuitive it was to apply the guidelines.

Evaluators were able to identify applications, violations, and blind spots of guidelines, despite not having prior experience designing trading platforms. The cumulative data is presented in Table 2.2. For brevity, the table displays the updated text of the guidelines from the end of Phase 4.

2.7   Phase 4: Review of Revisions

In Phase 4, I incorporated evaluators' feedback by revising the guidelines. First, I rephrased the "Encourage Thoughtful Trading" guideline to "Encourage Deliberate Trading" to clarify the emphasis on deliberation and systematic processing. I also improved the order in which the guidelines were presented to make them easier to follow. They were numbered and labeled with the overarching research community they were inspired from (visual, behavioral, or financial) and sorted by type. I also ensured my final guidelines obeyed the phrasing conventions used by Amershi et al. [5]. These included limiting each guidelines to 10 words, without any conjunctions, and beginning with an action word. I also added a description to help clarify any potential ambiguities. This process resulted in the eight guidelines as seen in Table 2.2.

Table 2.2: Design guidelines for investing apps that encourage healthy investing behaviors. Guidelines are roughly split into visual design (V1 and V2), behavioral (B1 to B5), and financial (F1).

	Guideline	Robinhood	E-Trade
V1	**Focus on the Potential Instead of the Past** Display information that helps investors make investment decisions based on how the security will perform in the future, not how it has performed in the past.	Prominently features performance charts while all information relevant to future performance is below the fold.	Easy access to metrics such as analyst recommendations, price targets, income statements, etc. in addition to past performance.
V2	**Expose Risks** Help the investors understand exactly what they stand to lose or gain with the investments they make.	Highlights the systematic risks of investing in the stock market but not specific risks for individual securities.	Provides tools to calculate probability of a security reaching a certain price by a certain date. Displays beta values.
B1	**Encourage Diversification** Help investors put their money in a variety of financial instruments and industries.	Each position mentions its position diversity. Overall asset composition data is buried in account settings.	Shows the asset composition of a portfolio and compares it to sample portfolios. Security selection metrics are missing.
B2	**Encourage Deliberate Trading** Make it easy for investors to make well-thought out trades based on knowledge of market fundamentals.	One-click access to trading allows making trades despite lack of time, focus, or background or in the presence of stress and other distractions.	The website modality and interface complexity forces investors to take their time while making trades. Orders can be saved for later.
B3	**Encourage Long-Term Trading** Help investors think of trading as a long-term activity and discourage them from trying to catch minute-to-minute market movements.	Default time range in charts is one day, which can incentivize trying to catch the day-to-day market movements.	Default time range in charts is in the order of years. Gains are classified as long and short-term.
B4	**Discourage Active Trading** Limit investors' ability making frequent trades unless they understand risks associated with it.	Proceeds from sale are instantly immediately available to reinvest. Obeys SEC-mandated day trade restrictions.	Trades take upto 2 days to settle for cash accounts. Obeys SEC-mandated pattern day trade restriction for margin accounts.
B5	**Discourage Overreactions to Market News** Help investors interpret market news in a manner consistent with market fundamentals instead of acting on hype and behavioral factors.	Prominently features market news. Sends push notifications close to earning events. Highlights securities whose price moved the most.	Market news and top movers list is available but not the centerpiece of the home screen.
F1	**Minimize Roundtrip Costs** Minimize the amount investors have to pay for each trade in transaction costs and ensure these are transparent to the user.	Does not charge commissions or transaction fees for any type of security.	Does not charge commissions or transaction fees for most securities. Some contracts have a flat fee.

(a) Robinhood highlights short-term performance. Violates V1 and B4.
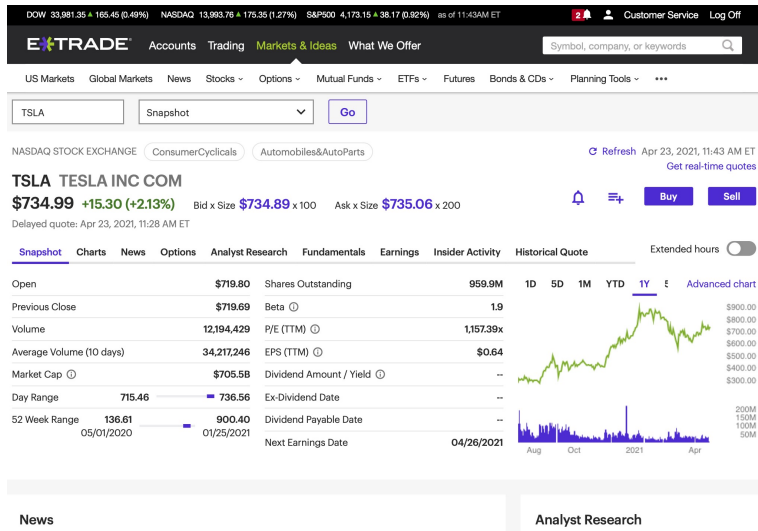
(b) E-Trade exposes long-term trends and highlights useful metrics. Applies V1, V2, B2, and B3.

Figure 2.1: Examples of trading apps evaluated in Phase 3 of the study and evaluators' feedback on how they apply and violate my guidelines. Images from my accounts on each platform.

## 2.8 Design Implications

2.8.1 New Interaction Models for Investing

The above guidelines may be useful not only for evaluating existing trading interactions but also new and emergent ones. For instance, consider Public, a trading app focused on making investing in the stock market "social". Public allows users to display their portfolio on their profile, and share their investment decisions with their friends (Figure 2.2a). It also curates lists of some of the most popular stocks among users of the app. These features capitalize on the availability heuristic and can potentially make investing a popularity contest; violating guidelines B2, B4, and B5. In contrast, Options AI includes data-driven visualizations of potential future values of a stock based in part on the prices of options sold on the stock (Figure 2.2b). Such an interface is in line with guidelines V1, V2, and B5.

Designers may also find guidelines useful in adopting ideas from other kinds of applications. For instance, mindfulness applications may offer multiple design patterns to encourage deliberate trading (B2), remove fixation on past performance (V1), and discourage overreactions to news (B5).

2.8.2 Applications Beyond Investing

While I developed my guidelines with the assumption that investments were in traditional asset classes such as stocks, bonds, and other regulated securities, they may apply equally well to newer, alternative investments. For instance, a cursory review of app stores for the Apple and Google's mobile platforms surfaces apps for speculating in cryptocurrencies such as Bitcoin (Figure 2.3a), equity crowdfunding, which allows low-cost investing in startup companies (Figure 2.3b), and even "democratized" investing in art that
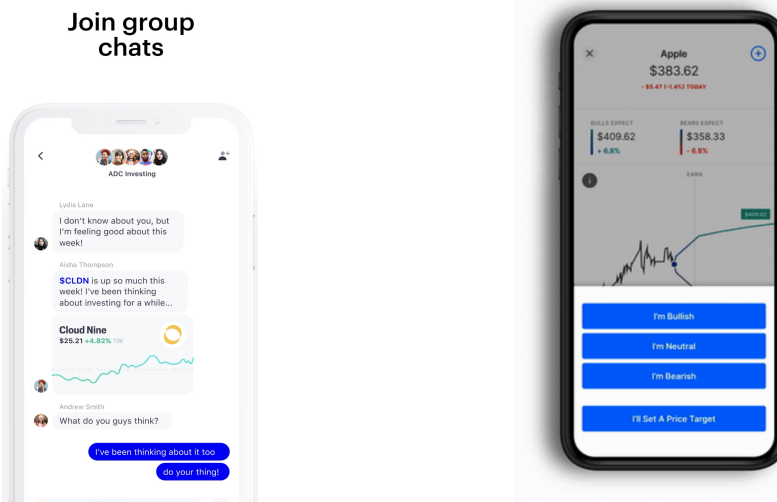
(a) Public turns the stock market into a social activity. Violates B2, B4, and B5.

(b) Options AI offers data-driven charts of a security's potential. Applies V1, V2, and B5.

Figure 2.2: Examples of some other investing apps and how they apply and violate my guidelines. Images from each platform's website and marketing materials.

allows users to purchase fractions of famous pieces of artwork (Figure 2.3c). While the markets targeted are varied, guidelines based on fundamental findings may still be relevant.

2.9 Discussion

I reviewed fundamental literature from the fields of finance, psychology, and design to come up with eight actionable design guidelines for retail investing applications. These efforts, and their subsequent evaluation, suggest that my guidelines can be useful in evaluating trading applications and recommend directions to improve the design of these applications.

2.9.1 Non-prescriptive Guidelines

This thesis was inspired by media accounts of retail investors suffering catastrophic harm as a result of poor investments. As such, I hypothesized that simple design guidelines might prevent such failures. However, my research suggests that designers, even relying on the most robust theoretical findings, must make trade-offs. Consequently, my guidelines are non-prescriptive as well. Factors such as the age of the target user, their risk appetite, prior experience with losses in investing, etc. may guide practitioners in making these trade-offs.

I also recognize that my guidelines, while theoretically sound, might be difficult to realize into actual products due to practical business concerns. For instance, companies whose revenues are driven by active trading may find it difficult to discourage the practice. Similarly, though not charging commissions can minimize roundtrip costs, it requires platforms to turn to more creative revenue streams, which have had mixed success so far [104]. While these concerns are beyond the scope of this thesis and my own expertise,
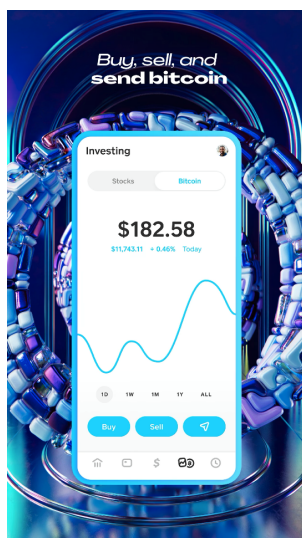
(a) Cash App allows retail investing in Bitcoin.
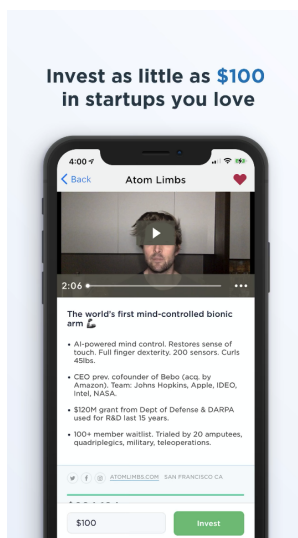
(b) Wefunder allows small investments in non-public companies.
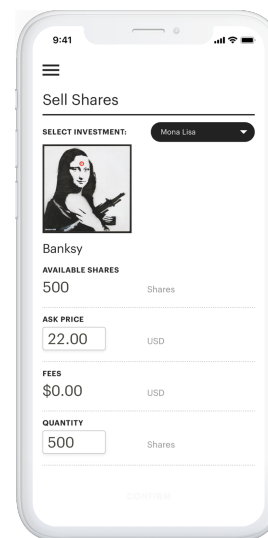
(c) Masterworks allows retail investing in artwork.

Figure 2.3: Some alternative investment platforms where my guidelines may be applicable. Images from each platform's website and marketing materials.

developing sustainable business practices around these guidelines may be a productive area for future work. It is also reasonable to believe that platforms are, in fact, incentivized to follow these guidelines because users are unlikely to stick with a platform on which they earn subpar returns.

2.9.2 Applicability to Vulnerable Populations

One side effect of my approach is that my guidelines are likely less effective for vulnerable populations. This is because of persistent population biases in the literature that I draw from, especially psychology [40, 94]. Many fundamental results were studied with white, rich, educated, and independent people [40], and wealth, independence, and education may well affect investing decisions. As such, my guidelines are best seen as the first step in a longer process of making investing more democratic in actuality, not just in rhetoric.

2.9.3 Limitations

The list of factors I was able to extract from Phase 1 is non-exhaustive. While my factors were the most prominent in the literature I reviewed, many other visual, behavioral, and financial factors may affect an investor's success in investing. Furthermore, the factors I extracted are limited to the extent I reviewed the literature. This is particularly challenging due to the interdisciplinary nature of investment and the many fields of expertise that may be relevant. Finally, some factors such as risk appetite and political inclination yield inconsistent or even contradictory guidance.

In evaluating the guidelines, I was only able to examine two investing apps that are popular in the American market. Unlike applications that are ready to use as soon as they are installed, trading platforms

require providing sensitive personal information and making a financial commitment. Similarly, I was unable to assess my guidelines against non-American investing apps such as *eToro* (popular in UK and Israel) because I could not open trading accounts on these platforms from the United States.

Furthermore, while I conducted my evaluation with human-computer interaction researchers and designers knowledgeable about the design process in general, I am missing two important voices: of financial experts and of users of investing apps. Since I was unable to recruit anyone from the financial services industry or do any qualitative work, it is hard to judge whether my guidelines will be effective in nurturing healthy trading habits in practice.

2.9.4 Future Work

Future research could explore the uses and value of these guidelines at various stages of design and for specific populations. I also see a need for triangulation of guidance from literature with more qualitative and ethnographic methods. For future practice, beyond the direct implications of my work, my guidelines may also serve as a useful starting point for discussions about *how* trading apps can encourage deliberate trading. Finally, my work may suggest future policy that requires trading platforms to disclose not only whom they serve, such as the investors with high net worth as is current practice, but also interactional patterns of public interest, such as how long users hold securities, how frequently they trade in response to news events, and the degree of diversification. Similarly, data sharing around interactions like whether investors who received free stocks when joining the platform take greater risks may improve future design.

Chapter 3

Designing Robinhood's Forest

(a) Investments are represented by trees that grow and shrink.

(b) When investments are sold, trees are felled.

(c) Portfolios are represented by forests with many different kinds of trees
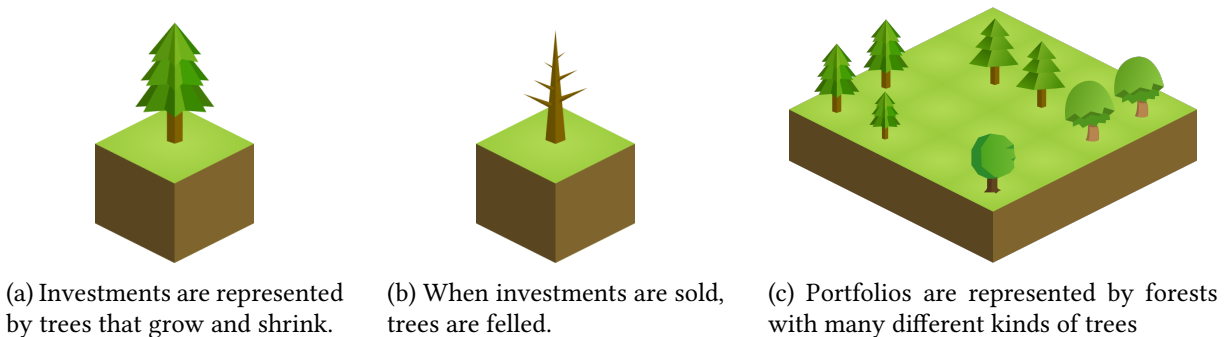
Figure 3.1: *Robinhood's Forest* is an idle game to improve non-expert investor behavior. Using an abstract representation of an investment portfolio, it nudges better investing behaviors, such as higher diversification, long-term investing, and discouraging decision making based on social pressure.

3.1   Introduction

Building on the work of the last chapter, this chapter introduces *Robinhood's Forest*, an idle game for improving investing behavior; in particular, increasing portfolio diversification and reducing trading frequency. *Robinhood's Forest* is built as an interface that provides users enjoyment by restricting, rather than encouraging, gameplay.

Unlike traditional digital games that emphasize player interactivity for engagement and enjoyment, idle games consider player interaction as optional or even unnecessary. In such games, players derive pleasure by delegating enjoyment to an other, usually a computer. As such, gameplay is frequently automated and often games are endless. Notable examples include *A Dark Room* and *Progress Quest*, which are self-playing role-playing games [31], as well as incremental games such as the satirical *Cow Clicker* and mainstream hit *Cookie Clicker* [80]. Using similar concepts is *Forest* (the inspiration behind my system), a game-like intervention that helps users stay focused on tasks and avoid distractions from their mobile phones. With *Forest*, users plant seeds in their forest that gradually grow into trees as long as they abstain

from using their phones.

Despite being passive, idle games are appealing to players because they 1) do not require constant attention, 2) provide players recurring gratification, even when they are absent from the game, 3) make compulsive gameplay (as with addictive games) safer through delegation, and 4) eliminate drudgery by delegating routine actions, while maintaining agency over consequential ones [31]. As such, they are designed to emphasize "interpassivity", rather than interactivity.

These qualities translate naturally to investing. As discussed previously, a large body of work suggests that retail investors tend to perform worse the more actively they trade so restricting gameplay can potentially result in better financial outcomes [75, 10]. Similarly, retail investors often derive gratification from seeing their investments do well in the short term [38], which may make them susceptible to compulsive trading [106].

As such, in designing *Robinhood's Forest*, I incorporated idle game mechanics to discourage constant attention to one's portfolio and provide recurring gratification from limiting investing actions, i.e. staying invested and not overreacting to market news and social pressure. I also borrow productivity app *Forest*'s metaphor of tending a forest to provide an abstract representation of investments in the form of tree, potentially encouraging diversification. These design concepts were implemented as a functional web app to study their effectiveness.

Using my prototype, I ran two small-scale lab studies to understand whether idle game mechanics had the potential to change trading behavior and, specifically, if using a forest metaphor may be effective. My prototype reduced trading frequency in participants, though they still desired additional data to help make decisions. They also indicated that they wanted to diversify their portfolio. Participants resonated with the forest metaphor and it seemed to induce better trading behaviors both consciously and unconsciously.

This chapter first describes the design of the prototype for *Robinhood's Forest*. Then, it describes the design of and results from the two studies. Finally, I outline the opportunities, tradeoffs, and new design questions introduced by this approach.

3.2   Related Work

Traditional digital games emphasize player interactivity and engagement to generate player enjoyment. In contrast, idle games have minimal to no player interaction. Such games are based on the premise that "waiting is playing" and players derive pleasure by repeating simple actions or automating them [4]. As such, these games are often endless (i.e. they seldom have states where players win or lose and the games end) and progress by themselves in the background. For instance, *A Dark Room* is a text-based game describing a firelit room, where automated characters fell wood, keep the fire going, and build the fantasy world. Player interactions are limited to infrequent decisions on what actions to delegate to automated characters. Instead of actively participating in the game world, players are interpassive and derive pleasure and the sense of being active from delegating play to an other, usually a computer [31]. In short, idle games are designed to be "interpassive", rather than interactive as traditional games are.

Idle games demonstrate that interpassivity can be rewarding. Notably, idle games do not require con-

stant attention from players and progress can be made even, and especially, when they are absent from the game [27, 31]. Rather than being completely absorbed in the game, the idling dynamic allows players to interact with the game in short game sessions last only a few seconds. This recurring gratification of gameplay is not only pleasurable, it may reduce compulsive gameplay or make it safer [26].

Unlike active games such as Pokemon GO, which have been extensively studied for their behavior change potential [78, 52], research on behavior change using idle games is limited. However, some recent work proposes possible design patterns for such games by surveying existing idle games [99]. This chapter extends this prior work by contributing a proof-by-demonstration system for changing investing behavior.

3.3   System Description

Robinhood's Forest is an idle game that aims to improve investing behavior guided by fundamental results from behavioral finance and literature on idle games. Its design is inspired by the productivity app *Forest*, from which I borrow the idea of tending a forest as an idle game activity. I extend this metaphor to investing apps, such as *Robinhood*, by using a forest metaphor as an abstract representation of an investor's portfolio in addition to features like performance visualizations and market news that support investing.

Robinhood's Forest is implemented as a React app that users can access from their computer or phone. The project is open source and available on GitHub (`https://github.com/shiftsayan/robinhoods-forest`) and a hosted version is also available (`https://robinhoods-forest.netlify.app/`). It uses data from Google Finance API for Google Sheets. When users add their stocks to *Robinhood's Forest*, their portfolio is stored on their device and not sent to a server, protecting user privacy.

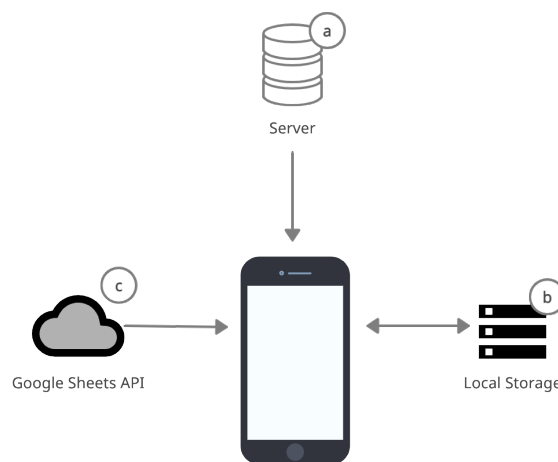Below, I describe the main elements of the system, along with the hypotheses they embody.

Figure 3.2: The *Robinhood's Forest* Architecture. The user interacts with the web app on their phone. a) Source code of the app is fetched from the server (hosted on Netlify). b) A user's portfolio is stored locally. c) Stock price data is obtained by calling a Google Apps Script that returns data from the Google Sheets Google Finance API.

3.3.1 Restricting Gameplay

Robinhood's Forest represents the shares a users owns in a company by a tree. As the stock performs well the tree grows visually and if the stock price drops, the tree withers and shrinks. When the investment is sold, the tree is felled leaving behind a stump. A portfolio of different stocks is represented by a forest with different kinds of trees. As with idle games, player interaction in *Robinhood's Forest* is limited to infrequent trading decisions and pleasure is derived from restricting gameplay. Instead of actively tending to their forest, players "idle", and passively watch their trees grow and investments yield returns.

As discussed in Section 2.4.2, retail investors often sell a stock that is "falling" in value to replace it with one that is "rising" in value. In reality, because future stock prices are unknown, they instead end up selling stocks at their lowest price and buying ones that are at their peak, reducing earnings. To combat this, when a stock is removed from the portfolio, the associated tree is felled leaving behind a stump. These stumps remain in the forest for a week, restricting available space. I hypothesize that the lack of land area to plant new trees may reduce frequent trading and discourage users from regambling any winnings. In sum, *Robinhood's Forest* embodies the hypothesis that an "idle" activity that encourages limited gameplay can reduce stock trading frequency and improve investor returns.

3.3.2 Nudging Behavior with Visual Metaphors

The abstract representation of investments as trees is at the core of *Robinhood's Forest*'s interface. They are deliberately designed to minimize visualizations of short-term fluctuations in prices. This helps reframe the concept of stocks as long-term investments, reduces overreaction to market news and social pressure, and encourages deliberate trading.

Similarly, *Robinhood's Forest* uses visual metaphors to encourage diversification. It does so by representing stocks of companies within the same industry with trees of the same species that look visually similar, encouraging users to create visually diverse forests as a way to diversify their portfolio. In sum, I hypothesize that leveraging visual metaphors will further reduce trading frequency and encourage diversification.

3.4 Study 1: Concept Validation

In developing *Robinhood's Forest*, I first ran a concept validation study with five participants that focused on whether idle game mechanics change trading behavior, and specifically, if using a forest metaphor may be effective. I used the results of this study to develop a functional prototype, which I studied with the same participants with their actual portfolios.

3.4.1 Participants

Since my tool's target demographic was first time investors, I recruited students in or recent graduates of Carnegie Mellon University through snowball sampling. Participants were screened based on whether they had used any investment platform in the past three months. All participants selected had less than two

years of experience in the stock market and used services such as Robinhood (3 participants), Interactive Brokers (1 participant), Charles Schwab (1 participant), and E-Trade (1 participant). One participant had accounts with multiple brokerages. Two participants identified as male and three as female.

3.4.2 Method

In this within-subjects study, participants saw two mockup interfaces and were asked to make trading decisions involving fictitious stocks. The first mockup showed an initial prototype of *Robinhood's Forest* and used the forest metaphor. The second resembled the interface of a typical trading app such as Robinhood. Selected screen from each mockup are shown in Figure 3.3.

To create the scenario, I selected five existing "small cap stocks" from different industries in the Russell 2000 Index, and gave them pseudonymous names while preserving their industry identity (for instance, "Silvergate Film" for an entertainment company). Successive screens showed participants stock prices over five months, derived from actual underlying stocks. To create the second scenario, I gave the same companies different pseudonymous names and altered the stock prices marginally. At the start of each scenario, I explained the design of the mockup participants would use. At each month, participants were asked what trading decision (buy, sell, or hold) they would make and when they expected to next check their portfolio.
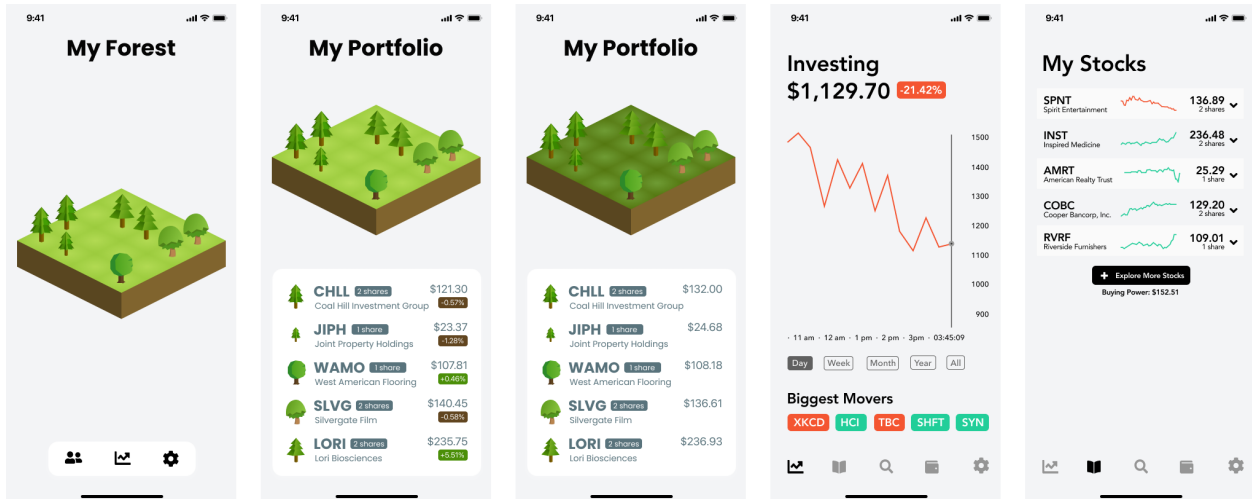
Figure 3.3: Subset of the screens used for the concept validation study. The first mockup (first three screens) showed an initial prototype of *Robinhood's Forest* and used the forest metaphor. The second (last two screens) resembled the interface of a typical trading app such as Robinhood.

3.4.3 Results

Four out of the five participants made fewer trades and held positions for longer using the *Robinhood's Forest* flow. On average, participants performed 3.8 stock transactions over the five month period when using the traditional interface and 1.8 trades when using the idle game interface. However, due to the small sample size, these results, while suggestive, are not statistically significant.

Participants also said they liked the user interface and forest metaphor and found it easy to understand. However, when asked to compare the idle game and traditional interfaces, all participants valued the performance visualizations offered in a typical trading app. Together, these results suggest that while an idle game-like interface might successfully nudge investor behavior, users also desired more data to inform their trading decisions.

3.4.4 Iterative Changes

Based on participant responses, I added a chart of the past performance (price changes) for each stock and links to analyst reports about the company. To discourage overreactions to market news and short-term price changes but still display data demanded by participants, this information is only shown after tapping the stock ticker and is "below the fold". Similarly, to encourage long-term trading, I added a "Gardening since..." label to each stock. Figure 3.4 shows screens of *Robinhood's Forest* through various stages of iteration.
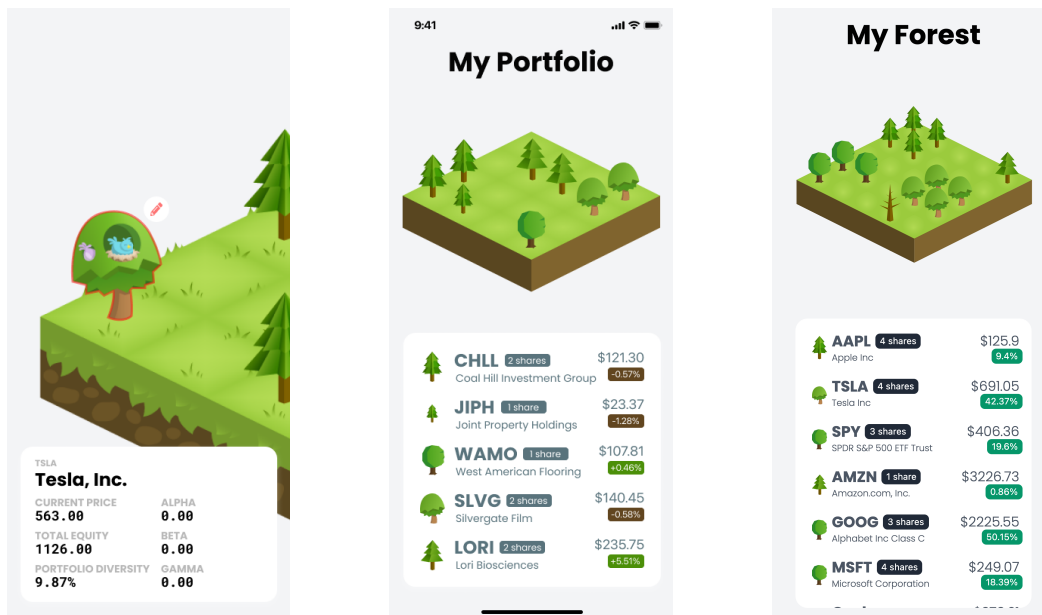
Figure 3.4: Screenshots of *Robinhood's Forest* through various stages of development. Initial prototyping was made with Figma (extreme left) and the final prototype was an interactive React app (extreme right).

3.5 Study 2: Individual Portfolio Simulation

The concept validation study suggested that compared to traditional interfaces, an idle game-like interface may improve investing behavior by reducing trading frequency. This follow-up study was designed to study whether the visual metaphors used encourage diversification. Recall that the concept validation study used fictitious stocks and a fixed portfolio and so could not study what participants wanted to do with their own portfolios. Furthermore, I wanted to develop a more nuanced understanding of participant

behavior using *Robinhood's Forest*. So, this study focused on participants' own stock portfolio (rather than fictitious stocks) and does not use a comparison interface.

3.5.1 Participants

For this study, I sought to recruit the same participants who had participated in the pilot so I could make comparative observations. Four participants continued participation but one participant dropped out due to scheduling issues and so I recruited a new participant through snowball sampling. Like previous participants, they had some, but fewer than two years, of investing experience. All participants (including those that only participated in one study) were compensated $10. Protocols for both studies were approved by the Carnegie Mellon University Institutional Review Board.

3.5.2 Method

Before the study, participants were asked which securities they wished to see in their portfolio on *Robinhood's Forest* and a version with their customized portfolio was deployed on Netlify. The study was structured as a structured interview. First, participants were told about the forest metaphor and game mechanics behind the prototype and given some time to explore the interface by themselves. Then, the interviewer conducted the interview, which focused on 1) how participants understood the concepts of *Robinhood's Forest* (such as the metaphors and mechanics), 2) how they felt it would influence their investing behavior, and 3) their suggestions for how to improve the application.

These interviews were audio recorded and then transcribed. I employed thematic analysis methods [16] to analyze interview transcripts. The resulting major themes are described below, along with quantitative results where applicable.

3.5.3 Results

Robinhood's Forest encouraged participants to diversify but degree varied across participants

All five participants reported that they wanted to expand their forest to have a diverse selection of trees, corresponding to a more diversified portfolio. However, specifically how they chose to diversify varied, and was sometimes suboptimal.

Some participants saw the unplanted areas in the forest and wanted to diversify across industries. For instance, P5 wanted "different trees from different things [industry segments]", which results in uncorrelated stocks and better diversification. Others chose to buy more stocks in companies they had fewer stocks in, as opposed to new companies. P1 said: "I think I have three shares of Google, maybe like adding another share might be worthwhile, just like looking at how well Google is doing..." While this may make the portfolio somewhat more diversified, this is suboptimal as stocks remain similarly concentrated.

Idle game-like interfaces also influence unconscious investing behavior

On the topic of frequent trading, respondents had mixed feelings. One participant said that seeing tree stumps might prevent them from trading too frequently by reminding them of recent sales of stocks. But

other participants suggested that it was unlikely that the system would reduce their trading frequency, because they were already very deliberate about their investing decisions. For instance, P3 said "So whenever I'm actually putting in more money or... trying to sell a security, I actually put in a lot of thought into every single decision I make, because those, like decisions are so rare." Similarly, P1 reported that their trading was based on detailed stock information that was still present in the interface and so unlikely to change: "What I'm looking at right now: my eyes are going towards the stocks and like the numbers in there. I think I'm less focused on the trees." However, this was at odds with participants' actual behaviors. These same participants (including P1 and P3 above) made fewer trades in actuality while using the *Robinhood's Forest* mockup than with a more traditional interface during the concept validation study.

This difference between how participants expect to behave and how they actually behave suggests that idle game-like interfaces can effectively change behaviors in ways that participants are aware of, such as creating diversified portfolios, but also in ways they are not, such as reducing frequency of trading. Furthermore, the mockup in Study 1 included the stock information that P1 mentions (the "numbers"), and participants still had lower trading frequency in the *Robinhood's Forest* prototype, suggesting an effect on implicit behaviors despite the presence of detailed information.

Trees were effective as game objects of interpassivity but had unintended consequences

Participants embraced the idea of watching their trees grow as an enjoyable, interpassive activity. Without prompting, two participants told me how they wanted me to extend this visual metaphor, suggesting that the tree metaphor afforded interpassivity. P4 suggested "I think it'd be cool... if dividend stocks had some extra things for you to know [that it is one]." A dividend stock is one that primarily provides returns on investment as dividend payments, rather than growth in price, and so does not grow or shrink in my current implementation. Other suggestions had no equivalent in actual stock trading, such as decorating with tree houses. P5 suggested "Well, I think for Christmas, you should put out a Christmas update to put a bow on the trees".

While these visual metaphors provide interpassivity benefits, I also found they might lead users astray. For instance, P1 told me they liked the metaphor because "You water your trees daily and they grow so maybe that's something related to: you check your portfolio like daily and that's a good thing to do (emphasis added)". However, prior work suggests that investors who view their portfolio more frequently trade more frequently, leading to lower returns. I discuss this tradeoff between interpassive enjoyment and unintended consequences in Section 3.6.2.

Ambiguous representations caused confusion

At the start of my user study, I described how trees represented different stocks in the interface. Yet, all participants were confused about how exactly the mapping worked. P5 asked "These trees are all the same size, even though the stocks are various, like very different prices?" In actuality, trees were rendered to be a fixed size on stock purchase, so they could show price changes visually. Similarly, P1 and P4 were confused whether trees represented one share of stock or one firm.

Because all participants understood that trees grew or shrank in the interface based on changes in underlying stock prices any of these assumptions would likely yield the same high-level behavior. However, it is possible that they may nudge different investing behaviors to different extents. I discuss this further in Section 3.6.1.

Robinhood's Forest is a visually appealing interface

All five participants in the study said they could see themselves using an extension of _Robinhood's Forest_ as their trading app. Participants also all liked the user interface of the app, finding the design to be "pleasant on the eyes" and a "pretty good visual". I caution here that this may be the result of a demand characteristic bias as participants knew me, the interviewer.

3.6 Design Implications

3.6.1 Using Idle Games to Change Unconscious Behaviors

Tuning specific behaviors

With _Robinhood's Forest_, I saw that participants increase diversification in their investments but the specific ways they do so vary. Specific design choices based on my approach may be better able to target these specific behaviors. For instance, _Robinhood's Forest_ depicts all shares held in a particular company by a single tree, which obscures the user's exposure to that company. An alternative design might highlight this exposure (e.g. showing more trees for larger holdings), which may nudge better diversification behaviors.

My prototype did not use social persuasion, which may open up opportunities to tune specific behaviors. For instance, P2 suggested "Yes... the overall growth or the overall diversification, those things could be public because that might get someone else to diversify as well." Still, they maintained that "some level of privacy in terms of what your portfolio contains" was essential.

Overcoming reactance

A vast body of social psychological research demonstrates that explicit or overt attempts to persuade or change behaviors tend to trigger resistance among participants called "reactance" [17]. Such reactance can provoke participants to engage in harmful behaviors [85], develop negative attitudes towards the content [87, 67], and even adopt behaviors opposed to ones that were encouraged [20].

My studies suggest that participants were not always aware of when idle games changed their behavior (e.g. reducing trading frequency) and that they appreciated other (e.g. visual) aspects of the interface, suggesting an opportunity to circumvent reactance. Indeed, other researchers have found that making motivational messages less obvious, or intermixing with other messaging improves their effectiveness [50]. My work so far suggests that idle games may be one way to do so, especially for investing behaviors.

3.6.2 Idle Games Introduce New Questions for Designers

Idle games are designed to restrict interactivity and delegate gameplay [31], a goal that is at least superficially at odds with introducing new interactive functionality. This challenge is especially pronounced when responding to user feedback. For instance, participants made suggestions like being able to add labels to trees (P5) and choosing which tree species were depicted (P2). However, these features may also lead to a model where participants derive joy from interacting with the game directly, rather than passively. More generally, idle game-like interventions make the role of the designer even more important, as even "common sense" additions may decrease enjoyment from gameplay.

A related question is which actions should be delegated or automated. Automating actions may improve user outcomes, but may also reduce enjoyment. Navigating this trade-off requires deliberate design. For example, investors frequently automate actions such as rebalancing a portfolio (selling assets that have risen too far and buying underpriced assets) because this generally boosts returns. However, if enjoyment in the idle game is tied to performing these infrequent actions (e.g. pruning a tree that has grown too far), then designers may want to reserve them for the game user.

3.7 Discussion

I developed *Robinhood's Forest*, an idle game to improve investing behaviors. Through two small-scale studies, I demonstrate the potential of this approach, as well as outline new opportunities, challenges, and design considerations.

3.7.1 Limitations

This chapter provides initial support for the usefulness of idle game-like interfaces for improving investing behavior. The current system and its analysis have several limitations. First, I limited my testing to a small number of in-lab participants (as is common practice in game testing). Second, while Study 1 simulated the effects of a five-month long investing time frame, I did not study long term effects on participants' own portfolios. Future work could do so, and also study effects with a larger number of participants.

Similarly, testing with a large number of participants with a variety of portfolios can quantify the benefits of an idle game-like intervention, including how much more money participants earned through better investing. A larger study would also provide a better picture of the different ways participants respond to game elements. For instance, even at my small scale, I saw a variety of ways participants wanted to diversify their portfolios.

3.7.2 Future Work

While I developed *Robinhood's Forest* with the assumption that investments were in stocks, the same metaphors may also apply to newer, alternative investments, such as cryptocurrency or equity crowdfunding, which allows low-cost investing in startup companies. While these investments are varied, users may find idle game mechanics to be helpful in nudging better investing behavior. Going broader still, idle

games may be helpful metaphors for limiting and changing behaviors in other activities, such as consuming social media. I hope this study helps other researchers and practitioners consider and implement this approach in other interactive applications.

Some idle games, such as *Cow Clicker*, have included social interpassive elements. Future work could consider how limiting social gameplay may be helpful for behavior change. Similarly, *Robinhood's Forest* currently has no delegated actions. Future work should explore how delegating repetitive activities (e.g. dividend reinvestment) to the computer may eliminate drudgery and improve enjoyment.

Finally, future work could also consider the benefits of including visual representations that have no equivalent in the real world as a safe place to siphon off otherwise compulsive urges of trading in non-consequential ways. For instance, users in Study 2 suggested including flowering trees and also accessorizing trees with seasonal ornaments, tree houses, etc.

Chapter 4

Conclusion

This thesis was inspired by media accounts of retail investors suffering catastrophic harm as a result of poor investments. Despite the large impact that design patterns can have on investing behaviors, research on this topic is unfortunately lacking. This thesis starts to fill this gap of design guidance by making two overarching contributions. First, it introduces a set of design guidelines for trading platforms based on fundamental results from related fields that may encourage more successful investing behaviors. These guidelines can be useful in evaluating trading applications and recommend directions to improve the design of these applications. Second, it presents a prototype for *Robinhood's Forest*, an idle game for improving investing behavior. In particular, the idle game mechanics and visual metaphors of the interface helped increase portfolio diversification and reduce trading frequency in users in two small-scale studies. Overall, this work suggests that investing is an activity worthy of attention from designers and design researchers and doing so is necessary to transform investing from an activity fraught with risks and reserved to those with privilege into one that is truly democratic.

Bibliography

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