

M.Sc. Thesis in Business & Management
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Do sludges on neo brokers increase trading frequency?

Exploring the moderating effect of financial literacy on sludges

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Abstract

The choice architecture of neo brokers has been subject to criticism due to potentially harmful effects on investors. Interdisciplinary research has identified design features on neo brokers that may cause increased risk-taking and overly frequent trading. However, there is a lack of empirical evidence regarding the direct relationship between these features and investors' trading frequency. We address this gap, building on the theoretical concept of sludging. Whereas nudges are small changes to choice architectures intended to lead people to better decisions, sludges can make them worse off. Thus, the purpose of this study is to examine whether sludges on neo brokers influence investors to trade more frequently. In an experimental study with $N = 285$ participants in two randomized groups, we simulate several rounds of trading. We find that participants exposed to a neo broker choice architecture trade 53 percent more than those presented with a traditional broker interface. We also explore potential heterogeneous effects of sludges on investors depending on their objective and subjective financial literacy, as well as their financial literacy overconfidence. Moderation effects are not significant, but an exploratory analysis shows that prior experience in the stock market among low-income individuals weakened the effect of sludges on trading frequency. Our findings contribute to the field of consumer financial decision-making by demonstrating that sludges are effective in the context of neo brokers. They also point to the relevance of protecting consumer welfare, especially regarding vulnerable groups.

Key words: Nudges, sludges, choice architecture, neo brokers, financial literacy

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II. List of key concepts

<i>Choice architecture</i>	The way in which information or options are framed in a decision environment (Thaler & Sunstein, 2008).
<i>Nudge</i>	A small change in a choice architecture that subtly influences peoples' behavior and decision-making. It is intended to steer individuals towards making a decision that is in their best interest, while preserving their freedom of choice (Thaler & Sunstein, 2008).
<i>Digital nudge</i>	Nudges in the digital sphere. They guide user behavior in digital environments using design, information, and interaction elements, while preserving the users' freedom of choice (Schneider et al., 2018; Weinmann et al., 2016).
<i>Sludge</i>	The negative counterpart of nudge. Sludges work the same, but do not lead individuals to decisions in their best interest. They either facilitate making bad decisions or complicate making good decisions (Newall, 2022; Thaler, 2018).
<i>Payment for order flow</i>	A business model used by neo brokers. Acting as intermediaries who connect investors to market makers, they receive a small fee for every transaction. This allows the platforms to charge investors minimal or zero transaction fees (Elsas et al., 2022; Meyer et al., 2021).
<i>Objective financial literacy</i>	The financial knowledge and skills a person possesses. This knowledge is externally measurable (Allgood & Walstad, 2016; Lusardi, 2008).
<i>Subjective financial literacy</i>	An individual's perceived financial knowledge. It describes the self-assessed level of that knowledge (Allgood & Walstad, 2016).
<i>Overconfidence</i>	"The overestimation of one's actual ability, performance, level of control, or chance of success" (Moore & Healy, 2008).
<i>Financial literacy overconfidence</i>	The overestimation of one's financial literacy. It occurs when individuals perceive it to be higher than it factually is (i.e., when subjective financial literacy > objective financial literacy) (Xia et al., 2014).

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1. Introduction

1.1 Research problem

Every day, people make an average of 20,000 decisions – some consciously, many unconsciously (Gigerenzer, 2008; Tönnemann, 2008). These decisions extend to all areas of life, such as social, leisure or financial (Gigerenzer, 2008). Sometimes, people's minds lead them to misjudge and make the wrong decisions (Kahneman & Tversky, 1974). For years, trying to better understand the factors that influence consumer decision-making has been a key research topic in the field of marketing (e.g., Bettman et al., 1991).

Research has shown that the environment in which people make decisions can heavily influence their choices (Thaler & Sunstein, 2008). Thaler & Sunstein (2008) use the term *choice architecture* to describe how information or options are designed in a decision context. The authors argue that changes in choice architectures, even if they are small, can impact people's decision-making. *Nudges* are intentional changes, designed to predictably influence people's behavior without prohibiting any options or changing people's economic incentives (Thaler & Sunstein, 2008). Importantly, nudges must be in the interest of the person they are directed at (Thaler & Sunstein, 2008). If they harm the individual, they can be called *shudges* (Thaler, 2018; Thaler & Sunstein, 2021).

In today's digital landscape, consumers make a large share of their decisions online. Thus, the use of digital nudges in the form of design elements in user interfaces becomes increasingly important (Reeck et al., 2023; Schneider et al., 2018). By reaching multiple people simultaneously, they can be a powerful tool to guide consumer choices (Weinmann et al., 2016).

Financial decisions are one type of consumer decisions that increasingly take place online (Cai, 2020). In recent years, new financial technology companies (FinTechs) have contributed to this increase (Cai, 2020). These companies use technology to offer innovative financial solutions to consumers (Schueffel, 2017). One type of FinTechs are neo brokers. Neo

brokers such as Robinhood in the United States or Trade Republic in Germany have gained popularity in recent years (Tan, 2021; Welch, 2022). The brokers come in the form of smartphone-native digital platforms that offer individuals an easy and (mostly) feeless access to investing, claiming to democratize finance (Barber et al., 2022; Tan, 2021). The majority of investors on neo brokers are young and first-time investors with relatively little financial knowledge (Barber et al., 2022; Kritikos et al., 2022).

However, there is a considerable amount of criticism concerning the business model and practices of neo brokers. Interdisciplinary research from finance, behavioral economics, and user interface design has critically examined design features of the apps. Scholars have identified the most common features such as the reduced choice set and simplified display of information, as well as gamified elements like rewards in the form of points or badges, leaderboards, notifications, and playful illustrations. According to this research, these features make the trading experience very intuitive and game-like, potentially influencing investors' decision-making (Barber et al., 2022; Chapkovski et al., 2021; Chaudhry & Kulkarni, 2021; Fleming et al., 2022; Tan, 2021). A key issue is overly frequent trading, which usually leads to negative returns and can thus harm consumer welfare (Barber et al., 2022; Tan, 2021). Experimental evidence, however, is lacking on whether the design features on neo brokers increase investors' trading frequency. Only Fleming et al. (2022) found in an experiment that rewards in the form of points led investors to more frequent trading, but no study so far has tested the effect of the most common neo broker features in conjunction, as in a real-life interface, on trading frequency.

Previous research on the direct effect of neo brokers' design features on investor behavior is not only scarce, but also distributed over domains. The domain of choice architecture research has identified various techniques that can influence consumer behavior,

and analyzed their effectiveness (Johnson et al., 2012; Mertens et al., 2022; Münscher et al., 2016).

Our analysis synthesizes the design features identified by prior research and analyzes their effect on trading frequency. Building on the theoretical concept of sludging, we view the design elements in question as sludges that do not support investors with making decisions that are in their best interest, as frequent trading can be harmful for investors (Barber et al., 2022; Chaudhry & Kulkarni, 2021).

In an experiment with $N = 285$ participants and two randomized groups (neo broker vs. traditional broker), this paper empirically investigates how sludges on neo brokers impact trading frequency. Hence our research question is: *May sludges on neo brokers increase trading frequency?* We examine this by controlling for gender, age, income, and previous stock investment experience. In addition, three potential moderators are considered:

The effect of sludges depends heavily on the addressee (Bryan et al., 2021; Mrkva et al., 2021). One key characteristic that contributes to the heterogeneity of investors is financial knowledge: Many researchers have shown that an individuals' level of financial literacy influences the quality of financial decision-making (Lusardi, 2008; Lusardi & Mitchell, 2014; Panos & Wilson, 2020; van Rooij et al., 2011).

Mrkva et al. (2021) showed that objective financial literacy moderates the effects of sludges. The authors measured the effect of default and sorting of options sludges in the context of answering single-choice questions. For example, a wrong answer option was selected per default when participants first saw the questions. Less financially knowledgeable participants kept false default options more often than others and were thus more impacted by the sludges. This is also reflected in the experimental findings of Chapkovski et al. (2021): the researchers showed that a gamified broker interface led participants to make significantly riskier

investments than on a traditional broker. Participants with a slightly higher (1 standard deviation) financial literacy score were 56 percent less impacted by a gamified broker interface.

Allgood and Walstad (2016) argue that perceived (i.e., subjective) financial literacy influences investment decisions to the same extent as factual (objective) financial literacy. Due to these findings, we include both objective and subjective financial literacy as moderators in our analysis.

Xia et al. (2014) found that if there is a substantial difference between subjective and objective financial knowledge, financial literacy overconfidence may occur. It describes the overestimation of one's knowledge, which occurs when individuals perceive their financial literacy to be higher than it factually is. The authors showed in their empirical study among Chinese investors in 2012 that financial literacy overconfidence is positively correlated with stock market participation (Xia et al., 2014). We expect that the exposure to a simple and gamified interface may cause overconfident investors to trade even more. Thus, we also test financial literacy overconfidence as a moderator.

We find in our study that on average, participants in the neo broker group traded 53 percent more than those in the traditional broker group. Regression analysis shows that this difference is significantly driven by sludges on neo brokers, even when controlling for a variety of other investor characteristics. There were no significant moderating effects for objective or subjective financial literacy on the effect of sludges on trading frequency in general. Only for low-income individuals we find a significant moderating effect of prior investment experience (alternate proxy for objective financial literacy). We find evidence that investment experience made low-income individuals less affected by sludges (i.e., they traded less). In contrast, people in this group without prior experience were more affected. A moderating effect of financial literacy overconfidence was not detected. This, however, might be attributable to the small number of participants in our sample exhibiting overconfidence.

1.2 Purpose of this research

Research gaps

With this thesis, we aim to address three research gaps. 1.) Experimental evidence is lacking on whether the most common design features of neo brokers (Top Movers list, simplified information, rewards, playful illustrations, push notifications) directly affect investors' trading frequency. Manipulating the effect of these features combined allows to better understand whether the design of real-life neo broker interfaces may impact investor decision-making. 2.) There is also a substantial research gap on nudges in the context of stock investing (Cai, 2020). 3.) Research on sludges is scarce in general (Luo et al., 2021).

Theoretical and practical contributions

The purpose of this study is to examine the effect of neo brokers' choice architecture on the trading frequency of investors from the perspective of sludging and its underlying theoretical considerations. We synthesize the findings of interdisciplinary research and apply theoretical concepts and methods from choice architecture research to the context of FinTechs. We thereby aim to contribute to the field of consumer decision-making. In line with the prevailing "heterogeneity revolution" (Bryan et al., 2021) in the domain of nudge research, we want to explore the effects of sludges on investors with different characteristics, by building on and extending the model of Mrkva et al. (2021). From a practical perspective, our study aims to improve the understanding of consumer risks on neo brokers and thus give implications for their protection.

Delimitations

The scope of this paper is delimited in the sense that we explicitly do not investigate the comparative effect of different neo broker choice architecture techniques on decision-making. The selection of sludges we analyze is not exhaustive, rather aims to depict the most

common sludges on neo brokers. We also do not examine all possible investor characteristics that could contribute to heterogenous sludge effects.

1.3 Thesis outline

The first section will comprise a review of the literature on nudges, digital nudges, nudges in consumer financial decision making, sludges and the heterogeneity of nudge (sludge) effects. It will then describe neo brokers and their investors, before examining the impact of sludges on neo broker investors. The theory part will then outline the psychological foundations of nudging and sludging, explaining the impact of choice architecture elements on investors. It will then elaborate on heterogenous effects of nudges depending on knowledge and examine the role of financial literacy overconfidence. Afterwards, the methods used will be discussed before the next part presents the results of our analysis. Next, we will discuss the results of our tested hypotheses and outline implications as well as limitations and directions for future research. Finally, the last part will reach a conclusion.

2. Literature review

In reviewing the literature on nudges, digital nudges, and nudges in consumer financial decision making, we create a foundation for examining sludges and the heterogeneity of nudge and sludge effects. We also explain the FinTechs neo brokers and describe the characteristics of neo broker investors. Finally, we review prior research on the effects of sludges on neo broker investors.

2.1 Nudges

The concept of nudge was popularized by economists Richard Thaler and Cass Sunstein in their 2008 book, “Nudge: Improving Decisions about Health, Wealth, and Happiness”. It builds on psychological factors that influence human decision-making and focuses on the context in which individuals make decisions. When confronted with uncertainty or risk,

humans often rely on *heuristics*, which are mental shortcuts and can lead to errors in judgment (Tversky & Kahneman, 1974). An important reason for the latter is that heuristic thinking is influenced by even minor environmental influences (Thaler & Sunstein, 2008; Tversky & Kahneman, 1974). Therefore, the context in which individuals make decisions can strongly impact their outcomes. Thaler & Sunstein (2008) employ the term choice architecture to describe the way in which information or options are framed in a decision environment. Examples are healthy products that are placed at eye level on supermarket shelves or a prominent website pop-up that encourages to opt-in to receiving a newsletter (Thaler & Sunstein, 2008; Weinmann et al., 2016). The likelihood of certain decision outcomes can thus be influenced by making small changes to choice architectures, i.e., individuals can be nudged to make a specific choice (Thaler & Sunstein, 2008). We will further elaborate on the psychological foundations of the concept in the theoretical background.

Importantly, nudging should have positive consequences for individuals, meaning that they are better off with the outcome of their decision than they were before (Thaler & Sunstein, 2008). Since there is no “neutral” choice architecture, Thaler & Sunstein (2008) argue that it is the designers’ responsibility to create environments that make choosing the best option easy and straightforward. Crucially, nudges do not substantially change individuals’ economic incentives, thereby respecting their freedom of choice. The authors state accordingly that nudges have to be easy to avoid (Thaler & Sunstein, 2008). Following the supermarket example, this would mean that placing healthy foods at eye level on the shelves would be a nudge, but banning unhealthy foods would not (Thaler & Sunstein, 2008).

The number and variety of nudges is growing (Sunstein, 2014). Three common nudges are simplification, increases in ease and convenience, and disclosure (Sunstein, 2014). Simplification means reducing unnecessary complexity that confuses consumers. This helps because consuming large amounts of complex information can deter individuals from making

decisions or lead to errors (Thaler & Sunstein, 2008). For example, a study in the UK found that simplifying the documentation of a tax reminder by reducing text and using simple language increased local tax payments (John & Blume, 2018).

Increases in ease and convenience are achieved by removing barriers that cause individuals to view a decision as difficult or ambiguous. When a choice is easy, humans are more likely to make it, especially when they also perceive it as fun (Sunstein, 2014). For instance, a study found that conveniently placing healthy food options in a school cafeteria significantly increased the sales of healthy lunches (Hanks et al., 2012). Similarly, children chose to eat a more nutritious type of bread when it came in a fun shape (van Kleef et al., 2014).

According to Sunstein (2014), disclosure means making available the information that is important to a decision. Under the premise that this information is also comprehensible and accessible, disclosure can facilitate better decision-making. An example is visibly presenting the full cost of a credit card, rather than hiding it in the fine print. This can help consumers to better assess whether they are making a choice that is suitable for them (Sunstein, 2014).

2.2 Digital nudges

Today, consumers make many important decisions in the digital sphere, where choice architectures come in the form of user interfaces (Reeck et al., 2023; Weinmann et al., 2016). Digital nudges guide user behavior in digital environments using design, information, and interaction elements, while preserving the users' freedom of choice (Schneider et al., 2018; Weinmann et al., 2016). These digital choice architectures have the power to influence the decision-making of many individuals simultaneously as they reach many people at the same time (Cai, 2020; Weinmann et al., 2016). Many of them are common nudges that are simply transferred to the digital world. One example are defaults, where options on websites or apps are already selected for the user and they have to actively opt-out to change them (Schneider et al., 2018). However, the online world also creates opportunities for the emergence of nudges

specific to the digital realm (Weinmann et al., 2016). The variety of design and interaction elements of user interfaces makes it possible, for example, to implement creative and entertaining gamification elements (Weinmann et al., 2016). For instance, gamifying user authentication processes with visual elements made users choose more secure passwords (Raptis et al., 2021).

2.3 Nudges in consumer financial decision-making

The area of application of nudges that we focus on is consumer financial decision-making, and specifically the domain of retail investing (Lynch, 2011). To foster customer relationships and support private customers with achieving financial goals, banks and other financial institutions increasingly employ nudges (Cai, 2020). Research has mainly investigated nudges that are aimed at supporting individuals with contributing to their pension plans and health insurances, as well as paying off debt in time (Agarwal et al., 2015; Thaler & Benartzi, 2004). When it comes to stock investing and trading behavior, there are still significant research gaps that should be filled, since influencing people's investment decisions can impact their lives heavily and is a powerful tool for institutions (Cai, 2020; Fleming et al., 2022).

In financial markets, there are two main nudge tools. The first one is to adjust how investment choices are presented, e.g., default opt-ins to retirement savings plans (Cai, 2020). The second one is to present information in a specific way, e.g., consumer protection messages in promotional materials (Cai, 2020). Influencing decision-making in financial markets is a complex endeavor, since it is a high-risk, high-uncertainty context with many behavioral challenges such as cognitive biases (Martelli, 2017). This complexity is driven by three different characteristics of the financial context: First, the complexity of financial products is higher relative to other ordinary ones (Erta et al., 2013). Second, individuals are required to make trade-offs between the present and the future (even if they often fail to do so) (Erta et al.,

2013). And third, the rarity of some financial decisions prevents individuals from learning from their past experiences (Erta et al., 2013).

2.4 Sludges

While Thaler & Sunstein (2008) clearly appeal their readers to “nudge for good”, there are also choice architecture interventions that do not have positive consequences for individuals. Hence, choice architectures that lead individuals to harmful decisions are also being investigated – using terms such as “bad nudges” (Mrkva et al., 2021), “dark nudges” (Newall, 2019), and “anti-nudge[s]” (Neuss & Zielke, 2022). Thaler and Sunstein have extended the concept of nudges by introducing the term sludge, which describes a choice architecture that harms individuals (Thaler & Sunstein, 2021). Thaler's (2018) definition of sludges includes both added frictions that make it harder for individuals to make the right decisions, as well as elements of choice architectures that simplify making bad decisions. An example of the application of sludges is the process of purchasing tickets at European low-cost airlines (Weinmann et al., 2016). Displaying non-essential options, such as seat selection or priority boarding, encourages customers to choose them. While this can lead to profits for the airline, it is often not in the best interest of the consumer, as it leads to unnecessary expenses (Weinmann et al., 2016).

2.5 Heterogeneity of nudge and sludge effects

The effect of a nudge or sludge depends on the addressee and context, as human behavior is highly complex and influenced by diverse factors (Bryan et al., 2021; Lehner et al., 2016). The aspect of *heterogeneity* should therefore be considered when examining the effects of choice architecture techniques. This is because the replication of findings has been challenging, in the sense that effect sizes and concrete outcomes vary for different populations and contexts (Bryan et al., 2021).

For instance, multiple experimental studies by Mrkva et al. (2021) show that the effect of a nudge (defaults, sorting, and reduced options) on decision accuracy is moderated by the socioeconomic status (SES), domain knowledge, and skills of an individual in a given context. In their study, participants were given single choice questions with different choice architecture manipulations. People with lower SES and knowledge experienced a stronger positive effect from being nudged (i.e., they answered more accurately). However, nudges also had a stronger effect on individuals with a lower SES, less knowledge, and skills and thus caused them to be worse off compared to the other group (Mrkva et al., 2021).

Therefore, it has been suggested that the focus should be shifted from investigating general effects of nudges and nudges to understanding heterogeneous effects (Bryan et al., 2021; Mrkva et al., 2021; Reeck et al., 2023). In other words, the “heterogeneity revolution” encourages to examine for which populations and in which contexts certain nudges are effective, instead of trying to answer the question if nudges work in general (Bryan et al., 2021).

2.6 Description of neo brokers

FinTech companies are a new part of a financial sector that uses technology to enhance financial operations through innovation (Schueffel, 2017). One area in which they are active is retail investing, where neo brokers have become popular alternatives to traditional brokerages (Tan, 2021).

Neo brokers have seen a strong increase in users and shares per user in recent years with a peak during the Covid-19 pandemic in March 2020 (Tan, 2021; Welch, 2022). Platforms such as Robinhood in the US or Trade Republic in Germany are FinTech broker apps (neo brokers), that allow retail investors to trade ETFs, stocks, derivatives and other securities (Chaudhry & Kulkarni, 2021; Kritikos et al., 2022). Retail investors (on neo brokers) are investing their personal capital without professional investment experience (Chaudhry & Kulkarni, 2021).

Neo brokers use the *payment for order flow* model. This means that for every trade executed, Robinhood receives a small fee for the service of routing the investor to the market maker, who actually sells the stock. It allows the platforms to charge its users zero to minimal fees by relying on a high trading frequency (Elsas et al., 2022; Meyer et al., 2021).

Some claim that neo brokers give access to the stock market for previously unrepresented groups by eliminating obstacles such as trading fees, and by offering an intuitive app interface (Barber et al., 2022). Low-income individuals can participate in the stock market due to the absence of fees, as research indicates that even low additional costs can deter these groups from stock market participation (Vissing-Jørgensen, 2002). Thus, neo brokers seem to be democratizing finance by making it more accessible (Chaudhry & Kulkarni, 2021; Tan, 2021).

2.7 Neo brokers' investor characteristics

More than 50 percent of traders on Robinhood and Trade Republic are young (below 35 years), first-time investors with relatively low financial literacy (Barber et al., 2022; Kritikos et al., 2022). They also have fairly small portfolios on average (Robinhood: ~\$1000 – \$5000), compared to investors using other brokerages (E-Trade: ~\$69,000) (Constine, 2020; Tan, 2021).

2.7.1 Young and novice investors

These novice and inexperienced investors need to be guided into making informed financial decisions (Wijland et al., 2016). Therefore, neo brokers that give these groups access to the stock market could be seen as helping young people to invest and thus contributing to the democratization of finance.

However, there are also several studies that claim the opposite: On Robinhood, investors pursue different goals than on traditional brokers (e.g., Barber et al., 2022; Tan, 2021). According to Barber et al. (2022), only a small fraction of investments is driven by traditional,

risk-averse goals such as taking advantage of tax losses, saving for retirement, or covering liquidity requirements.

The fact that neo brokers attract non-institutional, small and novice investors is one explanation why investors on Robinhood conduct more attention-driven, speculative trades. In other words, these investors conduct more investments that are not driven by traditional financial goals (Barber et al., 2021, 2022; Seasholes & Wu, 2007). *Attention-driven buying* occurs as individual investors have to make the difficult decision of which stocks to buy among all available ones (Barber & Odean, 2008). Therefore, purchases by individual traders are generally often focused on stocks that have grabbed their attention, thus have been added to their consideration set (Barber & Odean, 2008; Odean, 1999). Specifically, these are stocks that are covered in the media, with unusually high trading volume or with exceptionally high one-day profits (Barber & Odean, 2008). Importantly, attention-driven trading occurs predominantly on the buying side. Investors are likely to buy rather than sell stocks that are mentioned in the media (Barber & Odean, 2011). This can be explained by the fact that traders do not need to search for stocks they sell as they already own them (Barber & Odean, 2008).

Speculative trading describes the buying and selling of short-term highly volatile stocks (Barber et al., 2022; Tan, 2021). Overly frequent trading refers to making significantly more trades in a given time frame than the average retail investor makes on other brokers (Barber et al., 2022). Some research has found that Robinhood investors tend to exhibit more speculative behaviors and a higher trading frequency than traditional investors (Barber et al., 2022; Tan, 2021). Investors on Robinhood traded 40 times as many stocks (per dollar in the average investor's trading account) as on the traditional broker Charles Schwab in the first quarter of 2020 (Barber et al., 2022).

2.7.2 Levels of financial literacy

Another aspect to consider when looking at novel, small and inexperienced investors is the question if and how their level of financial literacy impacts investment behavior. Financial literacy describes the knowledge and skills to understand and interpret financial concepts (Lusardi, 2008). The level of these competencies influences how well individuals are able to make financial choices (Lusardi & Mitchell, 2014). With regards to financial literacy, it is sometimes argued that FinTechs, including neo brokers, provide investors with a chance to improve their financial literacy through simple and easy access to financial platforms (Panos & Wilson, 2020). However, FinTechs are also criticized for harming inexperienced investors that do not possess the necessary financial literacy to make decisions in an environment where speculative buying behaviors are provoked (Panos & Wilson, 2020). The easy and feeless access to investing is criticized for attracting investors with low financial literacy to trade highly risky products such as options and cryptocurrencies (Chaudhry & Kulkarni, 2021; Tan, 2021).

Allgood & Walstad (2016) differentiate between actual (objective) and perceived (subjective) financial literacy. Objective financial literacy is the true externally measurable level of an individual's financial knowledge (Allgood & Walstad, 2016; Lusardi, 2008). Subjective financial literacy describes a person's subjectively perceived and self-assessed level of financial knowledge (Allgood & Walstad, 2016). In their study, the authors show that both can be equally important in determining how well individuals are able to make financial decisions (Allgood & Walstad, 2016).

When there is a discrepancy between objective and subjective financial knowledge, i.e., when people perceive their knowledge as higher as it is in fact, the concept of *financial literacy overconfidence* becomes relevant (Xia et al., 2014). *Overconfidence* is defined as an “overestimation of one's actual ability, performance, level of control, or chance of success”

(Moore & Healy, 2008). While people are generally bad at correctly estimating their own abilities, they especially overestimate themselves when it comes to tasks that are difficult, such as complex investment decisions (Moore & Healy, 2008). Overconfidence has been thoroughly researched as an influence factor on investor decision-making. Finance research has linked overconfidence to various risky behaviors like participating in competitive markets and games, and high trading frequency especially on discount brokers (which includes neo brokers) (Barber & Odean, 2001; Benos, 1998; Camerer & Lovallo, 1999; Grinblatt & Keloharju, 2009). Participating in the stock market is potentially harmful to them, since overconfident retail traders may suffer losses due to their lack of adequate abilities (Xia et al., 2014).

2.8 Impact of sludges on neo broker investors

Adding to the outlined aspects in the previous section, there has been public and academic criticism towards several aspects of neo brokers' business model and app design. Examples of public criticism include the following two cases: In the European Union, lawmakers' debate regarding the payment for order flow model has led to a proposal to prohibit this business model (Elsas et al., 2022). One of the main reasons is that it potentially harms investors (Elsas et al., 2022). In Massachusetts, regulators issued a complaint against Robinhood in 2020 for i.e., "[the] use of strategies such as gamification to encourage and entice continuous and repetitive use of its trading application" (Dagley et al., 2020). Examples of academic criticism specifically relate to the following aspects: Several researchers have described how a simplified app design and gamified elements encourage frequent and overly speculative trading, resulting in negative abnormal returns (e.g., Barber et al., 2022; Chapkovski et al., 2021; Chaudhry & Kulkarni, 2021; Tan, 2021). The different choice architecture manipulations on neo brokers can therefore be considered sludges. These app characteristics will be discussed in detail in the following paragraphs.

2.8.1 Simplified app design and “Top Movers” list

The interface design of an app directs the attention of investors and can thereby elicit certain behaviors. Robinhood’s app design is very simple (Barber et al., 2022; Tan, 2021). By managing frictions, the app offers a very intuitive and easy user experience (Ash et al., 2018; Fleming et al., 2022; Tan, 2021). Managing frictions refers to increasing or reducing frictions on the app, thus guiding investors’ decisions. One example of reducing friction is that Robinhood displays only five stock indicators, while other online brokers list several hundred (Barber et al., 2022). An example of increasing friction is that canceling trades on Robinhood requires more clicks than finalizing trades, which can encourage people to conduct more trades (Tan, 2021). This management of frictions contributes to a very easy user experience, which potentially influences inexperienced investors in their decision making (Tan, 2021).

Another core element of neo brokers are the “Top Movers” lists. On Robinhood, the list shows only 20 constantly changing stocks “with the largest absolute percentage price changes from the previous-day close” (Barber et al., 2022). On Trade Republic, the “Top Movers” list continuously updates and displays five “Best Performer” and five “Worst Performer” stocks (Trade Republic Bank GmbH, 2023). Barber et al. (2022) examined the effect of Robinhood’s “Top Movers” list on investor attention and found that Robinhood traders were likely to follow recommendations of “Top Movers”. Their study showed that Robinhood’s simplified display of information led retail investors to buy stocks that attracted their attention. In their empirical analysis using Robinhood stock data from 2018 to 2020, they discovered that 35 percent of stock purchases by Robinhood investors were centered on 10 stocks, versus just 24 percent for other retail investors, which led to below average returns. This kind of concentrated buying by Robinhood traders and can amplify buying-side herding behaviors, which have also been associated with negative returns (Barber et al., 2022).

In summary, the way (financial) information is presented influences investment behavior particularly for people with low financial literacy (Frydman & Wang, 2020; Loos et al., 2020; Panos & Wilson, 2020). It also allows neo brokers to steer investors towards investment decisions more in the interest of the platforms in terms of trading frequency and speculative trading (Ash et al., 2018; Barber et al., 2022; Chaudhry & Kulkarni, 2021). Thus, it can potentially harm investors.

2.8.2 Gamification and gamblification

Several other design features on neo brokers, here specifically on Robinhood, lead investors towards a high trading frequency (Tan, 2021). These features partially use the technique of gamification which be defined as “the use of game design elements in non-game contexts” (Deterding et al., 2011).

In the field of behavioral economics, an experimental study with 600 participants from the Unites States, United Kingdom, Canada, and Australia, revealed that gamified design features typical to neo brokers increased retail investors’ risk-taking by 6.05 percent (Chapkovski, 2022). Similarly, Tan (2021) analyzed news articles and legal filings on Robinhood and other neo brokers. He concluded that the app design led to higher risk taking and trading frequency. A qualitative analysis by Chaudry and Kulkarni (2021) in the domain of user interface design showed that several design elements on the neo broker Robinhood are likely to encourage unhealthy trading behaviors. Finally, Fleming et al. (2022) examined gamified app features in their experimental study among 2,430 Canadian participants. Their results suggest that collecting rewards in the form of points increased investors' trading frequency by 40 percent and displaying short top lists increased investors' likelihood of trading these stocks by 14 percent. The following paragraphs will explore the design elements and their effects in more detail.

Three design features evoke a higher trading frequency in particular: First, to buy a stock, investors use a swipe-up gesture. For young digital natives who grew up with the swipe logic of smartphones, this movement makes confirming a transaction easy and intuitive (David & Cambre, 2016; Tan, 2021). Second, to show fluctuations in stock prices, the colors red and green are used to attract attention (Tan, 2021). Third, when the market closes, the app background turns black (Chapkovski et al., 2021; Tan, 2021). This use of colors helps to make trading more appealing, as Robinhood's young target group is used to well-designed apps that use colors to support information (Reeck et al., 2023; Tan, 2021).

An example for a gamified app feature is confetti for a first trade on the platform (Tan, 2021). Badges for spending time on the app and motivating messages in the language style of the popular reddit.com community r/wallstreetbets are further gamified elements (Chapkovski et al., 2021; Tan, 2021). The community r/wallstreetbets is a thread in the online forum reddit.com, where retail investors exchange knowledge and give advice on buying or selling certain financial products (Chapkovski et al., 2021). Some neo brokers even show leaderboards where users can see their peers' performance (Fleming et al., 2022). The use of social comparison can create competition and thus help platforms to motivate their users to trade more often and to buy riskier products (Fleming et al., 2022). Moreover, personalized push notifications lead some users to visit the platform ten times per day (Fleming et al., 2022; Tan, 2021). For a referral, customers can receive a free stock that they scratch off a digital lottery ticket (Chapkovski et al., 2021; Tan, 2021). Robinhood has removed the confetti feature from its platform due to persistent criticism, but the other gamified elements are still in place (Langvardt & Tierney, 2021; McCabe, 2021).

The neo broker Robinhood has also added risky products such as cryptocurrencies and margin trading to their platform, offering further game-like add-ons (Tan, 2021). As they have economic value, they cannot be considered elements of a choice architecture (Thaler &

Sunstein, 2008). Nevertheless, they also contribute to frequent and potentially speculative trading (Tan, 2021).

Beyond classifying the described features as gamification, some researchers even consider them as elements of gamblification (Newall & Weiss-Cohen, 2022). Gamblification describes the use of design features borrowed from gambling, such as promising large wins or encouraging a high frequency of use (Fleming et al., 2022; Newall & Weiss-Cohen, 2022). This can result in people losing money and suffering from gambling-caused illnesses such as anxiety or depression (Newall & Weiss-Cohen, 2022).

In summary, these gamified or potentially gamblified elements can cause riskier investment behavior, such as frequent and more speculative trading (Chapkovski et al., 2021; Newall & Weiss-Cohen, 2022). Thus, the outcome of the choice architecture manipulations on neo brokers is likely to harm investors (Chapkovski et al., 2021; Tan, 2021).

2.8.3 Design features as elements of a choice architecture

To further illustrate in which way the outlined design features can be seen as elements of a choice architecture, we will categorize them into a framework. This helps us to transfer the findings from the reviewed interdisciplinary research to a marketing perspective and analyze the design elements through a choice architecture lens.

The taxonomy by Münscher et al. (2016) stems from the domain of behavioral decision making and focuses on the concrete design of choice architecture interventions. It includes three categories: *Decision information*, *decision structure*, and *decision assistance*, that reflect different streams in the research of decision making. Techniques that belong to the category ‘Decision information’ deal with how available information is displayed to decision-makers, without changing the options themselves. This includes translating available information into a more comprehensible format, making certain information explicitly visible or providing individuals with social reference points. ‘Decision structure’ involves choice architecture

interventions that change how options are arranged (i.e., what is displayed). The techniques in this category include the design of defaults, changing the effort required to (de)select an option, modifying the range of options as well as the consequences of choosing them. ‘Decision assistance’ comprises techniques that further support individuals with making a decision. These can come in the form of reminders or the facilitation of individuals’ commitment to a choice (Münscher et al., 2016).

According to these descriptions and the previously outlined characteristics of neo brokers’ interface design, we made a categorization that is displayed in Table 1. It demonstrates the variety of choice architecture elements used on neo brokers that might have the power to influence investors’ behavior. Following the evidence of previous research, we assume that this influence results in negative consequences for investors.

Table 1

Application of Münscher et al.’s (2016) taxonomy

Category	Technique/ subtype	Specification on neo brokers
Decision information	Simplification	Display of only five stock indicators
	Framing	Colors red and green for stock price fluctuations, black background when market closes
	Feedback	Confetti; motivational messages; badges
Decision structure	Provide social reference point	Leaderboards with information about peers’ investments
	Change range of options	“Top Movers” with few stocks is presented as a pre-selected list to choose from
	Change grouping of options	“Best” and “worst” performers are grouped in lists
Decision assistance	Change option-related effort	Making a trade takes fewer clicks than cancelling a trade; swipe-up gesture to buy a stock
	Provide reminders	Personalized push notifications remind investors to carry out activities

Note. The application of Münscher et al.’s taxonomy allows a categorization of the identified design features as elements of a choice architecture. Taxonomy retrieved from “A Review and Taxonomy of Choice Architecture Techniques,” by R. Münscher et al. 2016, *Journal of Behavioral Decision Making*, 29: 511–524. Copyright 2015 John Wiley & Sons, Ltd.

3. Theoretical foundation

In the previous section, we have summarized research showing that the choice architecture of neo brokers can lead to negative consequences for investors. We aim to gain a better understanding of the factors at play in this effect. This includes examining whether there is a direct relationship between the choice architecture techniques and an increased trading frequency. We also aim to understand on which group of investors the manipulated choice architecture elements have the strongest influence, given that the financial literacy of investors can play an important role in their decision-making (Allgood & Walstad, 2016; Lusardi & Mitchell, 2014). Approaching the issue from a marketing perspective allows us to build on a theoretical basis from the field of consumer decision-making. Specifically, we will refer to mechanisms in the psychology of human decision-making, which the concept of nudging is based on.

3.1 Psychological foundations of nudges and sludges

Influential research in behavioral sciences has shown that humans do not act (fully) rationally when making decisions, as assumed in mainstream economics (Simon, 1955). Rather, it was shown that individuals have bounded rationality, which means that their ability to make entirely rational decisions is limited (Simon, 1955). This is due to cognitive constraints (such as biases, limited time and incomplete information) and contextual factors (Simon, 1955; Tversky & Kahneman, 1974). Nudges and sludges take advantage of the latter to change people's behavior in a predictable way, guiding them towards a choice, without making any options unavailable (Thaler & Sunstein, 2008).

More precisely, the underlying theoretical assumption of the nudge concept is the “dual structure of the human mind” (Thaler & Sunstein, 2008). The highly influential dual-process theory by Stanovich & West (2000) distinguishes between two systems of thinking: *System I*

is intuitive and automatic, whereas *System II* is reflective and rational. In other words, the automatic system can be considered fast, the reflective system slow (Kahneman, 2011). System II requires a high processing effort and allows to complete mentally challenging tasks like evaluating the criteria of complex decisions (Kahneman, 2011). Therefore, it seems intuitive to address System II when trying to persuade individuals to change their behavior. For instance, by providing a large amount of information or clear economic incentives that will make them adopt the desired attitude (Abrahamse et al., 2005). However, it has been shown that these tools are not necessarily effective in changing how people act, because there is what is called an “intention-behavior gap” (Sheeran, 2002). While providing information is relevant for decision-making, it does not suffice to change behavior, because this is often an intuitive process (Lehner et al., 2016). Plainly stated, it is impossible for humans to always employ the demanding System II because they are busy, and the world around them is highly complex. People simply do not have the capacity to deeply contemplate every decision (Thaler & Sunstein, 2008). Instead, individuals often rely on System I, which uses *heuristic thinking* by relying on past experiences, biases, and emotional aspects. The use of such mental shortcuts eases an individuals’ cognitive load and facilitates thinking at a higher speed while requiring less energy (Kahneman, 2011). While the heuristics pertaining to automatic thinking can be useful in many cases (for example when making simple and repetitive decisions), they can also impact decision-making negatively. “Rules of thumb” can lead to systematic errors in logic, probability, or rational choices when making complex judgments or decisions that require effortful thinking (Tversky and Kahneman, 1974).

This is what behavioral interventions tie into: Because the automatic system is highly susceptible to even small environmental aspects, the context in which individuals make a decision has a significant impact on its outcome. Thus, in order to nudge or sludge people towards making a certain choice, it is possible to leverage their heuristic thinking by designing

a choice architecture in a way that will increase the likelihood of this choice (Thaler & Sunstein, 2008). By appealing to System I, nudges overcome the assumption that it is always necessary to change attitudes in order to change behaviors (Lehner et al., 2016).

3.2 Choice architecture impact on investors

Choice architecture interventions are effective in places where decisions are infrequent or difficult, there is no quick feedback, and there is uncertainty regarding the choice's effect (Thaler & Sunstein, 2008). Based on what was outlined in the previous section, the stock market is a complex and uncertain environment. In that sense, it fits this description very well. As described, there is a variety of sludges on neo brokers that potentially influence investor behavior towards a high trading frequency, which generally bears negative consequences (Barber et al., 2009, 2022; Barber & Odean, 2000).

Due to the fact that a given sludge can invoke different cognitive processes, it is not meaningful to provide theoretical explanations of specific linear relationships between sludges and psychological mechanisms (Münscher et al., 2016). In other words, several intervention techniques can be associated with several cognitive processes (Münscher et al., 2016). However, it is appropriate to outline some main considerations on decision-making processes that concern the categories of the framework by Münscher et al. (2016), which we employed to classify the identified sludges. We will now theoretically discuss the potential impact of some of the techniques included in these categories that were identified on neo brokers.

First, choices can be influenced by the manner in which *decision information* is presented to an individual (Münscher et al., 2016). Simplifications can improve the balance between the available information and an investors' information-processing capabilities. An overload of difficult information can lead to errors in judgment and even deter individuals from making a decision (Jacoby, 1984). Therefore, simplifying information can be especially effective when complexity is high, as in the case of decisions concerning financial products

(Sunstein, 2014). Presenting information in a manner that activates certain values and attitudes of decision-makers, such as using green and red colors to indicate stock performance, is another technique called framing (Lehner et al., 2016). It can influence individuals' subjective evaluations of the presented options (Loke, 1989). Furthermore, various elements on neo brokers give users feedback, e.g., when they receive non-monetary rewards such as badges for their activities. Because individuals usually do not receive information on the consequences of their behavior in decision processes, giving them feedback can improve their ability to make a choice, as it positively affects attention and processing (Münscher et al., 2016). Finally, it is useful to provide people in decision-making processes with information on what others are doing (Melnyk et al., 2019). By providing features that present the activities of their peers to investors, neo brokers invoke descriptive social norms that can serve as important points of orientation (Cialdini et al., 1990). This could potentially lead them to behave similarly, e.g., buy certain stocks because others also did.

Second, the choice architecture of neo brokers also contains elements that direct the *decision structure* of investors (Münscher et al., 2016). Presenting a low range of options, like in the “Top Movers” list, can be used to avoid overwhelming investors (Johnson et al., 2012). The mental effort of having to evaluate a high number of options can lead individuals to not choosing any option at all (Johnson et al., 2012). At the same time, the number of alternatives has to be carefully chosen, as too few options bear the risk of not matching the preferences of all investors (Johnson et al., 2012). The grouping of options, i.e., into “Best” and “Worst” also plays a role in facilitating decision making. When individuals do not have fixed preferences before choosing an option, they develop their preferences over the course of the decision process, which means that the sets of available options can strongly influence choices (Chang & Liu, 2008; Slovic, 1995). Another factor related to the decision structure is the effort necessary to choose an option (Münscher et al., 2016). Neo brokers' choice architecture is

strongly characterized by the absence of frictions; it is easy to create an account, to transfer money on this account, and making a trade can require a gesture as easy as swiping up on the screen (Tan, 2021). Therefore, there are very low barriers to carrying out investments on the platforms, which might increase the likelihood of investors to choose a stock to buy (Barber et al., 2022; Münscher et al., 2016; Tan, 2021).

Third, choice architectures can provide *decision assistance* to individuals in order to support them with following through with their intentions (Münscher et al., 2016). A technique that belongs to this category and is observable on neo brokers is the provision of reminders in the form of push notifications (Chapkovski et al., 2021). Reminders can make the information they contain more salient and accessible in the minds of individuals, increasing the likelihood of this information guiding their decisions and behavior (Münscher et al., 2016). Therefore, reminders are another element that can attract investors to frequently perform trading activities on the platform.

To summarize, choice architectures of neo brokers take advantage of various techniques that have the potential to facilitate and guide decision-making. The overarching theme resulting from the previous paragraphs is that the platforms seem to aim to make investment decisions as easy as possible. This makes sense, because a high number of trades caters towards the business model of neo brokers (Elsas et al., 2022). However, as pointed out earlier, frequent trading generally has negative financial consequences for investors, which is why the outlined choice architecture elements should be considered sludges (Barber et al., 2009, 2022; Barber & Odean, 2000). Having explained the potential psychological impact of the identified elements on investors, we hypothesize:

H1: The most common sludges on neo brokers lead to a higher trading frequency.

We do not distinguish between the effects of different sludges, as this would exceed the scope of the paper. Instead, we examine the combined effect of frequent sludges on neo brokers.

This also corresponds to the experience users have on neo broker apps, as they are exposed to multiple sludges at once. These were explained in Table 1 and are further specified below in Table 2.

3.3 Heterogenous effects depending on knowledge

After hypothesizing on the effect that sludges on neo brokers might have on average on investors, we will now consider the heterogeneity of this group. As we outlined earlier, an important finding of current research is that the effect of a nudge or sludge depends on the population it is directed at, as well as the context (Bryan et al., 2021). The context is described by the kind of choice architecture manipulation used and the kind of promoted behavior (Mrkva et al., 2021).

The characteristics of investors on neo brokers were outlined earlier, with an emphasis on how their financial literacy can influence their behavior. When it comes to financial decisions, specifically, research has shown that a high level of objective financial literacy can mitigate the negative effect of heuristic biases on individuals' judgment (Ahmad & Shah, 2022). In other words, more domain knowledge can improve information processing and therefore prevent errors in judgment. We aim to add to this stream of research by examining the moderating effect of financial literacy on sludges in the context of neo brokers.

For this purpose, we will draw on the research model employed by Mrkva et al. (2021), who found that financial literacy moderates nudge (sludge) effects. We extend their theoretical line of reasoning regarding consumer behavior to the context of retail investing, which is appropriate because consumer behavior and financial investment choices are closely linked (Thaler, 1980). Lim et al. (2016) argue that both fields investigate individual decision-making using elements of psychology and sociology, which is why the application of consumer behavior constructs in the financial context is a fruitful approach.

Mrkva et al. (2021) explain that knowledge affects consumer behavior, because a lower ability to deal with information in consumption contexts elicits anxiety and decision uncertainty, which in turn lead to consumers having more unstable preferences. As opposed to stable ones, uncertain preferences can more easily be influenced by heuristic thinking (Chernev et al., 2015; Huh et al., 2014; Hutchinson & Alba, 1991). This is in line with dual process theories of information processing (Kahneman, 2011; Stanovich & West, 2000). Since investment decisions are complex and often limited in time, it can be argued that individuals with low financial literacy performing activities in the stock market can lack adequate cognitive capacity (e.g., Martelli, 2017). Hence, following the theoretical considerations outlined in the beginning of this section, they are also more likely to engage in heuristic processing when exposed to choice architectures in the investment context. This can be observed, e.g., in their increased proneness to attention biases, which was covered earlier. For the outlined reasons, we expect that sludges on neo brokers will have a stronger effect on investors with low financial literacy than on investors with high financial literacy. We therefore introduce the following hypotheses:

H2a: High objective financial literacy will weaken the effect of the most common neo broker sludges on trading frequency.

H2b: Low objective financial literacy will strengthen the effect of the most common neo broker sludges on trading frequency.

We emphasized the objective nature of financial literacy in these hypotheses, since Mrkva et al. (2021) pointed out the need to examine the role of subjective vs. objective knowledge. Financial literacy has been proven to influence individuals' decisions in both its subjective and its objective form. Self-assessed financial knowledge can be equally important as actual knowledge in understanding people's financial behavior (Allgood & Walstad, 2016). Therefore, considering both forms of financial literacy is an avenue to better understanding the

moderating effect of knowledge on sludge effects. Aiming to extend the model by Mrkva et al. (2021), we therefore hypothesize:

H3a: High subjective financial literacy will weaken the effect of the most common neo broker sludges on trading frequency.

H3b: Low subjective financial literacy will strengthen the effect of the most common neo broker sludges on trading frequency.

3.4 The role of financial literacy overconfidence

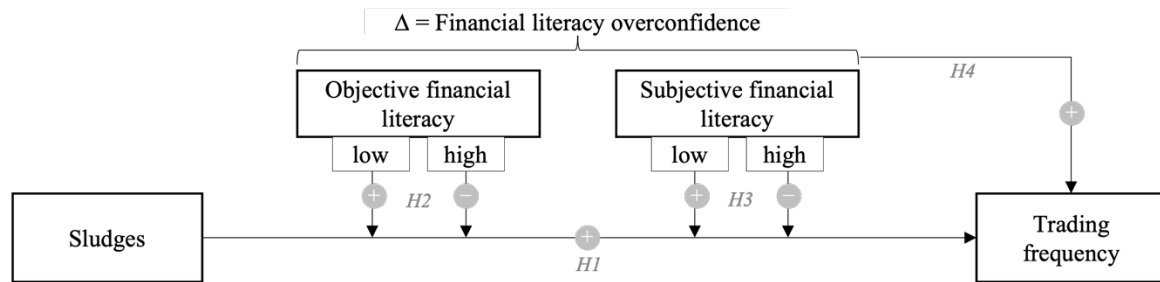
Financial literacy has been thoroughly researched as an aspect that influences individual financial decision-making (e.g., Lusardi & Mitchell, 2014; van Rooij et al., 2011). Nevertheless, it is not the only factor that shapes the behavior of investors. Many aspects such as numerous psychological biases can interfere with their ability for sound judgment based on knowledge (Martelli, 2017). While a high level of objective financial literacy generally leads to better decisions, this positive effect can be overridden if investors rely more on their automatic than their reflective thinking style (Glaser & Walther, 2014). In addition, when investors perceive their knowledge as higher than it factually is, they are subject to financial literacy overconfidence, the delta between subjective and objective financial literacy (Xia et al., 2014). This predicts participation in the stock market (Xia et al., 2014). As this constitutes a relevant aspect regarding the role of financial literacy, we will also incorporate it in our study. Its underlying theoretical considerations will be described in the following.

While there are numerous potential drivers for overconfidence, research has often linked the overestimation of one's abilities to the *illusion of knowledge* and the *illusion of control* (Barber & Odean, 2002; Odean, 1999; Skala, 2008). The illusion of knowledge plays a role since especially in the digital realm, there is an abundance of data available (Barber & Odean, 2002). It describes the phenomenon where people mistakenly assume that their predictions improve the more information they take into account (Barber & Odean, 2002; Hall

et al., 2007). In the worst case, overconfidence leads people to assume that their information is valuable, while they actually do not have any information at all (Odean, 1999). The illusion of control is the overestimation of being in control, i.e., the belief that one can influence events, even if these events in fact only depend on chance (Taylor & Brown, 1988). Hence, the illusion of control is most likely to occur when control is low, which is true in the context of the stock market (Moore & Healy, 2008).

The overconfidence resulting from overestimating one's objective knowledge is associated with risky behaviors (Barber & Odean, 2001; Grinblatt & Keloharju, 2009). Therefore, we believe that it is necessary to state a fourth, competing hypothesis. This hypothesis competes with H2 a/b and H3 a/b because it does not assume that knowledge can alleviate harmful effects of sludges on individuals. Rather, considering the concept of overconfidence, it predicts that higher perceived (subjective) financial literacy leads to an even stronger effect of sludges. We expect that an investor who is already inclined to frequent trading due to an overestimation of knowledge might engage in this behavior even more when sludged to do so.

H4: Financial literacy overconfidence will strengthen the effect of sludges on trading frequency.

Figure 1*Research model*

Note. Our research model shows the direct effect of neo broker sludges on trading frequency (H1). The examined moderators are objective (H2 a/b) and subjective financial literacy (H3 a/b), as well as financial literacy overconfidence (H4). Financial literacy overconfidence is the delta between subjective and objective financial literacy.

The research model of this study (Figure 1) builds on the one employed by Mrkva et al. (2021) and illustrates the relationships that were hypothesized in this section.

4. Method

Our method section outlines the scientific research approach and research design. Then, the data analysis is explained, before finally analyzing data quality.

4.1 Scientific research approach

The aim of the study is to examine the effect of neo broker sludges on investors' trading frequency, and to understand whether financial literacy moderates this relationship. For this purpose, a deductive research approach has been used (Bryman et al., 2019). The hypotheses are based on well-established theory, as described in the previous theory section. Based on what was outlined, we aim to analyze new relationships between existing concepts. We operationalize these concepts and measure them in an experiment, which allows us to draw conclusions about the theoretical assumptions that led to our hypotheses (Bryman et al., 2019).

This type of quantitative statistical inference approach based on empirical data is typical to the domain of choice architecture research (Mertens et al., 2022).

Conducting an experiment allows us to analyze the direct link between the most common neo broker sludges on trading frequency, by randomizing participants into groups and holding all other factors aside from the choice architecture constant (Bryman et al., 2019). By rigorously planning the data collection in this way, we aim to achieve precise measurements and a high internal validity. In addition, this approach allows us to generate a considerable amount of data, which is critical, as differences between individuals related to psychological factors that influence consumer decision-making may be small (Bryman et al., 2019).

4.2 Research design

Before conducting the experiment, we preregistered it with AsPredicted. The form can be found at <https://aspredicted.org/r85gh.pdf> and in Appendix C. In conducting the survey, we changed the title of our study because it better matched the emerging focus of our topic. We also specified in the hypotheses H2 a/b and H3 a/b that we are referring to the most common sludges on neo brokers. Other than that, the preregistration was adhered to.

4.2.1 Data collection and sample

We collected data through an online survey using Qualtrics. Respondents accessed the survey through a link shared in our personal networks, which is why our participants constituted a convenience sample. To incentivize participation, respondents could participate in a lottery with the chance to win one of two 10 EUR Amazon gift vouchers upon completion of the survey.

The sample size was pre-determined by a power analysis using the tool G*Power 3.1 (linear multiple regression: fixed model, R^2 deviation from zero) which established that a sample size of $N = 138$ would be sufficient for our analysis (Faul et al., 2007, 2009). To ensure

that we had sufficient data if responses had to be excluded, we collected $N = 300$ responses between March 14th and March 19th, as specified in our preregistration. Thus, we concluded that our sample size was sufficient.

Regarding sampling criteria, we did not set fixed quotas for geographics, gender, age, stock market experience and income for simplification. We included an attention check to filter for valid responses only. Responses from people below the age of 18 were excluded, as most countries require a minimum age of 18 to trade stocks (Brandon, 2021; *bpb*, 2023). Apart from that, our target population was not restricted, as neo brokers can be accessed by people from different age groups, countries, income levels and different levels of financial experience.

In total, 15 respondents had to be excluded, 8 of which did not accept the GDPR guidelines and 6 of which failed the attention check and 1 who was below the age of 18 years. Through randomization, $n = 145$ were allocated to the traditional broker group and $n = 140$ to the neo broker group.

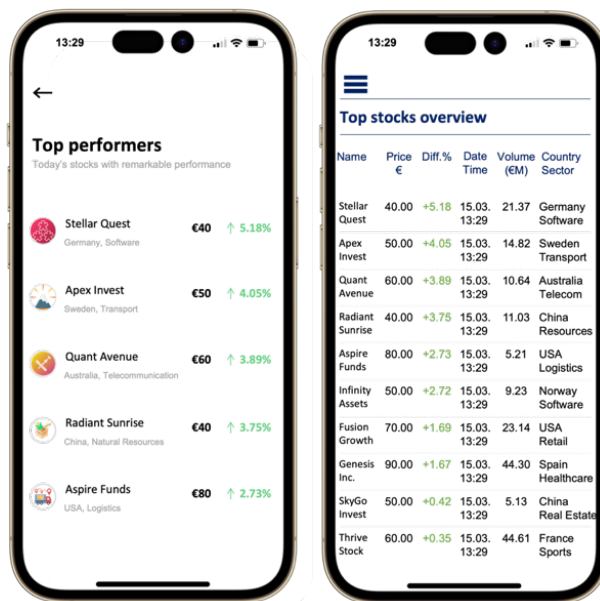
4.2.2 Survey design

Our experimental design was a single factor between-subjects experiment executed via a Qualtrics survey (Bryman et al., 2019). The entire survey can be found in Appendix B. Before beginning the questionnaire, participants were asked for their consent to the GDPR regulations. The first questions covered the moderators of first subjective and then objective financial literacy, as well as previous stock market participation. We measured the moderators before the dependent variable in order to avoid posttreatment bias because it was likely that the financial literacy measures would be affected by the experimental manipulation (Montgomery et al., 2018). Within the objective financial literacy scale, we included an attention check to ensure that participants carefully proceeded through the questions. There were no further attention checks after this as the trading simulation itself produced error messages when participants did not follow the instructions.

Upon starting the trading simulation, participants were then given detailed instructions explaining that they had been gifted 500 EUR by a family member to invest in fictitious stocks as part of a simulation. We decided to use windfall money (an unexpected financial gain) for the endowment, being aware that windfall vs. earned endowments lead to different spending behaviors, because the amount spent by participants was not relevant for our analysis (Carlsson et al., 2013). The instructions stated that the goal was to increase the received amount of money by investing as much or as little as the participant wanted in a maximum of four rounds. Subsequently, participants were randomized in one of the two groups and exposed to the according stimulus material, which will be described in the following.

Figure 2

Screenshots in first trading round



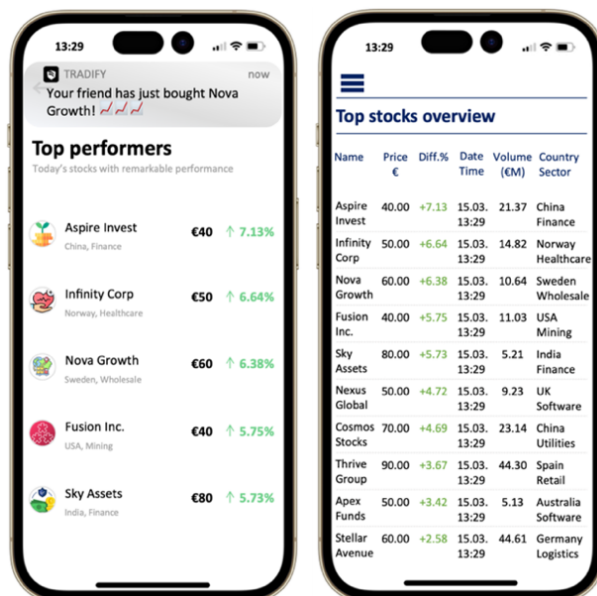
Note. Neo broker group (left) and traditional broker group (right). Choice architecture techniques in neo broker screenshot: simplification, low range of options.

The material for both groups consisted of images from smartphone screens, displaying fictional stockbrokers. These imitated the user interface design of a traditional bank (traditional broker group) and a neo broker (neo broker group) respectively. Before choosing design elements, we reviewed existing examples of such applications and replicated their typical

features to provide realistic representations of both brokers (traditional brokers: DKB, Commerzbank, Comdirect; neo brokers: Robinhood, Trade Republic, eToro). First, participants were presented a screenshot of a welcome interface to their respective broker app. Then, in each trading round, they were shown a screenshot of a list with the fictitious top stocks of the day (Figure 2 and 3). Below the screenshot, participants saw the same list again, this time as a buying interface with input fields to enter the amount of money in EUR to be invested next to each stock.

Figure 3

Screenshots in third trading round



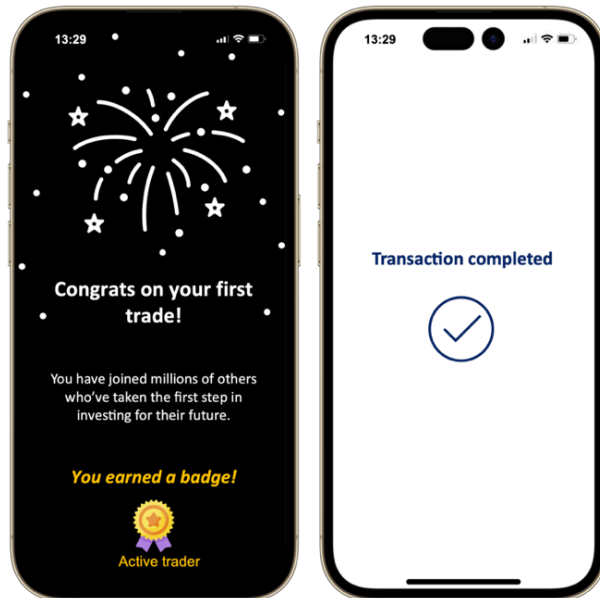
Note. Neo broker group (left) and traditional broker group (right). Choice architecture techniques in neo broker screenshot: simplification, low range of options, reminder, social reference point.

Alternatively, it was possible to choose the option “I do not want to invest in any stocks” in each round, which ended the simulation and lead participants directly to the manipulation check items. Every round the available stocks changed to create a new choice set where participants had to decide whether to invest or not. When participants chose to invest, they were shown a screenshot that confirmed their transaction (Figure 4) and were subsequently

shown their current balances (amount of money not invested, amount of money invested this round, stock value development) so they could keep track.

Figure 4

Confirmation screens after first trading round



Note. Neo broker group (left) and traditional broker group (right). Choice architecture technique in neo broker screenshot: feedback.

Profits and losses

All participants received a positive performance for each of their investments (Factor 1.1 in round 1, 1.05 in round 2, 1.1 in round 3, 1.1 in round 4). Although this is not a realistic representation of the actual stock market, we decided to refrain from including additional conditions assigning profits and losses to avoid insufficient power for analysis. We chose this approach to ensure that the variable of return was kept constant between groups, since it has a large influence on investment behavior and controlling for it on a rounds basis would have added unnecessary complexity to our analysis (Odean, 1998; Weber & Camerer, 1998).

Sludges in neo broker group

We included sludges from the categories of decision information, structure, and assistance in the stimulus material of the neo broker group (Münscher et al., 2016). The digital

sludges we designed are typical for neo brokers, as described in the literature section (e.g., Barber et al., 2022; Chapkovski et al., 2021; Chaudhry & Kulkarni, 2021; Tan, 2021). Table 2 illustrates the concrete choice architecture interventions we employed and where they were used (entire survey in Appendix B).

Table 2

Operationalization of sludges

Category (Münscher et al., 2016)	Technique (Münscher et al., 2016)	Concrete intervention	Location
Decision structure	Change range of options	Reduced choice set (vs. traditional broker group)	All trading screens, buying interface
Decision information	Simplification	Less information (vs. traditional broker group)	All trading screens, buying interface
	Social reference point	Push notification (social)	Trading screen round 4
	Feedback	Playful illustration and motivational message	All confirmation screens
	Feedback	Achievement badge	Confirmation screens 1,3,4
	Feedback	Motivational thank you screen	Next to trading screen round 4
Decision assistance	Reminder	Push notification	Trading screen round 2

Note. Choice architecture categories and techniques, their concrete design in our study, and on which screenshots in the trading simulation they are located.

After completing the trading simulation, either by choosing not to invest in any stocks in a given round or by proceeding through all four rounds, participants were asked questions that checked the effect of the manipulation. Subsequently, they were asked to provide information about the demographic variables gender, age, nationality, education, and gross household income. Finally, we thanked them for their participation and provided some information about the background of our research.

4.2.3 Measures

Independent variable

The independent variable was the experimental group. As outlined above, the neo broker group was shown stimulus material containing sludges during the trading simulation,

while the traditional broker group was not. In the analysis, we incorporated the independent variable as a dummy variable, with 0 = traditional broker group, 1 = neo broker group.

Manipulation check

After completing the trading simulation, participants were shown three different screenshots. The two groups were respectively given the screenshots that they had previously seen in the simulation. With three items, we measured whether the manipulation (being sludged) was successful, using a 7-point Likert scale, ranging from 1 = fully disagree to 7 = fully agree (items in Table 3). As the three items measured different constructs, inter-item reliability was not relevant (Cronbach, 1951). Therefore, we did not calculate Cronbach's alpha.

Table 3

Manipulation check items

Technique	Screenshot	Question
	Neo broker group	
Change range of options, simplification	Trading round 1	"The screenshot above contains a lot of information."
Feedback	Trade confirmation round 2	"The screenshot above looks motivating, fun and exciting, just like a mobile game."
Social reference point, reminder	Trading round 3	"There is information on the screenshot that invites me to behave like a friend"
	Traditional broker group	
-	Trading round 1/2/3/4	"The screenshot above contains a lot of information."
-	Trade confirmation round 1/2/3/4	"The screenshot above looks motivating, fun and exciting, just like a mobile game."
-	Trading round 1/2/3/4	"There is information on the screenshot that invites me to behave like a friend"

Note. For each screenshot we tested whether the applied techniques (Münscher et al., 2016) were effective.

Dependent variable

The dependent variable was trading frequency. Participants could complete zero to four trading rounds. Each round was coded with a dummy variable, 1 = trade made and 0 = no trade made. Thus, the dependent variable was a sum between zero and four for each participant.

Moderators

We measured subjective financial literacy via the single item “*Please rate how you would describe your overall financial knowledge*” on an 8-point Likert scale ranging from 1 = very low to 8 = very high (Allgood & Walstad, 2016). The variable was successfully measured in this way in previous studies, which is why we assumed sufficient quality in terms of reliability and validity (Allgood & Walstad, 2016; Lusardi & Mitchell, 2014).

Objective financial literacy was measured via eight items that we selected from Lusardi’s well-accepted scale for financial literacy, including four items about basic financial knowledge and four items about advanced knowledge (Lusardi, 2008; Lusardi & Mitchell, 2014; van Rooij et al., 2011). Each item had four single choice answer options, one of which was correct and which included one option that read “Don’t know / Refuse to answer” (Lusardi, 2008; Lusardi & Mitchell, 2014; van Rooij et al., 2011). A correct answer was coded with one, an incorrect answer or refusal with zero, and the results were subsequently summed. The scale showed an internal consistency of $\alpha = .73$, which is considered acceptable (Cronbach, 1951).

Financial literacy overconfidence was not measured but computed as the delta between subjective and objective financial literacy (Xia et al., 2014). When there was no difference, participants had correctly estimated their financial literacy and in case of a negative delta, they had “financial literacy underconfidence”. We excluded all deltas smaller or equal to zero ($n = 212$) as our focus was overconfidence. Due to the low number of participants exhibiting overconfidence ($n = 73$), our results could not clearly measure whether financial literacy overconfidence strengthens the effect of sludges on neo brokers.

Covariates

Previous stock market participation was measured with the single item “*Have you ever invested in the stock market before?*” with the possible answers “yes” = 1, “no” = 0, and “don’t know/refuse to answer” = 0. We measured gross annual household income on an 11-level

interval scale with 10,000 EUR steps, with the last step being “more than 100,000 EUR”. Because we did not geographically restrict our sample, we could not mirror an income distribution, instead ensured a scale level with equal distances that allowed us to include the variable in our regression. Age was measured via an open text field, nationality could be selected via a dropdown list, and the answer options for gender were “male”, “female”, “other”, and “prefer not to say”.

4.3 Data analysis

The dataset was first examined for missing data, duplicates, as well as outliers. We did not make any further exclusions than those preregistered and mentioned in the sample description. All our analyses were conducted in SPSS 29.0.

In order to check the success of our manipulation, we conducted independent samples t-tests to investigate differences in the means between the neo broker and traditional broker group (e.g., Field, 2009). To analyze the link between our independent and dependent variables, we used a multiple regression analysis. This method for statistical inference allows to assess the degree to which variation in a single result variable can be explained by two or more predictor variables (Field, 2009). Specifically, for H2-H4, we employed moderation analyses to test for interaction effects, which occur when the relationship between the dependent variable and one independent variable depends on the level of another independent variable (i.e., our moderators). For the moderation analyses, we used the “PROCESS” tool in SPSS, which facilitates observed variable OLS and logistic regression path analyses (Hayes, 2022). We will elaborate on the exact model employed in the results section.

After the main analysis, we conducted further exploratory analyses. For this we again conducted several moderation analyses, using the “PROCESS” tool in SPSS (Hayes, 2022).

4.4 Descriptive statistics

In our study, the sample exhibited a large variety of ages, educational backgrounds, gross household incomes, and nationalities. The detailed description of our sample can be found in Table 4.

Table 4

Sample description

Category	Characteristic	Value
Previous investment experience	Yes	201
	No	84
Gender	Female	109
	Male	170
	Prefer not to say	4
	Missing	2
Age	Mean	31.41
	Standard deviation	12.82
	Minimum	19
	Maximum	88
	Missing	34
Education	High school degree	39
	Bachelor's degree or comparable	127
	Master's degree or comparable	108
	PhD or higher	10
	Missing	1
Gross household income	0 - 10,000€	39
	10,000 - 20,000€	49
	20,000 - 30,000€	36
	30,000 - 40,000€	0
	40,000 - 50,000€	32
	50,000 - 60,000€	38
	60,000 - 70,000€	0
	70,000 - 80,000€	22
	80,000 - 90,000€	9
	90,000 - 100,000€	7
	More than 100,000€	23
	Prefer not to say	30
Nationality	Total number of represented nationalities	29
	Germany	155
	United States	35
	Sweden	17
	Other	44
	Missing	34

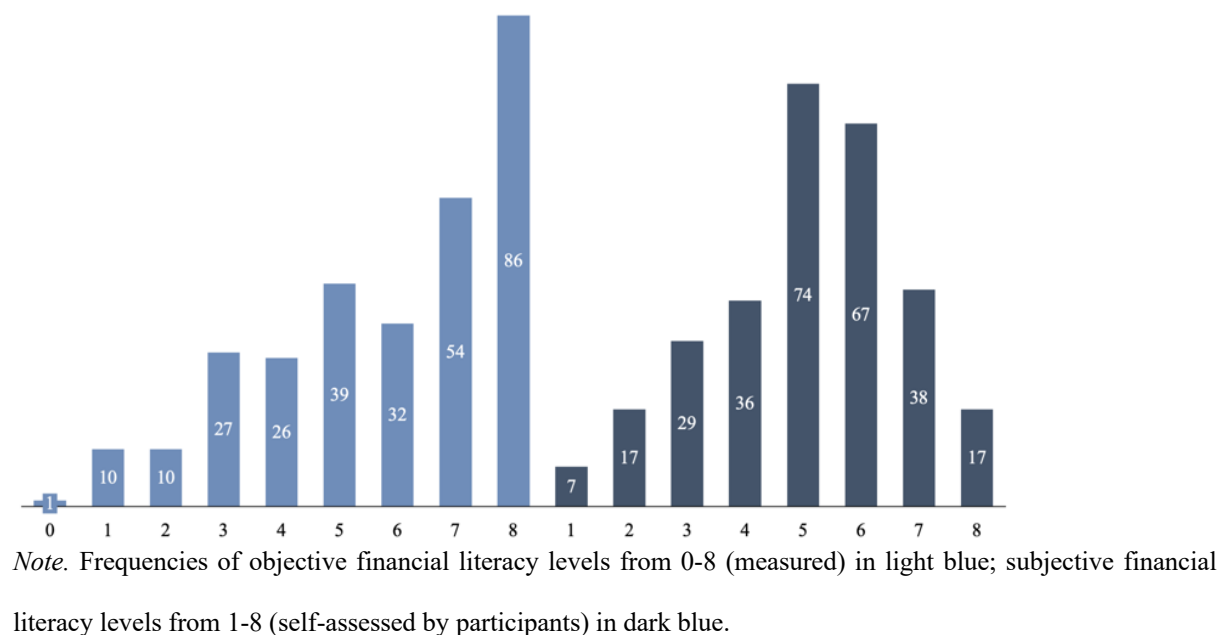
Note. Value indicates *n* unless stated otherwise.

Average trading frequency was 53% higher for neo brokers. Participants in neo broker group traded on average 53% more rounds than participants in the traditional broker group without controlling for other effects (Table 5, Appendix A). The difference was significant at the 99.9% significance level ($t = -4.01$) (Appendix A).

Regarding financial literacy, objective financial literacy ($Mean = 5.85$, $SD = 2.08$) was slightly higher than subjective financial literacy ($Mean = 5.07$, $SD = 1.67$). A detailed overview can be found in Figure 5. Financial literacy overconfidence was exhibited by 73 participants. 164 people showed „underconfidence“, and 48 participants estimated their financial literacy correctly. This shows that few participants were overconfident.

Figure 5

Frequencies of financial literacy levels



4.5 Data quality

To ensure the trustworthiness of the results of quantitative studies, it is important to discuss the implications of the methodological approach for validity and reliability. Especially with regard to generalizability of findings, transparency with regard to data quality is essential (Bryman et al., 2019)

4.5.1 Reliability

Reliability refers to the degree of consistency of a study, which indicates whether it would generate the same results when repeated (Bryman et al., 2019). The first measure we took towards this is reporting in detail how the study was conducted in the above sections, which facilitates replication. We planned the steps of our study carefully beforehand, preregistered it on AsPredicted for further transparency and adhered to data collection standards. Second, the multi-item scale we used for objective financial literacy was tested for reliability. Cronbach's alpha (> 0.7) revealed that there was sufficient inter-item consistency (Cronbach, 1951).

4.5.2 Validity

Construct validity

A high degree of construct validity refers to the accurate measurement of constructs (Rosenthal & Rosnow, 2008). The multi-item scale we used for objective financial literacy has been tested and validated in previous studies, also in combination with the single-item question of self-reported financial knowledge (Allgood & Walstad, 2016; Lusardi & Mitchell, 2014; van Rooij et al., 2011). A similar trading simulation was conducted by Fleming et al. (2022). However, due to the novelty of this research field, large parts of the stimulus material and resulting manipulation check items were designed independently by us. Although the measurements did not suffer from many outliers and revealed the success of our manipulation, the use of these items might constitute a possible limitation to the construct validity of this study. The use of our stimulus material in future research could further validate these measures.

Internal validity

Internal validity requires that causal relationships in an experiment can actually be attributed to the manipulation (Rosenthal & Rosnow, 2008). One of the factors contributing to internal validity is that our experiment follows a between-subjects design, where participants were

randomly allocated to two groups (Bryman et al., 2019). Experimental instructions and questions were identical for both groups, with the only difference being the stimuli they were exposed to in their respective group. We held the factor of profit constant, where each participant received the same percentage of return on their investment in each round. However, it was up to the participants to decide how much they would invest, which subsequently influenced the amounts displayed in their fictional account balance. In the trade-off between making the scenario as realistic as possible and holding all factors constant, we decided that stock investments without different prices and amounts would harm our external validity too much. However, we cannot exclude that different balances did not influence trading frequency as well.

External validity

External validity describes the extent to which findings are generalizable to other settings and individuals (Bryman et al., 2019). The stimulus material was designed to strongly resemble real-world application interfaces. Our scenario description was also carefully formulated to be as realistic as possible, so participants could easily imagine the situation. Furthermore, we provided login and confirmation screens in addition to the trading screens, which imitated the use of an application in real life. In the individual trading rounds, the top lists of stocks changed, which would also be the case when using a broker app at different points in time. Although our version was as sophisticated as possible in lab conditions, it is still possible that participants would behave differently in the field.

4.5.3 Robustness

For robustness, we included covariates into each analysis. We controlled for age, gender, gross household income and previous stock investment experience. Age and gender were included as they can both have a significant influence on financial behavior and literacy (Lusardi & Mitchell, 2011). The same applied to income (Lusardi & Mitchell, 2014). We included previous investment experience as it can be a proxy for financial literacy (van Rooij

et al., 2011). Throughout all analyses the observed results remained the same with covariates included.

5. Results

For our quantitative data analysis, we first describe the results of the manipulation checks, which were derived via independent samples t-tests. Subsequently we present the test results of H1, which were analyzed with a multiple regression model and an independent samples t-test. We then report the results of H2 a/b, H3 a/b and H4 which we explored with a moderator analysis. Finally, we describe further exploratory analyses.

5.1 Manipulation check

Following, we examined whether the sludges in our experiment were also subjectively perceived as intended by our participants. We tested the results of our manipulation check via independent samples t-tests. For the first check (effect of simplification and low range of options), we observed a significant difference between the traditional broker ($Mean = 3.56$, $SD = 1.85$) and neo broker group ($Mean = 4.74$, $SD = 1.76$), indicating that participants in the neo broker group perceived the amount of information to be higher at the 99.9% significance level ($t = -5.43$). This result indicates the success of the manipulation.

With the second check we tested the effect of the feedback sludge on the confirmation screen. Since Levene's test showed inequality of variance in this case ($p < .05$), the more robust Welch's t test results were interpreted (Delacre et al., 2017). They presented a significant difference between the traditional broker ($Mean = 3.54$, $SD = 1.84$) and neo broker group ($Mean = 5.22$, $SD = 1.66$), revealing that participants in the neo broker group perceived the screenshot as more gamified than participants in the traditional broker group at the 99.9% level ($t = -8.10$). Thus, the manipulation was successful.

With the third test we examined the effect of the social reference point sludge. The traditional broker ($Mean = 2.82$, $SD = 1.76$) and neo broker group ($Mean = 4.74$, $SD = 1.88$) again exhibited significant differences, confirming that participants in the treatment group did feel more invited to behave like their friends at the 99.9% level ($t = -8.86$).

5.2 Analysis of hypotheses

Hypothesis 1

Before fitting our regression model, we investigated whether our data met the required assumptions. First, the measured values needed to be independent, which was ensured by a randomization approach. Second, we examined the requirement of normal distribution of residuals. A Breusch Pagan test of our model indicated that the null hypothesis of homogeneity of variances had to be rejected ($p < .05$), which is why we conducted a regression with heteroskedasticity-robust standard errors in SPSS. We checked the resulting heteroskedasticity-consistent coefficients against the linear regression coefficients obtained with the OLS estimators. The deviations were not substantial, indicating that the conclusions of the OLS regression were not compromised by heteroskedasticity (see Appendix A). Third, we examined whether there was multicollinearity by examining the variance inflation factors (VIF) in the model. The resulting VIF values were slightly above 1, and only $VIF > 5$ are problematic (Ziegler, 2016) (see results in Appendix A). Thus, multicollinearity did not pose a problem for our analysis.

To test H1, we conducted a linear multiple regression analysis. We gradually included predictors and conducted individual regressions for each model (Table 5). Regression I containing the full factor set was statistically significant at the 99.9% level ($F(5, 217) = 5.90$ $p < .001$). Thus, H1: *The most common sludges on neo brokers lead to a higher trading frequency*, was not rejected. Overall, 12% of the variance could be explained by the model including all predictors ($R^2 = .12$). Cohen's f^2 was 0.14, indicating a small to medium effect size (Cohen,

1969). Our analysis showed a higher trading frequency for participants in the neo broker group. Trading frequency was also higher for participants with investment experience and for females. Young people and participants with more income also traded more. Thus, sludges on neo brokers, previous stock investing experience and gender were significant explanatory factors for trading frequency, whereas income ($B = .05, p = .49$) and age ($B = -.12, p = .109$) were not statistically significant. Sludges on neo brokers had the strongest influence on trading frequency ($B = .70, p < .001$). Previous investing in the stock market also positively influenced trading frequency ($B = .63, p = .005$), as well as gender, where female investors traded more ($B = .53, p = .011$).

Table 5

Overview of regressions H1

Explanatory variables/ statistics	Regr. I	Regr. II	Regr. III	Regr. IV	Regr. V	Regr. VI	Regr. VII	Regr. VIII	Regr. IX
Group	.70*** [3.52]	.58*** [3.06]	.60*** [3.28]	.70*** [3.91]					.73*** [4.01]
Invest. exp.	.63*** [2.83]	.74*** [3.55]	.67*** [3.33]	.57*** [2.88]				.61*** [3.01]	
Gender	.53** [2.57]	.51** [2.58]	.42** [2.24]				.40** [2.11]		
Age	-.02 [-1.61]	-.01 [-1.03]				-.01 [-.71]			
Income	.02 [.70]				-.01 [-.26]				
Intercept	1.15*** [3.48]	1.06*** [3.51]	.81*** [3.97]	1.0*** [5.40]	1.77*** [10.12]	2.01*** [7.77]	1.59*** [13.3]	1.31*** [7.75]	1.38*** [10.85]
R ²	.12	.11	.10	.08	.00	.00	.02	.03	.05
Adj. R ²	.10	.09	.08	.07	.00	.00	.01	.03	.05
<i>p</i>	<.001	<.001	<.001	<.001	.792	.478	.036	.003	<.001

Note. Regression results (H1) to derive the influence of different predictors on trading frequency. Each cell contains the B and [t-value]. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Hypotheses 2a and 2b

Hypotheses 2 a/b stated that objective financial literacy moderates the effect of sludges on trading frequency. We expected that high objective financial literacy would weaken the effect of sludges on trading frequency (H2a), whereas low knowledge was expected to strengthen it (H2b). To test this effect, a moderator analysis was performed using the

PROCESS macro model number 1. We checked for multicollinearity by examining the variance inflation factors (VIF) in the model. The resulting values were all slightly above 1 and thus not problematic (Ziegler, 2016) (see Appendix A). A Breusch Pagan test revealed heteroskedasticity, which is why we conducted a regression with robust standard errors. Checking the resulting heteroskedasticity-consistent coefficients against the linear regression coefficients obtained with the OLS estimators showed that the deviations were not substantial (Hayes & Cai, 2007) (see Appendix A). Therefore, the conclusions of the moderator analysis were not compromised by heteroskedasticity. The model employed a bootstrapping approach to evaluate the significance of the effects at differing levels of the moderator. Using the PROCESS macro v4.2 by Andrew F. Hayes in SPSS with bias-corrected 95% confidence intervals ($n = 5000$), we tested the significance of effects moderated by objective financial literacy (Hayes, 2022). The dependent variable was trading frequency and the predictor variable was the group (neo broker vs. traditional broker). As covariates we included gender, age, income, and previous investment experience. The model explained a significant proportion of variance in trading frequency, $R^2 = .17$, $F(7, 215) = 6.12$, $p < .000$. However, the interaction between objective financial literacy and sludges on neo brokers was not statistically significant ($B = .07$, $Bse = .10$, $t = .76$, $p = .449$, CI $[-.12; .26]$). Thus, a participant's objective financial literacy did not significantly moderate the effects of sludges on trading frequency and Hypotheses 2a and 2b were rejected.

Hypotheses 3a and 3b

Hypotheses 3 a/b stated that subjective financial literacy moderates the effect of sludges on trading frequency. We expected high subjective financial literacy to weaken the effect (H3a), whereas low subjective financial literacy to strengthen it (H3b). Using the same PROCESS macro v4.2 by Andrew F. Hayes in SPSS with bias-corrected 95% confidence intervals ($n = 5000$), we tested the significance of effects moderated by subjective financial

literacy (Hayes, 2022). Multicollinearity was again not problematic as all variance inflation factors were all slightly above 1 (Ziegler, 2016) (see Appendix A). We again tested for heteroskedasticity and concluded as in H2 a/b that it would not negatively impact the moderator analysis (see Appendix A). The dependent variable was trading frequency, the predictor variable was the group, and the moderator variable was objective financial literacy. We again included all covariates from the model for H1.

The model also explained a significant proportion of variance in trading frequency, $R^2 = .13$, $F(7,215) = 4.55$, $p < .001$. However, the interaction between subjective financial literacy and sludges on neo brokers was not statistically significant ($B = .05$, $Bse = .12$, $t = .43$, $p = .667$, CI $[-.18; .28]$). Therefore, subjective financial literacy did not have a significant moderating effect on the relationship between sludges on neo brokers and trading frequency and hypotheses 3 a/b were rejected.

Hypothesis 4

Hypothesis 4 stated that financial literacy overconfidence will strengthen the effect of sludges on trading frequency. As explained in the method section, the variable was computed as the delta between subjective financial literacy and objective financial literacy. Subsequently, we recoded the variable, so it only accounted for positive values, i.e., overconfidence, because we did not hypothesize on underconfidence or a correct estimation of knowledge. To examine whether financial literacy overconfidence moderated the relationship between sludges on neo brokers and trading frequency, another moderator analysis with an identical approach as the analyses for H2 a/b and H3 a/b was conducted. Again, the examination of multicollinearity did not raise any concerns since all VIFs were smaller than 2 (Ziegler, 2016) (see Appendix A). We also tested for heteroskedasticity and concluded as before that it would not invalidate the moderator analysis (see Appendix A). As before, the dependent variable was trading frequency and the predictor variable was the group. We included all covariates from the basic model in

H1, and the moderator variable used was financial literacy overconfidence. The model explained a significant proportion of variance in trading frequency, $R^2 = .34$, $F(7, 42) = 3.07$, $p < .05$. Nonetheless, the interaction between financial literacy overconfidence and treatment group did not reveal a statistically significant effect ($B = -.09$, $Bse = .25$, $t = -.38$, $p = .706$, CI $[-.60; .41]$). Therefore, H4 had to be rejected. Financial literacy overconfidence did not moderate the effects of sludges on trading frequency.

Table 6

Moderator analysis for H2 a/b, H3 a/b and H4

Explanatory variables/ statistics	H2 a/b			H3 a/b			H4		
	<i>B</i>	<i>SE</i>	<i>t</i>	<i>B</i>	<i>SE</i>	<i>t</i>	<i>B</i>	<i>SE</i>	<i>t</i>
Intercept	1.27	.33	3.88***	1.09	.34	3.24***	.81	.72	1.12
Group	.73	.19	3.81***	.70	.20	3.55***	.30	.36	.80
Invest. exp.	.37	.23	1.60	.73	.23	3.23***	.57	.43	1.35
Gender	.44	.20	2.18**	.47	.21	2.24**	.02	.46	.04
Age	-.01	.01	-1.40	-.02	.01	-1.64	-.01	.03	-.23
Income	.03	.03	.80	.03	.03	.85	-.01	.08	-.18
Obj. fin. lit.	.13	.07	1.86*						
Subj. fin. lit.				-.11	.08	-1.41			
Fin. lit. overc.							-.39	.18	-2.11
Group x obj. fin. lit.	.07	.09	.76						
Group x subj. fin. lit.				.05	.12	.43			
Group x fin. lit. overc.							-.09	.25	-.38
R^2			.41			.36			.58
Adj. R^2			.17			.13			.34
<i>p</i>			.0000			.0001			.0106

Note. Moderator analyses results. Each model explains a significant proportion of the variance in trading frequency, but the results indicate no significant moderation effects. For each hypothesis the B, standard error and t-value is given. P-values are shown as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.3 Exploratory analyses

For the exploratory analysis, we split the dataset into various groups to explore potential results for sub-samples. For the two dummy variables gender and previous stock investing experience, we split the data into two groups respectively. For gender, we split the data into female and male, and for previous stock investing experience, we split it into experience and no experience. For the continuous variable income, we split the data into quartiles. We decided to split the data for the continuous age variable into two groups instead of quartiles. This was

due to the fact that the first and second quartile only contained people aged 19-24 and 25-26 and the third and fourth quartile people aged 27-33 and 34-88. Thus, the explanatory power of these groups would not have been given. The same applied to the variable education, where we also decided on a split into two groups. The first group contained people with a high school or Bachelor's degree/ comparable and the second group people with a Master's degree/ comparable or a PhD or higher.

We again used the PROCESS macro v4.2 by Andrew F. Hayes in SPSS with bias-corrected 95% confidence intervals ($n = 5000$). For each of the previously defined groups, we conducted moderator analyses with trading frequency as the dependent variable and the experimental group as the predictor variable. We conducted one analysis per moderator (objective financial literacy, subjective financial literacy, and financial literacy overconfidence), which resulted in three analyses per sub-group. We also included all covariates from the model into each analysis, except for the one used for each respective sample split. In total, we thus conducted 35 further moderator analyses (see Appendix A). None of the performed analyses with sufficient power returned significant effects. Thus, objective, and subjective financial literacy as well as financial literacy overconfidence did not moderate the relationship between sludges on neo brokers and trading frequency in the sub-samples.

In addition, we conducted further exploratory analyses using previous stock investment experience as a moderator (see Appendix A). We considered this to be appropriate as previous investment experience has commonly been used as a proxy for objective financial literacy (van Rooij et al., 2011). The groups defined beforehand as well as the dependent variable and predictor remained the same in these analyses. In total, we conducted 10 further analyses, examining the effect of this moderator for each sub-group. For the lowest quartile in income (up to 20,000 EUR gross household income, 83 people) the analysis showed significant effects. 22% of the variance could be explained by the model ($R^2 = .22$, $F(5, 77) = 4.44$, $p < .01$).

Previous investment experience moderated the relationship between sludges on neo brokers and trading frequency. This was statistically significant at the 99% level ($t = -3.17, p = .002$). Participants with no experience traded more on the neo broker than on the traditional broker. Thus, sludges on neo brokers increased the trading frequency of inexperienced people from the lowest income group.

6. Discussion

Before discussing the results of the study, we will briefly summarize our findings and how they contributed to answering our research question: *May sludges on neo brokers increase trading frequency?*

The results of this study, consistent with previous research, revealed that sludges on neo brokers had a significant positive effect on investors' trading frequency (H1). As opposed to the findings of Mrkva et al. (2021), our study did not find support for the moderating effect of objective or subjective financial literacy (H2 a/b and H3 a/b). However, an exploratory analysis of the sample in the lowest income quartile revealed that previous experience in the stock market moderated the effect of the sludges on trading frequency. Participants who reported never having invested in the stock market displayed a significantly higher trading frequency in the neo broker group than in the traditional broker group. Finally, our study did not show that financial literacy overconfidence strengthened the effect of sludges on trading frequency (H4).

6.1 Effect of neo broker sludges on trading frequency

The results of the conducted study found support for hypothesis 1: The most common sludges on neo brokers did lead to a higher trading frequency. Participants who were exposed to the neo broker interface traded significantly more than those who were presented the interface of a traditional broker. This is consistent with various studies, which identified the potentially problematic choice architecture techniques we manipulated in our study. Unlike

this paper, previous studies did not test the effects on trading frequency in an experimental setting (Ash et al., 2018; Barber et al., 2022; Chaudhry & Kulkarni, 2021; Tan, 2021). Our results suggest that the high trading frequency on neo brokers is, to some extent, due to the sludges present in the apps' user interface. In addition, our findings show that the theoretical concept of nudging (sludging) was supported in the context of retail investing on neo brokers.

Our study adds to previous research showing that choice architecture techniques have a small to medium effect on consumer behavior in different contexts (Mertens et al., 2022). An adjacent context of neo broker platforms, for example, is that of social media platforms such as Facebook. It was shown that the interfaces of the popular platforms, similar to neo brokers, also contain nudges that reduce friction (Anderson & Wood, 2021). According to Anderson & Wood (2021), the presence of these nudges supports the formation of user habits and thereby increases the likelihood of continued use of the platforms. This is in line with our findings and further supports the academic relevance of examining the effects of choice architecture techniques in digital contexts.

Most studies in the domain of choice architecture research investigate nudges, thus focus on techniques aimed at improving consumer welfare (Luo et al., 2021). While our study took the same theoretical lens, we examined the techniques as sludges, because a high trading frequency has been proven to lead to losses for retail investors (Barber et al., 2009, 2022; Barber & Odean, 2000). Assuming that investors do not intend to realize losses, their preferences might thus be disregarded by the designers of neo broker choice architectures, which goes against the purpose of nudging (Thaler & Sunstein, 2008). Our findings therefore allow us join other researchers in taking a critical position regarding the simple and gamified interface design of neo brokers. Apart from a higher trading frequency, there is also evidence about an effect regarding increased risk behavior (Chapkovski et al., 2021). Similarly, Arnold et al. (2022) demonstrated that push notifications served as attention-triggers and thereby also

led individuals to take on higher risk. Tan (2021) thus argues that the positive narrative of FinTechs contributing to the democratization should be challenged. Taking the case of Robinhood as an example, he states that there is a tension between the platforms' pursuit of profit through large trading volumes and the need to protect their investors from engaging in speculative and risky behaviors (Tan, 2021). Another account therefore even goes so far as to report a growing trend of "gamblified" investment products, describing those that borrow design features from gambling, appeal to individuals susceptible to gambling-related harm and lead most investors to realize losses (Newall & Weiss-Cohen, 2022). It is undeniable that neo brokers support formerly underrepresented groups with accessing the world of finance (Brown, 2020). Nevertheless, in accordance with the position of the outlined research, the results of our study also point to the importance of critically evaluating the platforms in terms of consumer welfare.

6.2 Moderating effect of financial literacy

Our results did not confirm hypotheses 2 a/b and 3 a/b. Thus, no moderating effect of objective or subjective financial literacy on the relationship between sludges on neo brokers and trading frequency could be detected.

Hypotheses 2 a/b – Objective financial literacy

Previous research found that the effect of nudges is weaker on knowledgeable consumers than on those with very little knowledge (e.g., Camerer et al., 2003; Mrkva et al., 2021). Suspecting that investors' knowledge might decrease the potential negative impact of sludges on them, we built on the research model by Mrvka et al. (2021) and included objective financial literacy as a moderator. This is in line with previous research that encouraged examining the boundary conditions of nudge (sludge) effects by taking into account potentially heterogenous aspects (Bryan et al., 2021). However, unlike Mrkva et al. (2021), we did not find a moderating influence of objective financial literacy on the effect of nudges (sludges).

We will discuss the potential reasons for this in the following paragraphs: First, the possibility that no moderation effect exists for the used variable. Second, that it could be considered an explanatory variable instead of a moderator. Third, key differences in our study design vs. the one by Mrkva et al. (2021) might have caused divergent findings. Finally, it is possible that further alternative variables, which were not included in our study, might be at play.

To begin with, it is possible that we had to reject H2 a/b because objective financial literacy simply does not moderate the relationship between sludges on neo brokers and trading frequency. However, there is evidence against this reason. In line with the findings of Mrkva et al. (2021), another study shows that the effect of a gamified choice architecture on risk-taking was significantly weaker for individuals with high financial literacy (Chapkovski et al., 2021). Mrkva et al. (2021) also found that apart from financial literacy, the level of financial experience had a significant influence on the effectiveness of nudges. Therefore, using previous stock investment experience as an alternative moderator for objective financial literacy in our exploratory analysis seemed appropriate.

Indeed, we found that individuals without previous stock market experience exhibited a higher trading frequency when confronted with sludges in the neo broker group. This was only the case in lowest income quartile (up to 20,000 EUR gross household income). People with a gross household income of up to 20,000 EUR belong to the lowest income quintile in Germany (where the largest share of our participants were from) (*bpb*, 2020). This fits with previous findings showing that people with relatively low income tend to have lower levels of financial literacy (Lusardi & Mitchell, 2014).

This moderation effect in the lowest income quartile is also in line with Mrkva et al.'s (2021) findings regarding socioeconomic status (SES). SES is defined by education level, income and occupation (Saegert et al., 2006), and was discovered to moderate the effect of nudges on decision accuracy (Mrkva et al., 2021). While we did not find moderation effects of

previous stock market experience in groups of different education levels, our exploratory findings did confirm a stronger impact of sludges on people with a relatively low income and no investment experience.

This raises the question whether sludges on neo brokers can potentially cause financial harm to individuals who do not have previous investment experience and already belong to a low-income group. As we established with H1, the most common sludges on neo brokers increase trading frequency. Studies found that a high trading frequency leads to on average lower returns (Barber et al., 2009, 2022; Barber & Odean, 2000). Thus, sludges on neo brokers might reduce consumer welfare especially for people in low-income brackets and a lack of experience in the stock market.

Another possible explanation for the rejection of H2 a/b is that objective financial literacy could be considered an explanatory variable instead of a moderator. Although we built on previous evidence that knowledge can moderate the effect of sludges, it can also be considered from a different perspective. Research has shown that investors' financial literacy influences their decision-making (e.g., Allgood & Walstad, 2016; Lusardi & Mitchell, 2014). There is evidence that higher financial literacy can contribute to making better financial decisions, such as participating in the stock market and diversifying one's investment portfolio (Abreu & Mendes, 2010; van Rooij et al., 2011). However, other research has revealed that in some cases, the influence of financial literacy is absent or weak, and that even the decisions of highly knowledgeable investors are rather driven by behavioral aspects (Bodnaruk & Simonov, 2015; Glaser & Walther, 2014). Taken together, objective financial literacy as an explanatory variable in our analysis might have explained the trading frequency of participants to some extent. Future studies should determine whether this is the case, and more importantly, if higher knowledge may improve investment decisions in the context of neo brokers.

Further, it is possible that the differences in our study design from the one employed by Mrkva et al. (2021) account for divergent results. Mrkva et al. (2021) found that objective financial literacy moderated the effect of default and number of options nudges. The nudges were implemented in the answer options of multiple-choice questions that each had one accurate answer (Mrkva et al., 2021). Key differences in our study therefore are the types of nudges (sludges) used in the manipulation and the dependent variable (decision accuracy vs. trading frequency). Across different areas, choice architecture manipulations that affect the decision structure are most effective compared to those targeting decision information or decision assistance (Mertens et al., 2022). Defaults, which are a technique belonging to the category of decision structure, are often found to be the most effective nudges (Beshears & Kosowsky, 2020; Hummel & Maedche, 2019; Sunstein, 2014). This is particularly true in the context of financial decisions (Hummel & Maedche, 2019). Therefore, it is also possible that we did not find a moderating effect of objective financial literacy because it rather appears for certain types of nudges (such as defaults). Since we manipulated a combination of the most common choice architecture techniques used on neo brokers, a potential moderation of the effect of individual techniques might have diffused due to the presence of other sludges.

Finally, it can be argued that trading frequency in a neo broker context is a variable that is subject to more potential influencing factors than, e.g., a variable such as decision accuracy on multiple-choice questions (as examined by Mrkva et al., 2021). The complex nature of human behavior plays a role in the effect of choice architecture techniques on behavior and can thus be a reason why findings from some experiments are not detectable in others (Lehner et al., 2016). Therefore, other heterogeneous characteristics of investors apart from financial literacy might influence the impact of sludges. One possible avenue might be to consider the goals and preferences of investors and how they are reflected in their behavior. This would be in accordance with a study by Thunström et al. (2018), which demonstrated that nudge effects

had distributional (positive or negative) consequences on individuals depending on their habitual spending patterns. In describing gamblified investment products, Newall & Weiss-Cohen (2022) mention that these products might attract people who are at risk of experiencing harm that is normally related to gambling. If neo brokers are ‘gamblified’, then it is possible that the mentality of investors on the platform leans towards speculation and risk-taking, versus the assumed risk-averse mindset typical of investors (Newall & Weiss-Cohen, 2022). Following this line of thought, it is possible that the influence of financial literacy is less important in the context of risky and short-term investing.

Hypotheses 3 a/b – Subjective financial literacy

Mrkva et al. (2021) stressed the importance of examining the role of perceived and actual knowledge on the effectiveness of nudges. In our study, hypotheses 3 a/b had to be rejected: We did not find a significant moderating effect of subjective financial literacy on the effect of neo broker nudges on trading frequency. Thus, it is possible that subjective financial literacy does not moderate this relationship. However, other reasons for the rejection of H3 a/b should be considered. We measured the variable using a single item where participants assessed their own financial literacy (Allgood & Walstad, 2016). A measure that asks individuals to provide a self-assessment of their knowledge in multiple dimensions concerning stock investments might capture the variable more accurately. When examining knowledge in the context of FinTechs, it might also be necessary to consider how well people cope with the new technology and digital infrastructure (Lyons & Kass-Hanna, 2021).

6.3 Moderating effect of financial literacy overconfidence

In our study, hypothesis 4 had to be rejected. Financial literacy overconfidence did not strengthen the effect of nudges on trading frequency. Based on previous studies, we expected that a larger proportion of our sample would be overconfident (Barber & Odean, 2002; Moore & Healy, 2008; Odean, 1999; Skala, 2008). However, only a minority exhibited overconfidence

while the majority estimated their financial literacy correctly or even was underconfident. Thus, our results cannot establish whether financial literacy overconfidence strengthens the effect of sludges on neo brokers.

We did not exclude participants from our experiment who had never used neo brokers. Thus, our sample consisted of people who might or might not be using neo brokers in real life. This was the right choice for our study, as neo brokers attract people without previous investment experience (Barber et al., 2022; Kritikos et al., 2022).

However, it also means that the proportion of people on neo brokers who exhibit financial literacy overconfidence in reality might be much higher. Trading frequency on neo brokers is higher than on other online brokers (Barber et al., 2022). Previous studies found that an increased trading frequency can indicate overconfidence (Kumar & Goyal, 2015; Odean, 1999). However, we also know that neo brokers attract people with little investment experience (Barber et al., 2022; Kritikos et al., 2022). Some studies find that overconfidence increases with experience (Gervais & Odean, 2001; Kirchler & Maciejovsky, 2002). Thus, the occurrence of overconfidence on neo brokers and how it can influence investors' trading frequency should be investigated in future studies.

Furthermore, another reason why we did not find a moderating effect of financial literacy overconfidence could be the used measure of overconfidence. Both scales we used to measure objective and subjective financial literacy are well established (Allgood & Walstad, 2016; Lusardi, 2008; Lusardi & Mitchell, 2014; van Rooij et al., 2011). However, as we did not find a moderation effect for H2 a/b (objective financial literacy) and H3 a/b (subjective financial literacy), it is possible that using the delta between subjective and objective financial literacy did not work in this context. Future studies should check this by applying other measures of financial literacy overconfidence.

6.4 Practical implications

We add to previous research on neo broker sludges (e.g., Chapkovski et al., 2021) with our finding that the most common choice architecture manipulations increase trading frequency. Due to their harmful impact, our study also points to risks for consumers, who should be better protected in this context.

A practical implication resulting from our study is that consumers should exercise caution when using neo brokers for their stock investments. Before selecting a brokerage, it can be helpful to become aware of advantages and drawbacks of the alternatives (Financial Conduct Authority, 2021). The websites of financial authorities represent valuable sources for this. For instance, the FCA in the UK published research that warns about increased risk-taking on neo brokers (Financial Conduct Authority, 2021). The Securities and Exchange Commission (SEC) in the US has launched an investigation in 2021, following a statement in which the authority raised concerns about the possibly adverse impact of some design elements (Michaels & Osipovich, 2021).

Consumers should also seek financial education before carrying out activities in the stock market to alleviate the risks associated with investing on neo brokers. Although the present study did not find a moderating effect of financial literacy, evidence from other research shows that it can alleviate the impact of sludges and generally help with making better financial decisions (Lusardi & Mitchell, 2014; Mrkva et al., 2021).

While we look at the issue in our study from a consumer perspective, ethical considerations should be considered from an institutional perspective to protect consumers. Protection from potentially harmful design elements is especially relevant, so that more vulnerable populations (such as low-income investors without investment experience) are able to make decisions in their best interest (Mertens et al., 2022). Strategies for this could be to implement regulations on providing more educational content on neo brokers, explicitly

tailored to certain groups, as well as clear information about possible risks (Tan, 2021). To do so, regulating authorities should gather data to better understand the impact of neo brokers' choice architecture (Fleming et al., 2022). Moreover, neo brokers could be incentivized to tailor gamified elements to investors' goals. This could support users with making better decisions, while also contributing to a FinTech ecosystem that is more balanced, transparent and risk-controlled (Sironi, 2016).

6.5 Limitations and future research

Methodological limitations

Our research contributes to a deeper understanding of the influence that neo brokers' choice architecture can have on investor decision-making. Nevertheless, the limitations of this study should be taken into consideration when interpreting the results.

Since we reached participants through our personal network, our data may not be uniquely generalizable due to potential selection bias. In terms of sample size, we exceeded the required number of participants determined by the conducted power analysis. However, a larger sample might have included more overconfident participants, which would have allowed a more powerful analysis of H4. In addition, participants with a college degree were overrepresented, which potentially affected the distribution of financial literacy and thus limits the representativeness of our sample.

To ensure that the measured effects are attributable only to the manipulations we made to the choice architecture in our stimulus material, we held other factors constant. Nevertheless, participants could decide how much fictional money to invest in each trading round, which affected the displayed account balance in between rounds. It is possible that this factor could have impacted the trading frequency of participants as well. Future experimental designs could overcome this limitation of internal validity by adding even more functions to the simulation.

The measures we took to make our trading simulation as similar to a real-world experience as possible were outlined in the method section. However, the type of the study as a simulation limits the generalizability of our results. It is possible that participants would exhibit different behavior in actual investment situations, since (1) the simulation was explicitly called fictional, (2) the functionality of our broker interfaces embedded in a survey did not have the same scope as an application on the market and (3) there were no real stakes (money) involved. Although our simulation was sufficiently realistic and optimized for lab conditions, future research should test the same questions in a field experiment to ensure external validity.

Finally, we did not ask participants about their experience with neo brokers. Although we do not consider this a substantial limitation, controlling for this variable might have contributed to an even more holistic interpretation of our findings. Therefore, we would recommend this to future studies focusing on the same context.

Directions for future research

Investigating the combined effect of the most common choice architecture elements on neo brokers enabled us to better understand whether the platforms bear risks for consumers. To gain an even more comprehensive picture of the factors at play and their relative importance, future research could investigate the effects of individual sludges comparatively. If certain sludges have a stronger impact than others on trading frequency, this will carry important theoretical implications for the research field concerned with the effects of choice architecture elements in different contexts. In addition, it could yield valuable practical implications for consumers and choice architecture designers that prevent consumers from suffering negative consequences. Moreover, as we focused on the most common sludges on neo brokers identified by prior research, we did not exhaustively investigate all potentially influential elements of the apps' choice architecture. Examining the impact of elements beyond those we studied could reveal important differences in user experiences across different neo broker applications. This,

in turn, could help to understand where these types of FinTechs generally stand in terms of consumer welfare.

As addressed in our discussion of H2 a/b, we also think that exploring further characteristics of investors on neo brokers might be a fruitful avenue for future research. Following Newall & Weiss-Cohen (2022), there might be a different mentality prevailing on neo brokers (i.e., one that is more risk-prone and speculative) vs. traditional brokers. Distinguishing investors in terms of their goals and preferences could therefore contribute to painting a more comprehensive picture of heterogeneous effects of choice architecture elements.

7. Conclusion

We examined the effect of the most common neo broker sludges on trading frequency, conducting an online trading simulation experiment with $N = 285$ participants. Previous studies had tested this relationship either not experimentally (Barber et al., 2022; Chaudhry & Kulkarni, 2021; Tan, 2021), with risk-taking instead of trading frequency (Chapkovski et al., 2021) or with a focus on rare app features (Fleming et al., 2022).

We also explored the boundary conditions regarding the heterogeneity of investors in terms of financial literacy. For that, we conducted three moderator analyses with objective financial literacy, subjective financial literacy, and financial literacy overconfidence as moderators. Previous research had only tested objective financial literacy as a moderator (Chapkovski et al., 2021; Mrkva et al., 2021) or stressed the importance of examining subjective financial literacy (Allgood & Walstad, 2016; Mrkva et al., 2021) and financial literacy overconfidence (Xia et al., 2014). The results of our experiment provided a deeper understanding of the factors at play. Our contributions are as follows:

We were able to analyze design elements on neo broker interfaces, that were identified in interdisciplinary research, from a marketing perspective. By employing appropriate theoretical concepts and methods from choice architecture research, we analyzed the impact of

sludges on trading frequency in an experiment. The results revealed that sludges on neo brokers increased trading frequency by 53 percent when controlling for previous investment experience, gender, age, and gross household income.

Considering the heterogeneity of investors, we did not find moderating effects for objective and subjective financial literacy, as well as financial literacy overconfidence. Nevertheless, our exploratory findings demonstrated that with previous investment experience as a moderator, low-income investors without experience traded significantly more due to their exposure to sludges than those with experience.

These findings led us to valuable implications. From a theoretical perspective, we can confirm that the concept of sludging is applicable to the context of neo brokers. We encourage future research in consumer-decision making to also examine design features on FinTech apps from a choice architecture perspective. Moreover, our exploratory findings support the notion that it is worth examining the heterogeneous effects of nudges and sludges to better understand potentially distributed effects on consumers. In the context of neo brokers, an interesting avenue for future research would be to examine the effects of choice architecture techniques depending on different investor goals and preferences.

From a practical perspective, our findings have led us to joining other researchers and public institutions in taking a critical viewpoint regarding the impact of neo brokers on consumer welfare (Barber et al., 2022; Chapkovski et al., 2021; Chaudhry & Kulkarni, 2021; Dagley et al., 2020; Elsas et al., 2022; Tan, 2021). Retail investors, especially those who have a low income and are not familiar with the stock market, should be made aware of the risks associated with neo brokers. Public institutions should introduce measures in the interest of consumers. There have already been some efforts to regulate sludges (e.g., gamification) on neo brokers (Dagley et al., 2020; Elsas et al., 2022). In addition to these existing attempts,

further measures should be taken to better protect consumers e.g., by regulating the use of sludges on neo brokers.

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VI. Appendix

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A. Statistical tables

Table 1

Variable overview

Construct	Variable name	Description	Values
Manipulation check			
Sludges (change range of options, simplification)	MCHECK1	Perceived amount of information on screenshot	After inversion: [low $\Leftrightarrow$ high] 1,2,3,4,5,6,7
Sludges (feedback)	MCHECK1	Perceived gamification of screenshot	[low $\Leftrightarrow$ high] 1,2,3,4,5,6,7
Sludges (social reference point, reminder)	MCHECK1	Perceived gamification of screenshot (social)	[low $\Leftrightarrow$ high] 1,2,3,4,5,6,7
Independent variables			
Previous investment experience	Invest. exp.	Reported previous participation in the stock market	[yes, no, don't know/ refusal] 1,0,0
Subjective financial literacy	Subj. fin. lit.	Reported subjective financial knowledge	[low $\Leftrightarrow$ high] 1,2,3,4,5,6,7,8
Objective financial literacy	Obj. fin. lit	Objective financial knowledge [Sum index finlit_obj_q1 + finlit_obj_q2 + finlit_obj_q3 + finlit_obj_q4 + finlit_obj_q5 + finlit_obj_q6 + finlit_obj_q7 + finlit_obj_q8]	[correct, incorrect, don't know/ refusal] 1,0,0 Max. 8 Min. 0

Financial literacy overconfidence	Fin. lit. overc.	Delta between subjective financial literacy and objective financial literacy, negative values excluded	[low $\Leftrightarrow$ high] 1,2,3,4,5,6,7,8
Experiment group	Group	Traditional broker group and neo broker group	[traditional broker, neo broker] 0,1
Gender	Gender	Reported gender	[male 0, female 1]
Gross household income	Income	Reported gross household income	[low $\Leftrightarrow$ high] 1,2,3,4,5,6,7,8,9,10,11 [0 -10,000€; 10,000 - 20,000€; 20,000 - 30,000€; 30,000 - 40,000€; 40,000 - 50,000€; 50,000 - 60,000€; 60,000 - 70,000€; 70,000 - 80,000€; 80,000 - 90,000€; 90,000 - 100,000€; More than 100,000€]
Age	Age	Reported age	
Dependent variable			
Trading frequency	Trad. freq.	Completed trading rounds	0,1,2,3,4

Table 2

Manipulation checks – Independent t-test results for both groups

Measure	Traditional broker group		Neo broker group		<i>t</i>	df	Two-sided <i>p</i>	Cohen's <i>d</i>
	<i>M_T</i>	<i>SD_T</i>	<i>M_N</i>	<i>SD_N</i>				
MCHECK1	3.56	1.85	4.74	1.76	-5.43	275	<.001	-.64
MCHECK2	3.54	1.84	5.22	1.66	-8.10 ^a	280.21	<.001	-.96
MCHECK3	2.82	1.76	4.74	1.88	-8.86	281	<.001	-1.05

Note. Welch's *t* test due to unequal variances, as Levene's test at *p* = .007.

Table 3*Linear regression for H1**Model Summary*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.346 ^a	.120	.099	1.43854

Note. Predictors: (Constant), Age, Group, Invest. exp., Gender, Income; Dependent Variable: Trad. freq.

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	61.033	5	12.207	5.899	<.001 ^b
	Residual	449.056	217	2.069		
	Total	510.090	222			

Note. Dependent Variable: Trad. freq.; Predictors: (Constant), Age, Group, Invest. exp, Gender, Income.

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.153	.332		3.478	<.001
	Group	.691	.196	.228	3.519	<.001
	Invest. exp.	.629	.222	.187	2.829	.005
	Gender	.527	.205	.172	2.571	.011
	Income	.023	.033	.051	.698	.486
	Age	-.015	.010	-.115	-1.607	.109

Note. Dependent Variable: Trad. freq.

Table 4*Linear regression with heteroskedasticity robust standard errors for H1**Coefficients*

	Value	Std. Error	t
(Intercept)	1.071	.361	2.970
Group	.750	.214	3.509
Invest. exp	.688	.242	2.841
Gender	.550	.223	2.467
Income	.021	.036	.591
Age	-.016	.010	-1.494

Note. rlm(formula = Trad. freq. ~ Group+Invest. exp.+Gender+Income+Age, data = dta, na.action = na.exclude, method = "MM", model = FALSE); Residual standard error: 1.62105; Degrees of freedom: 217.

Table 5*Independent t-test results for both groups for H1*

Measure	Traditional broker group		Neo broker group		<i>t</i>	df	Two-sided <i>p</i>	Cohen's <i>d</i>
	<i>M_T</i>	<i>SD_T</i>	<i>M_N</i>	<i>SD_N</i>				
Trad. freq.	1.38	1.43	2.11	1.63	-4.00	275.44	<.001	-.48

Note. Welch's *t* test due to unequal variances, as Levene's test at *p* = .003.

Table 6*Breusch Pagan test results**ANOVA*

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	47.098	5	9.420	2.618	.025 ^b
	Residual	780.874	217	3.598		
	Total	827.972	222			

Note. Breusch Pagan test results showing heteroskedasticity as *p* < 0.05.; Dependent Variable: sqres; Predictors: (Constant), Age, Group, Invest. exp., Gender, Income.

Table 7*Multicollinearity test for H1 regression**Coefficients*

Model		Collinearity Statistics	
		Tolerance	VIF
1	Group	.962	1.039
	Invest. exp.	.925	1.081
	Age	.799	1.252
	Income	.767	1.304
	Gender	.909	1.101

Note. Dependent Variable: Trad. freq.

Table 8*Multicollinearity test for H2 a/b moderator analysis*

<i>Coefficients</i>		<i>Collinearity Statistics</i>	
Model		Tolerance	VIF
1	Group	.958	1.043
	Invest. exp.	.816	1.225
	Age	.794	1.259
	Income	.767	1.304
	Gender	.891	1.122
	Obj. fin. lit.	.872	1.146

Note. Dependent Variable: Trad. freq.**Table 9***Multicollinearity test for H3 a/b moderator analysis*

<i>Coefficients</i>		<i>Collinearity Statistics</i>	
Model		Tolerance	VIF
1	Group	.962	1.039
	Invest. exp.	.842	1.187
	Age	.799	1.252
	Income	.759	1.318
	Gender	.869	1.150
	Subj. fin. lit	.820	1.219

Note. Dependent Variable: Trad. freq.**Table 10***Multicollinearity test for H4 moderator analysis*

<i>Coefficients</i>		<i>Collinearity Statistics</i>	
Model		Tolerance	VIF
1	Group	.930	1.076
	Invest. exp.	.794	1.260
	Age	.700	1.429
	Income	.793	1.261
	Gender	.836	1.196
	Fin. lit. overc.	.845	1.183

Note. Dependent Variable: Trad. freq.

Table 11*Results of exploratory moderator analyses with subsamples*

Subsamples		Group x Obj. fin. lit.	Group x Subj. fin. lit.	Group x Fin. lit. overc.	Group x Invest. exp.
Age	1 st half	.01 [.09]	.12 [.75]	.03 [.05]	-.42 [-.72]
	2 nd half	.09 [.57]	-.02 [-.13]	.01 [.05]	-.95 [-1.49]
Gender	Female	-.10 [-.56]	-.13 [-.66]	-.69 [-1.60]	-.72 [-1.12]
	Male	.13 [1.18]	.28 [1.73]	.14 [.46]	-.24 [-.35]
Invest. exp.	Yes	.12 [.95]	.23 [1.44]	.23 [.61]	n.a. ^b
	No	.19 [1.15]	-.06 [-.32]	-.32 [-.89]	n.a. ^b
Income	1 st quartile	.03 [.20]	.13 [.63]	.64 [1.14]	-2.11*** [-3.17]
	2 nd quartile	.12 [.73]	-.14 [-.81]	.14 [.33]	.50 [.65]
	3 rd quartile	-.02 [-.09]	.28 [.52]	n.a. ^a	-.21 [-.18]
	4 th quartile	-.06 [-.12]	.15 [.44]	.11 [1.00]	-.33 [-.45]
Education	High school/ Bachelor's degree	.11 [1.00]	-.08 [-.52]	.13 [.49]	-.92 [-1.66]
	Master's degree/ PhD	.23 [-1.11]	.28 [1.36]	-.83 [-2.44]	-.14 [-.18]

Note. Exploratory moderator analyses results. Each cell contains the unstandardized beta and [t-value]. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.; a. No data due to insufficient sample size.; b. No data as moderator cannot be the same as subsample.

B. Survey in Qualtrics

1 – Welcome screen

Welcome to our study!

We are conducting this survey as part of our Master's Thesis at the Stockholm School of Economics. It takes about 5-7 minutes to complete. You can choose to end the survey at any time by closing your browser window.

After you completed the survey, we will give you some information about the purpose of our research.

If you want to take part in the competition for one of two 10€ Amazon vouchers, please enter your e-mail address at the end of the survey.

If you have any questions, you are welcome to contact us at 42071@student.hhs.se.

Thanks a lot for contributing!
Paulina Grittner & Marie-Line Paul

21 – GDPR consent form

GDPR information

The student's project. As an integral part of the educational program at the Stockholm School of Economics, enrolled students complete an individual thesis. This work is sometimes based upon surveys connected to the subject. Participation is naturally entirely voluntary, and this text is intended to provide you with necessary information that may concern your participation in the study. You can at any time withdraw your consent and your data will thereafter be permanently erased.

Confidentiality. Anything you state in the survey will be held strictly confidential and will only be made available to supervisors, tutors and the course management team.

Secured storage of data. All data will be stored and processed safely by the SSE and will be permanently deleted when the project is completed.

No personal data will be published. The thesis is written by the students will not contain any information that may identify you as a participant.

Purpose of this study. The data gathered throughout this survey will be used to analyze the main elements in our thesis.

Your rights under GDPR. You are welcome to visit <https://www.hhs.se/en/about-us/data-protection/> in order to read more and obtain information on your rights related to personal data.

If you have any questions regarding this study or wish to withdraw your answers, please contact 42071@student.hhs.se.

I have read the information above and consent to take part in this study

No thank you I do not consent to take part in this study

2 – Subjective financial literacy

How would you assess your overall financial knowledge?

Financial knowledge describes e.g., planning budgets, knowing how to manage and pay off debt, and being able to choose between different loans and investment products.

1 (very low)	2	3	4	5	6	7	8 (very high)
-----------------	---	---	---	---	---	---	------------------

3 – Objective financial literacy (incl. attention check and question about previous investment experience)

Suppose you had €100 in a savings account and the interest rate is 20% per year and you never withdraw money or interest payments. After 5 years, how much would you have on this account in total?

More than 200€

Exactly 200€

Less than 200€

Do not know/ refuse to answer

Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?

More than today

Exactly the same

Less than today

Do not know/ refuse to answer

Assume a friend inherits €10,000 today and his sibling inherits €10,000 3 years from now. Who is richer because of the inheritance?

My friend

His sibling

They are equally rich

Do not know/ refuse to answer

Suppose that in the year 2024, your income has doubled and prices of all goods have doubled too. In 2024, how much will you be able to buy with your income?

More than today

The same

Less than today

Do not know/ refuse to answer

Here is an attention task for you, just to make sure that you continue to read all questions carefully. Please select the number eight below.

12

19

8

5

Which of the following statements describes the main function of the stock market?

The stock market helps to predict stock earnings

The stock market results in an increase in the price of stocks

The stock market brings people who want to buy stocks together with those who want to sell stocks

None of the above

Do not know/ refuse to answer

Which of the following statements is correct? If somebody buys the stock of firm B in the stock market:

He owns a part of firm B

He has lent money to firm B

He is liable for firm B's debts

None of the above

Do not know/ refuse to answer

Considering a long time period (for example 10 or 20 years), which asset normally gives the highest return?

Savings accounts

Bonds

Stocks

Do not know/ refuse to answer

When an investor spreads his money among different assets, does the risk of losing money:

Increase

Decrease

Stay the same

Do not know/ refuse to answer

Have you ever invested in the stock market (stocks, mutual funds, etc.)?

Yes

No

Do not know/ refuse to answer

4 – Introduction to trading simulation

Thank you for your replies and welcome to the investment simulation!

Please imagine the following scenario: You just **received 500€ as a gift** from a family member for the **purpose of investing** it in stocks. You can now **buy fictional stocks to ideally increase the 500€ you received**. Do **not spend more than the 500€** across all rounds.

The investment simulation will take place **in several rounds**. In each round, you will be **shown a list of stocks** and given the opportunity to buy them. There is **no time constraint**. You are free to invest **as many times as you wish**, you do not have to invest the entire amount. You can decide to **stop at any time** by selecting “I do not want to invest in any stocks”, **or to invest in each round**. In this case, the experiment will automatically end after 4 rounds. After each round, you will **see how much money you have left and the value of your portfolio**.

The **decisions you make in each round are independent** of each other, which means that you do not have to worry about the performance of your stocks throughout the rounds. You will **only buy** stocks and not sell them. Our measures **can therefore not judge your personal performance** as an investor, and you are **not competing** against other participants.

Please note that you will work with a **very reduced version of a stockbroker**. Stock performances are **not related to the current real world** market situation.

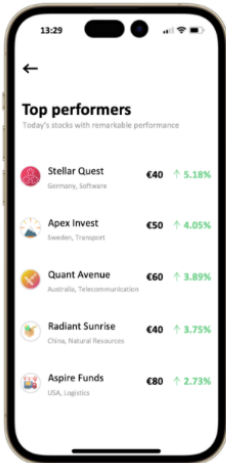
5 – Trading simulation neo broker

You have just logged into your stockbroker app Tradify.



Round 1

Look at this overview of today's top performing stocks in your broker and decide how much of your 500€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it. For example, to buy 2 stocks of Stellar Quest, you would enter 80€ into the field, because one costs 40€ as displayed in the overview.



Stellar Quest [Price: 40.00]	0
Apex Invest [Price: 50.00]	0
Quant Avenue [Price: 60.00]	0
Radiant Sunrise [Price: 40.00]	0
Aspire Funds [Price: 80.00]	0
Total	0

I do not want to invest in any stocks

6 – Trading simulation traditional broker

You have just logged into your stockbroker at Silver Oak Bank.



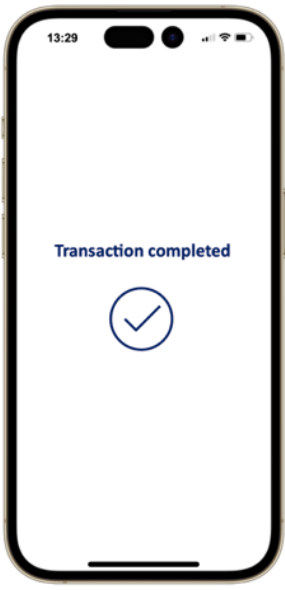
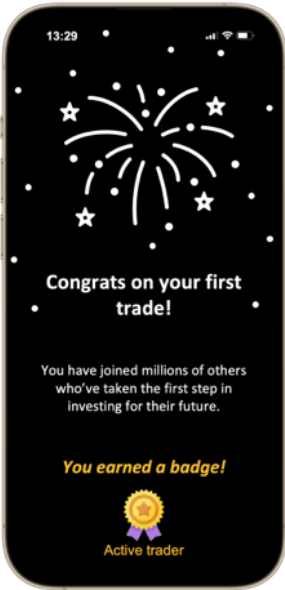
Round 1

Look at this overview of today's top performing stocks in your broker and decide how much of your 500€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it. For example, to buy 2 stocks of Stellar Quest, you would enter 80€ into the field, because one costs 40€ as displayed in the overview.



Stellar Quest [Price: 40.00] Marketplace: Best-execution Order type: Market order]	0
Apex Invest [Price: 50.00] Marketplace: Best-execution Order type: Market order]	0
Quant Avenue [Price: 60.00] Marketplace: Best-execution Order type: Market order]	0
Radiant Sunrise [Price: 40.00] Marketplace: Best-execution Order type: Market order]	0
Aspire Funds [Price: 80.00] Marketplace: Best-execution Order type: Market order]	0
Infinity Assets [Price: 50.00] Marketplace: Best-execution Order type: Market order]	0
Fusion Growth [Price: 70.00] Marketplace: Best-execution Order type: Market order]	0
Genesis Inc. [Price: 90.00] Marketplace: Best-execution Order type: Market order]	0
SkyGo Invest [Price: 50.00] Marketplace: Best-execution Order type: Market order]	0
Thrive Stock [Price: 60.00] Marketplace: Best-execution Order type: Market order]	0
Total	0

I do not want to invest in any stocks



Continue to the next page to see your account balance and returns.

Your depot now looks like this: You have **460€** left that are not invested. This round you chose to invest **40€**. The stocks you bought this round have increased in value and are now worth **44€**.

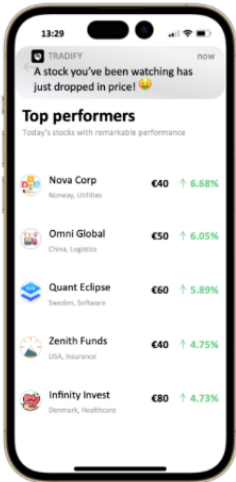
By going to the next page, you will enter the next round and can continue to invest. If you want to stop investing now, go to the next page and select the option "I do not want to buy any more stocks".

Round 2

Look at this overview of today's top performing stocks in your broker and decide how much of your remaining 460€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it.

Round 2

Look at this overview of today's top performing stocks in your broker and decide how much of your remaining 460€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it.

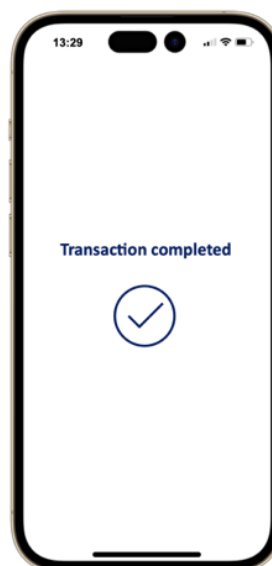


Nova Corp [Price: 40.00]	0
Omni Global [Price: 50.00]	0
Quant Eclipse [Price: 60.00]	0
Zenith Funds [Price: 40.00]	0
Infinity Invest [Price: 80.00]	0
Total	0

I do not want to invest in any stocks

Nova Corp [Price: 40.00 Marketplace: Best-execution Order type: Market order]	0
Omni Global [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Quant Eclipse [Price: 60.00 Marketplace: Best-execution Order type: Market order]	0
Zenith Fund [Price: 40.00 Marketplace: Best-execution Order type: Market order]	0
Infinity Invest [Price: 80.00 Marketplace: Best-execution Order type: Market order]	0
Celestia Inc. [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Aether Tech [Price: 70.00 Marketplace: Best-execution Order type: Market order]	0
Nexus Corp [Price: 90.00 Marketplace: Best-execution Order type: Market order]	0
Zenith Invest [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Cosmo Group [Price: 60.00 Marketplace: Best-execution Order type: Market order]	0
Total	0

I do not want to invest in any stocks



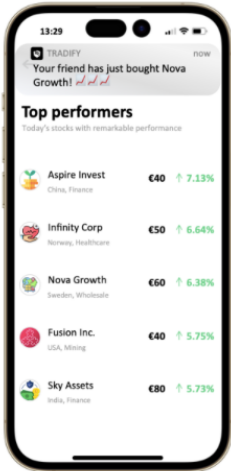
Continue to the next page to see your account balance and returns.

Your depot now looks like this: You have **420€** left that are not invested. This round you chose to invest **40€**. The stocks you bought this round have increased in value and are now worth **42€**.

By going to the next page, you will enter the next round and can continue to invest. If you want to stop investing now, go to the next page and select the option "I do not want to buy any more stocks".

Round 3

Look at this overview of today's top performing stocks in your broker and decide how much of your remaining 420€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it.



Aspire Invest [Price: 40.00]	0
Infinity Corp [Price: 50.00]	0
Nova Growth [Price: 60.00]	0
Fusion Inc. [Price: 40.00]	0
Sky Assets [Price: 80.00]	0
Total	0

I do not want to invest in any stocks



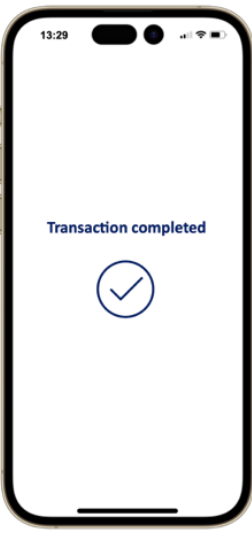
Round 3

Look at this overview of today's top performing stocks in your broker and decide how much of your remaining 420€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it.



Aspire Invest [Price: 40.00 Marketplace: Best-execution Order type: Market order]	0
Infinity Corp [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Nova Growth [Price: 60.00 Marketplace: Best-execution Order type: Market order]	0
Fusion Inc. [Price: 40.00 Marketplace: Best-execution Order type: Market order]	0
Sky Assets [Price: 80.00 Marketplace: Best-execution Order type: Market order]	0
Nexus Global [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Cosmos Stocks [Price: 70.00 Marketplace: Best-execution Order type: Market order]	0
Thrive Group [Price: 90.00 Marketplace: Best-execution Order type: Market order]	0
Apex Funds [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Stellar Avenue [Price: 60.00 Marketplace: Best-execution Order type: Market order]	0
Total	0

I do not want to invest in any stocks



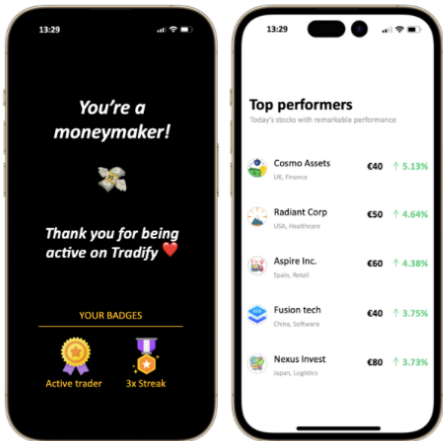
Continue to the next page to see your account balance and returns.

Your depot now looks like this: You have **380€** left that are not invested. This round you chose to invest **40€**. The stocks you bought this round have increased in value and are now worth **44€**.

By going to the next page, you will enter the next round and can continue to invest. If you want to stop investing now, go to the next page and select the option “I do not want to buy any more stocks”.

Round 4

Look at this overview of today's top performing stocks in your broker and decide how much of your remaining 380€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it.



Cosmo Assets [Price: 40.00]	0
Radiant Corp [Price: 50.00]	0
Aspire Inc. [Price: 60.00]	0
Fusion tech [Price: 40.00]	0
Nexus Invest [Price: 80.00]	0
Total	0

I do not want to invest in any stocks

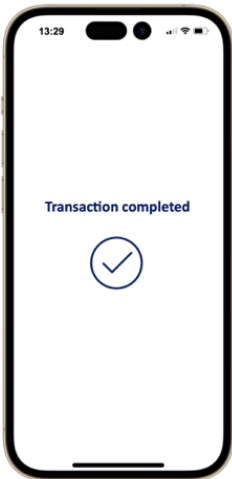
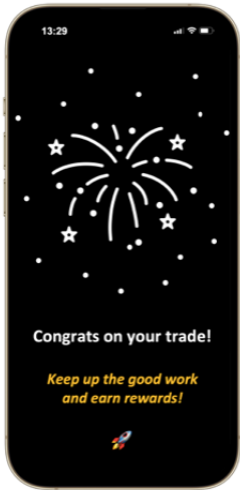
Round 4

Look at this overview of today's top performing stocks in your broker and decide how much of your remaining 420€ you want to invest in which stock. You may also decide not to invest at all. Below you can see in red how much you are currently spending. **Important:** You can only buy whole stocks. Purchase by entering the total amount of money you want to allocate to a stock into the field next to it.



Cosmo Assets [Price: 40.00 Marketplace: Best-execution Order type: Market order]	0
Radiant Corp [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Aspire Inc. [Price: 60.00 Marketplace: Best-execution Order type: Market order]	0
Fusion Tech [Price: 40.00 Marketplace: Best-execution Order type: Market order]	0
Nexus Invest [Price: 80.00 Marketplace: Best-execution Order type: Market order]	0
Apex Global [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Celestia Stocks [Price: 70.00 Marketplace: Best-execution Order type: Market order]	0
Quant Group [Price: 90.00 Marketplace: Best-execution Order type: Market order]	0
Omni Avenue [Price: 50.00 Marketplace: Best-execution Order type: Market order]	0
Genesis Sunrise [Price: 60.00 Marketplace: Best-execution Order type: Market order]	0
Total	0

I do not want to invest in any stocks

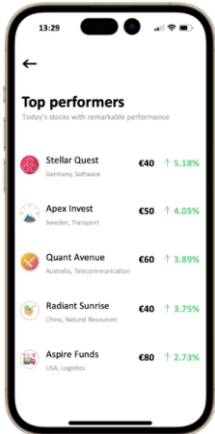


Continue to the next page to see your account balance and returns.

Your depot now looks like this: You have **340€** left that are not invested. This round you chose to invest **40€**. The stocks you bought this round have increased in value and are now worth **44€**.

7 – Manipulation check neo broker

You successfully completed the trading simulation. Please provide your opinion on the following questions:



The screenshot above contains a lot of information.

1 (fully disagree)

2

3

4

5

6

7 (fully agree)

8 – Manipulation check traditional broker

You successfully completed the trading simulation. Please provide your opinion on the following questions:



The screenshot above contains a lot of information.

1 (fully disagree)

2

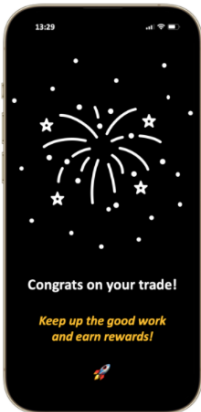
3

4

5

6

7 (fully agree)



The information on the screenshot looks motivating, fun and exciting, just like in a mobile game.

1 (fully disagree)

2

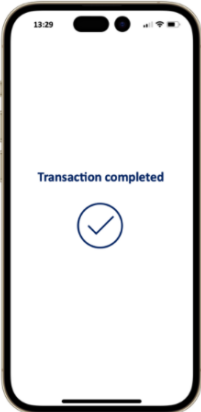
3

4

5

6

7 (fully agree)



The information on the screenshot looks motivating, fun and exciting, just like in a mobile game.

1 (fully disagree)

2

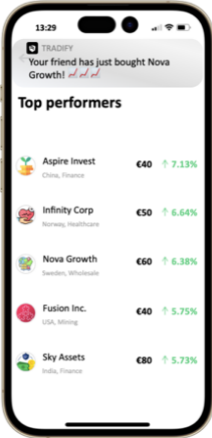
3

4

5

6

7 (fully agree)



There is information on the screenshot above that invites me to behave like a friend.

1 (fully disagree)

2

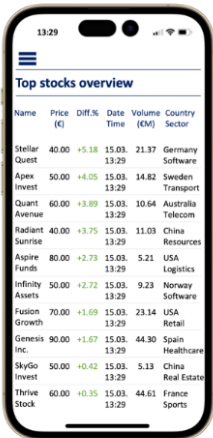
3

4

5

6

7 (fully agree)



There is information on the screenshot above that invites me to behave like a friend.

1 (fully disagree)

2

3

4

5

6

7 (fully agree)

9 – Demographic data

What is your gender?

Male

Female

Other

Prefer not to say

What is you age?

What is your highest education degree?

High school

Bachelor's degree/ comparable

Master's degree/ comparable

PhD or higher

What is your nationality?

What is your annual gross household income (in €)? If you are not entirely sure, simply provide an estimate.

0 - 10,000€

10,000 - 20,000€

20,000 - 30,000€

40,000 - 50,000€

50,000 - 60,000€

70,000 - 80,000€

80,000 - 90,000€

90,000 - 100,000€

More than 100,000€

Prefer not to say

10 – End of survey

You have successfully completed the survey. Thank you very much for contributing to our master thesis!

You may close this window now.

If you are interested, **here is some information about the purpose of our research:** Studies have found that certain elements like gamification or a simplified display of information in trading apps influence peoples' investment behavior. In easy and fun decision environments, people tend to invest more speculatively. We want to know how financial knowledge affects this relationship. Specifically, we are investigating if more knowledge weakens the effects of game-like elements and simplified information on the frequency of investing. For this, we created two experimental conditions. So, in the experiment, you could have either worked with a stockbroker that looks like one from a traditional bank with a lot of information and no "fun" elements, or you could have seen an easy-to-use trading app with game-like aspects. Either way, we hope you enjoyed participating!

Should you have any further questions, please do not hesitate to contact us via the email addresses below.

Marie-Line Paul 42066@student.hhs.se
Paulina Grittner 42071@student.hhs.se

C. Preregistration form



The role of financial literacy on trading frequency in neo brokers (#125083)

Created: 03/14/2023 08:40 AM (PT)

Public: 05/09/2023 05:06 AM (PT)

Author(s)

Paulina Grittner (Stockholm School of Economics) - 42071@student.hhs.se

Marie-Line Paul (Stockholm School of Economics) - 42066@student.hhs.se

1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

H1: Sludges on neo brokers lead to a higher trading frequency.

H2a: High objective financial literacy will weaken the effect of sludges on trading frequency.

H2b: Low objective financial literacy will strengthen the effect of sludges on trading frequency.

H3a: High subjective financial literacy will weaken the effect of sludges on trading frequency.

H3b: Low subjective financial literacy will strengthen the effect of sludges on trading frequency.

H4: Financial literacy overconfidence will strengthen the effect of sludges on trading frequency.

3) Describe the key dependent variable(s) specifying how they will be measured.

The dependent variable is trading frequency. Participants can complete 0-4 trading rounds. Each trade round is coded with a dummy variable, 1= trade made, 0 = no trade made. This means that the dependent variable would be a sum between 0 and 4.

4) How many and which conditions will participants be assigned to?

2 conditions: stock broker of a traditional bank, neo broker.

Participants are shown screenshots that mimic the interface of the respective broker they are assigned to. First, they see a login screen. In the individual rounds, they see a selection of stocks with corresponding information and can enter the amount of money they want to invest in the fictional stocks. After each investment, they get an approval screenshot. Screenshots for the neo broker condition include reduced information, simplified design and gamification elements, whereas the screenshots of the broker of a traditional bank contain more information, more options and are not gamified. To control for a potential influence that profits or losses could have, we only give profits to every participant after each round.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

We will use a multiple regression analysis with interaction terms to assess the effect of the different conditions on our DV trading frequency. We will add in subjective financial literacy, objective financial literacy and financial literacy overconfidence as moderators. We will control for gross household income of all participants, and as a robustness check, also for gender, age and whether a participant has ever invested in the stock market.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

Primary analyses will use no exclusions (including everyone who completed the key financial questions).

We will also include a robustness test that excludes people who failed the attention check.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

We will offer the study until the 21st March 2023 or until we have 300 participants (whichever comes first).

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

The moderator objective financial literacy is measured via 8 items. Each item has several answer options, where one answer is correct. The variable will be calculated as the sum of correct answers to the 8 items (correct = 1; incorrect = 0).

The moderator of subjective financial literacy will be measured with a single item „How would you assess your overall financial knowledge?“ on a scale from 1 (very low) to 8 (very high) (we use the 8-level likert scale here to match the score 1-8 of objective financial literacy).