Ceasing to Speculate:
An Experiment on Learning in Retail Traders

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Abstract

We design a laboratory experiment to study whether inexperienced traders learn to avoid trading after accumulating experience. In particular, we examine whether subjects overtrade as a result of overconfidence and strategic naivete—two commonly discussed departures from the rational expectations framework—and whether experience alleviates either bias. In the experiment, subjects observe a private signal and then decide whether to swap Arrow securities with a partner. A no-trade theorem applies so that under rational expectations, trade should never be realized. However, subjects may be willing to trade if (1) they believe their signals are more accurate than their partners’ or (2) they ignore the selection bias implied by trade. Surprisingly, we find that subjects trade more as they gain experience, and we provide evidence to show this trend is driven primarily by subjects with high-accuracy signals, who fail to account for selection bias and thus under-react to information about their partners’ signal qualities. After removing selection bias in one of our treatments, we find subjects no longer trade more with experience and are more responsive to their partner’s information quality.

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1 Introduction

Retail traders are known to trade too much. Early work documenting this tendency include Odean (1999) and Barber and Odean (2000), who use data from discount brokerage accounts to show that retail traders’ portfolios perform worse as they trade more. Others (e.g. Hong and Stein 2007) cite the tremendous volume of trading in modern financial markets as evidence of speculative trading—driven by information, rather than liquidity needs or risk aversion—seemingly at odds with no-trade theorems (Milgrom and Stokey, 1982). Fittingly, direct experimental tests of no-trade theorems suggest people have robust tendencies to engage in speculative trade and overtrade as a consequence.\textsuperscript{1}

One key challenge speculative trading poses for economists is that it implies disagreement, which is absent in the rational expectations framework. Explanations for disagreement are varying, including gradual information flow, limited attention, and heterogeneous priors. However, as Hong and Stein (2007) note, a unifying subtlety among these rationalizations is that traders must dismiss the information contained in their counterpart’s willingness to trade—either because they believe their own information to be superior (overconfidence) or because they fail to account for others’ information entirely (strategic naivete). To elaborate on the latter: traders who buy a company’s shares on the basis of good news about the company may not recognize that their counter-party may be motivated to sell based on bad news about the company. While overconfidence has proven influential in behavioral finance, experimental work also suggests that strategic naivete may also play an important role in generating speculative trade.\textsuperscript{2} In fact, an experiment by Magnani and Oprea (2017) studying inexperienced traders finds that overconfidence and strategic naivete are equally important and act as substitutes; when either is present, they find, inexperienced subjects commit no-trade violations at the same rate.

Given that retail traders suffer as a consequence of their tendency to undervalue the information implied by trade, why do they fail to learn? While experiments—both in the field and in the lab—have shown that experience plays an important role in determining behavior, the volume of evidence documenting overtrading in the world suggests that it is a robust phenomenon, persisting despite experience that traders accumulate. In this paper, we use a laboratory experiment to understand why. While there have been theoretical attempts to model learning in financial markets, empirical insights have been more limited, as it is difficult to infer traders’ information about assets and about their counterparts. The control offered by a laboratory environment allows us to bypass these limitations of observational data, as we can observe traders’ private information and control the extent of their information about others.

Our experimental design builds on the Arrow-security trading (AST) game developed in Magnani and Oprea (2017), who focus on the behavior of inexperienced traders. Subjects are sorted into

pairs, and each subject in a pair is endowed with an asset which pays out a low or high reward depending on which of two equally likely states is realized. Assets are assigned such that there is no aggregate uncertainty within a pair: if one subject’s asset pays out the high reward, then her counterpart’s asset pays out the low reward and vice versa. After receiving a signal about the more likely state, a subject may pay a transaction fee to trade assets with her partner, and assets are traded when both subjects in a pair choose to. The zero-sum nature of trade in this setting implies that in any symmetric equilibrium, neither subject in a pair should ever be willing to trade—regardless of the signal she receives. However, a subject may be willing to trade when (1) she believes her signal is more accurate than her partner’s (overconfidence) or (2) she fails to account for selection bias in her partner’s willingness to trade (strategic naivete). While both these channels may generate trade for inexperienced subjects—as demonstrated in Magnani and Oprea (2017)—our experiment is designed to evaluate whether either persists as subjects accumulate experience, potentially learning about others’ information quality and their strategies.

In order to study how subjects trade with experience, our design features a large number of rounds (40) and feedback after each round. Additionally, we introduce new design elements to separate the roles of overconfidence and strategic naivete. Subjects’ signal accuracies are determined before they participate in the AST game, via a real-effort task; subjects who successfully complete the task are endowed with a more accurate signal. Assigning accuracies beforehand allows us to directly observe the role of strategic naivete, as we can make subjects’ accuracies common knowledge prior to trading. For instance, if two subjects are revealed to have equally accurate signals, strategic naivete becomes a more plausible explanation for trade, as we may rule out overconfidence.

In a similar fashion, in order to observe the role of overconfidence, we show subjects their partners’ signal realizations—in addition to their own—before they make their trading decisions. In other words, subjects no longer must reason through possible contingencies before trading, as they observe their partners’ signal realizations directly. Essentially, a subject observes two signal realizations, one generated by her and one generated by her partner. Thus, in the scenario that a subject chooses to trade when encouraged to do so by her own signal and discouraged to do so by her partner’s, we may understand her decision to be driven by overconfidence. Our treatments are implemented between-session and toggle these two levers (showing subjects signal accuracies, showing subjects partners’ signal realizations) to understand how experience interacts with overconfidence and strategic naivete.

Our data exhibits two important aggregate patterns. First, in our baseline treatment (subjects are not shown accuracies or their partners’ signal realizations), subjects choose to trade more often as they gain experience; when their signals indicate their partners’ assets are more likely to yield the high reward, subjects choose to trade close to 60% of the time by the end of the experiment, compared to around 50% of the time at the beginning of the experiment. Second, we that find subjects’ perceptions
of their own signal accuracies (whether from experience or revealed through the experimental interface) heavily influence their decisions to trade; in all treatments, there is a substantial and persistent gap between the rates at which subjects with low-accuracy and high-accuracy signals choose to trade.

The role of signal accuracy is especially evident in the baseline treatment, in which the trend of increasing willingness to trade is driven entirely by subjects with high-accuracy signals, who trade more as they receive more correct signal realizations. On the other hand, subjects with low-accuracy signals choose to trade moderately less in later rounds. Strikingly, by the end of the experiment, behavior in the baseline treatment resembles that in our accuracy revelation treatment, in which subjects with high-accuracy signals persistently choose to trade far more often than those with low-accuracy signals (roughly 70% and 30% of the time, respectively). The parallel between these two treatments suggests that strategic naivete is the more important channel in generating persistent speculative trade: subjects are adept at understanding their own accuracies in the baseline treatment, and subjects with high-accuracy signals finish each treatment choosing to trade at a high rate.

To better understand the interaction of experience with subjects’ willingness to trade, we perform reduced form analysis on the feedback subjects receive—focusing on proxies for their accuracies, the accuracies of their partners, and the selection bias induced by partners’ strategies. Consistent with our aggregate analysis, we find that subjects in our baseline treatment are highly responsive to feedback about their own signal accuracy but under-react to feedback about others’ signal qualities and selection bias. However, comparison with our auxiliary treatments indicates that high-accuracy subjects’ under-reaction to information about others’ information quality is a consequence of their failure to internalize the selection bias implied by trade—in other words, their inability to learn about others’ strategies. In particular, when we reveal others’ signal accuracies, subjects receiving high-accuracy signals persistently choose to trade at the same rate, regardless of their partners’ signal accuracy and despite the fact they accumulate enough feedback to account for selection bias. On the other hand, when we show subjects their partners’ signal realizations, we find that even those with high-accuracy signals trade less when their feedback indicates their partners are likely to have highly accurate signals.

We additionally analyze the ex-ante profitability of trading and find that subjects with high-accuracy signals persistently choose to trade when doing so is unprofitable. Using our proxies, we calculate subjects’ expected gains from choosing to trade and find that by the end of the experiment, high-accuracy subjects are just as likely to choose to trade when the expected gain from doing so is negative as when it is positive. This pattern is consistent across treatments, except when we show subjects their partners’ signals. We conclude that persistent no-trade violations—those in which retail traders are expected to lose from trading—are primarily driven by traders’ struggle to internalize the selection bias implied by trade and that this effect becomes more pronounced for traders who have access
to higher quality information.

Our data exhibit an additional nuance: high-accuracy subjects choose to trade most frequently in the treatment in which we remove both overconfidence and strategic naiveté. We believe this result, while surprising, is consistent with our finding that strategic naiveté interacts with subjects’ perception of their signal accuracies. We speculate that inexperienced subjects have primitive “mental models” of when they should trade, and in particular, they possess heuristics that place excessive weight on the accuracy of their own signals. When told they possess high-accuracy signals at the start of the experiment, such subjects may ignore other elements of the experimental design—in particular, the signal realizations of their partners—intended to remove strategic naiveté. On the other hand, in the treatment in which only their partners’ signal realizations are shown, subjects may pay closer attention to their partners’ signal accuracies (revealed through feedback), as they are less sure of their own signal accuracy. We note that this pattern, in which people learn better when given less information, is documented in Esponda et al. (2020), who find that subjects become more adept at Bayesian updating when they are not presented with the likelihood function directly.

1.1 Related Literature

Our work adds to a nascent experimental literature studying speculative trade. Earlier work in this vein include Carrillo and Palfrey (2011), whose design and results emphasize the role of trading mechanisms in generating no-trade violations, and Angrisani et al. (2011), who find that no-trade violations may diminish over time when subjects receive precise feedback. Our results contrast with the latter’s finding, as we document that subjects may actually be more willing to trade as they learn their information is high quality.

Most similar to our paper, Magnani and Oprea (2017) examine the roles of both overconfidence and cursed reasoning (a specific form of strategic naiveté) for inexperienced subjects and conclude that the two behavioral forces act as substitutes. In their experiment, subjects act as though their partners trade at random (not based on the signals they receive) and as if their partners’ signals are essentially noise. Our work contributes several new insights. We find that with experience, strategic naiveté plays the more important role in generating speculative trade, as subjects are more capable of learning about others’ information quality than others’ strategies. Furthermore, we find that the prominence of strategic naiveté is apparent even among inexperienced subjects in our experiment, as subjects choose to trade less after being told others’ signals than after being told others’ accuracies. Finally, our results suggest overconfidence and strategic sophistication may actually be complementary, as subjects receiving high-quality signals are more willing to trade in the treatment in which we remove both overconfidence and strategic naiveté.

3We speculate the reason for this contrast is likely related to how we remove strategic naiveté from the experimental setting. We directly show subjects their signals, whereas Magnani and Oprea (2017) show subjects their partners’ strategies, so that subjects must still recognize the association between trade occurring and their partners’ signal. As emphasized by Esponda and Vespa (2014), people generally struggle exactly with this type of thinking.
accuracy signals are less responsive to information about their partners than those receiving low-accuracy signals.

We also contribute to a large behavioral finance literature supporting the link between overconfidence and trading. Notable examples of theoretical work in this vein include Odean (1998), Scheinkman and Xiong (2003), Gervais and Odean (2001); interested readers should reference Barber and Odean (2013) for a comprehensive survey. Observational studies typically rely on survey data and generally support the hypothesis that retail investors with higher assessments about their abilities trade more. Besides Magnani and Oprea (2017), experiments studying the link between overconfidence and trading include Deaves et al. (2008) and Bregu (2020), with both emphasizing overconfidence as a driver of trading. Our findings add the following insight: traders may actually have accurate perceptions of their own information quality, but those with high information quality are also more likely to be strategically naive and ignore selection bias.

The remainder of our paper is organized as follows. In Section 2, we outline the theory and design of our experiment. In Section 3, we highlight general features of the aggregate data, and in Section 4, we analyze how subjects’ experience interacts with overconfidence and strategic naivete. In Section 5, we discuss our findings our final treatment (where we remove overconfidence and strategic naivete) and selection bias in accuracies, and Section 6 concludes our paper.

2 The Experiment

Each session of our experiment proceeds in two phases. To study how trading changes with experience, we implement a version of the Arrow Security Trading (AST) game developed in Magnani and Oprea (2017), which takes place during the second phase. In brief, subjects must decide whether to trade with a partner on the basis of a private signal they receive. A no-trade theorem applies to the setting, so that in theory, trade should never occur with positive probability. Subjects play 40 repetitions of the AST game, receiving feedback after each round, so that they have the opportunities and information to learn from experience.

Our treatment design investigates the effect of experience on two widely cited causes of no-trade violations: overconfidence in one’s signal accuracy and strategic naivete (not accounting for the relationship between others’ actions and others’ information). In order to create a setting in which overconfidence is plausible, we determine the accuracy of subjects’ private signals via a guessing task implemented during the first phase of the experiment; subjects who submit correct responses are assigned higher accuracy signals in the AST phase of the experiment. In our basic treatment SN (show nothing), we do not inform subjects about their signal accuracies, but they have the opportunity to infer it
through experience. To disentangle this type of learning from increasing strategic sophistication, we show
subjects their signal accuracies and their partners’ signal accuracies in treatment SA (show accuracy); if
subjects trade less with experience, we may then attribute the change to subjects’ strategic sophistication.
Similarly, to account for changes in subjects’ strategic sophistication, we show subjects their partners
signals—in addition to their own—in treatment SS (show signals), so that subjects’ abilities to infer
their partners’ information from trade is irrelevant. Thus, subjects’ willingness to trade may be better
attributed to their beliefs about signal accuracies. In our final treatment, SAS, we show subjects both
types of information.

We discuss our experimental design as follows. In subsection 2.1, we detail the AST game and
the guessing task preceding it. In subsection 2.2, we establish how overconfidence and strategic naivete
may generate trade and explain our treatments design, highlighting how it controls for these different
channels in our data. Finally, we discuss further implementation details in subsection 2.5.

2.1 The AST Game

The AST game is a two-player game with private information. Each player in the game starts with a
different colored ticket (green or blue), so that, for instance, if subject i starts with a green ticket, her
partner starts with a blue ticket. At the end of the game, one ticket pays out a high reward of $14 while
the other pays out a low reward of $4. After observing private signals, each subject then decides whether
to keep her assigned ticket (a_i = T) or to swap tickets with her partner (a_i = K). Trade costs each
subject a transaction fee of $2 and occurs only if both subjects choose to trade.

Ex-ante, each ticket is equally likely to pay out the high reward. Subjects’ private signals are
binary—green (G) and blue (B)—and indicate which ticket is likelier to pay out the high reward. The
probability subject i’s signal matches the high reward ticket, \( \alpha_i \), is determined by subject i’s response in
the guessing task completed during phase 1. In our baseline treatment, SN, subjects are not told their
accuracies.

Proposition 1 below establishes a benchmark prediction for the experiment: trade should never
be observed in the data. Note that while we have not discussed subjects’ assumptions about the distribu-
tion of signal accuracies, the proposition holds for any common-knowledge distribution of accuracies.
Additionally, observe that the proposition rules out realized trades; there are equilibria in which subjects
may coordinate such that subject i chooses to trade with positive probability but subject \(-i\) never trades.
Of course, restricting attention to symmetric equilibria implies that subjects should never choose to trade
either.

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4Signals are described as “clues” in the language of the experiment.
5For all proofs, we refer interested readers to Magnani and Oprea (2017).
**Proposition 1**  *There is no Bayesian Nash Equilibrium in which trade occurs with positive probability.*

The logic of this particular no-trade result is most clearly illustrated by assuming the accuracies of both subjects are known and equal. Now consider the “intuitive” strategy in which subject $i$ trades if and only if she receives signal that does not match her asset—e.g. a subject starting with the green ticket receives a blue clue. For convenience, we will refer to this strategy as *trading with signal*. Trade occurs with positive probability when both subjects trade-with-signal, but only when the subjects receive opposite signals. As subjects’ signals are equally accurate, the expected value of both assets—conditional on trade—is equal, and hence both subjects suffer strict losses in expectation as a consequence of the trading fee. Therefore, there can be no BNE in which both traders employ this strategy.

**Implementation of AST Game**  The AST game takes place during the second phase of our experiment, after four rounds of the guessing task in phase 1. Subjects play 40 rounds of the AST game, with random re-matching and fixed roles (subjects always start with the same ticket color). Subjects’ signal accuracies are fixed across all rounds and are determined by their responses in the final round of the guessing task: subjects who respond correctly (incorrectly) receive a signal that matches the high reward ticket with 80% (50%) probability. We employ the strategy method, asking subjects to submit a trading decision for each possible signal realization. After each round, subjects receive the following information: (1) their signals and their partners’ signals; (2) their trading decisions and their partners’ trading decisions; (3) whether trade occurred; (4) the state of the world (i.e. which ticket paid out the high amount); and (5) their earnings.

**The Guessing Task**  Prior to playing the AST game, subjects complete a guessing task in order to determine signal accuracies. Subjects are shown a grid of 400 green and blue dots and are then asked to report whether green or blue is the more common color. Subjects complete three practice rounds before completing a fourth, incentivized round; those who respond correctly (incorrectly) in the fourth round receive signals that match the high reward ticket with 80% (50%) probability. We use the real-effort task to assign accuracies so that we may reveal signal accuracies as a treatment condition.

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6Magnani and Oprea (2017) use the same real-effort task to determine signals. However, in their design, the color of the high-reward ticket (asset in their experiment) is exactly the more common color. Subjects first submit strategies mapping signals to trading decisions and then complete the real-effort task, so that the color they report as more common is the signal that determines their actions. We use the real-effort task to assign accuracies so that we may reveal signal accuracies as a treatment condition.
round earn $10 ($5) and are assigned a signal that is 80% (50%) likely to match the high-reward ticket in the AST game.\footnote{Instructions for the AST game are dispersed after subjects complete the guessing task. In the instructions for the guessing task, we only inform subjects that responding correctly in the fourth round will lead to higher earnings.}

2.2 Channels for Trade

In addition to studying the role of experience on trading, our experiment focuses on understanding how experience interacts with two leading explanations for over-trading: overconfidence and strategic naivete. In this subsection, we discuss the theoretical role each explanation could play in the AST game.

2.2.1 Overconfidence

Overconfidence is commonly cited in the behavioral finance literature as a primary reason why retail traders trade so much—and at a loss. As Moore and Healy (2008) and Barber and Odean (2013) discuss, the term “overconfidence” encompasses three distinct beliefs people may hold about their abilities: (1) believing one’s ability is higher than it actually is—over-estimation; (2) believing one’s ability is higher than the average person’s—over-placement; and (3) believing one knows more about her own ability than she actually does—over-precision.\footnote{Moore and Healy (2008) provide the following illustration of over-precision. Consider a person who is asked to provide intervals to 10 numerical questions—e.g., what is the length of the Nile River—such that the correct answer is contained in the interval 90% of the time. An individual exhibits over-precision when fewer than 9 of her intervals contain the correct answer.} In our experiment, we focus specifically on the roles over-estimation and over-placement and how they change with experience.

Propositions 2 and 3 establish, respectively, that subjects may be incentivized to trade when they (1) believe their signal is accurate enough and (2) believe their signal is sufficiently better than their
partners’. First, recall our definition of trading-on-signal. A subject trades-with-signal when she trades if and only if her signal indicates her partner’s asset is more likely to yield the high reward; in other words, the subject naively trades according to the information she receives. Proposition 2 provides scope for trading via overestimation: trading-on-signal is optimal for a subject, given naive behavior from her partner, when she believes her signal is sufficiently accurate. Likewise, Proposition 3 establishes that trading-on-signal can be optimal for a subject when she believes her signal accuracy is sufficiently better than her partner’s. In summary, subjects have an incentive to trade if they believe their signals are sufficiently accurate—in the absolute sense and relative to others—but may incur losses through trade if these beliefs are overly optimistic.

**Proposition 2** Let \( \hat{\alpha}_i \) be subject \( i \)’s expectation of her signal’s accuracy. When \( \hat{\alpha}_i < \frac{3}{5} \), never trading is a dominant strategy, and when \( \hat{\alpha}_i \geq \frac{3}{5} \), trading-on-signal is a best-response to any constant strategy from her partner.

**Proposition 3** Let \( \tilde{\alpha}_i \) be subject \( i \)’s expectation of her partner’s signal accuracy, and let \( \hat{r}_i = \frac{\tilde{\alpha}_i}{1 - \hat{\alpha}_i} \) and \( \tilde{r}_i = \frac{\tilde{\alpha}_i}{1 - \tilde{\alpha}_i} \) be the signal-to-noise ratios of subject \( i \) and her partner, respectively. Trading-on-signal is a best response to any strategy from her partner if \( \frac{\hat{r}_i}{\tilde{r}_i} \geq \frac{6}{5} \).

### 2.2.2 Strategic Naivete

A different view of trading emphasizes failures of strategic reasoning as a source of overtrading. As Eyster et al. (2019) highlights, markets may exhibit higher trading volume when traders fail to invert the mapping from others’ signals to prices. More generally, evidence from past experiments suggest people struggle to behave optimally in settings with private information. For instance, subjects in both winner’s curse and Acquire-a-Company experiments consistently overbid for common value assets—see Charness and Levin (2009) and Ball et al. (1991) respectively.

The idea that agents fail to appreciate the link between others’ information and others’ actions, formalized as cursedness by Eyster and Rabin (2005), has proven particularly influential for understanding strategic shortcomings in settings with private information. Building their model with cursed agents, Eyster et al. (2019) demonstrates that cursedness can be a source of excessive trading, alternative to assumptions about overconfidence. In the lab, cursedness has also proven to be useful for understanding why people violate no-trade theorems; both Carrillo and Palfrey (2011) and Magnani and Oprea (2017) find support for cursedness in their data. Below, we formalize cursedness in the AST game and show that it allows for trade in equilibrium.

**Definition 1** Let \( \sigma_{-i} : \{B,G\} \rightarrow [0,1] \) describe subject \( -i \)’s strategy, such that after receiving signal \( s_{-i} \in \{B,G\} \), subject \( -i \) trades \((T)\) with probability \( \sigma_{-i}(s_{-i}) \). Additionally, let \( \overline{\sigma}_{-i}(s_i) \) describe trader
i's average strategy when subject i receives signal $s_i$, such that the probability of trading is given by

$$\sigma_{-i}(s_i) = \sum_{s_{-i} \in \{B,G\}} p_i(s_{-i}|s_i) \times \sigma_{-i}(s_{-i}),$$

where $p_i(s_{-i}|s_i)$ is the subject i's subjective probability, conditional on observing signal $s_i$, that subject $-i$ receives signal $s_{-i}$. We say subject i is $\chi$-cursed if she best responds to the mixture $\chi(s_i)$, where

$$\chi(s_i) = \sum_{s_{-i} \in \{B,G\}} p_i(s_{-i}|s_i) \times [\chi \sigma_{-i}(s_i) + (1 - \chi)\sigma_{-i}(s_{-i})].$$

In words, a cursed subject confuses the average distribution of actions her partner chooses with the distribution of actions her partner chooses after receiving a particular signal. When $\chi$ is 0, subjects are fully rational, and when $\chi$ is 1, subjects are fully cursed, behaving as if their partner’s always play the same mixed strategy given every signal realization. In a $\chi$-cursed equilibrium, each subject best responds to $\chi(s_i)$. Proposition 4 establishes that trading-with-signal may occur in equilibrium (there are always trivial no-trade equilibria) if subjects are sufficiently cursed. The intuition is that cursed subjects ignore the selection bias implied by trade. From the perspective of fully cursed subjects, their partners choose to trade 50% of the time at random; they fail to understand that the 50% of the time their partners choose to trade coincide exactly with the instances in which their partners’ signals disagree with their own.

**Proposition 4** There exists $m \in (0,1)$ such that for $\chi > m$, there exists a cursed equilibrium in which subjects trade-on-signal.

We note that alternative behavioral concepts—such as limited depth of reasoning (e.g. Camerer et al. 2004)— may be applied to explain why people struggle in strategic settings with private information. Additionally, recent work on contingent reasoning (see Esponda and Vespa 2014) suggests that people’s difficulty in such settings may actually be deeper, rooted in their struggle to process hypothetical scenarios, rather than simply overlooking correlations. As such, although cursedness has been applied in the past to study no-trade violations, we refer to failures of strategic reasoning as simply strategic naivete.

### 2.3 Treatments

We run four treatments to fully examine our two questions: (1) how does experience affect trading behavior and (2) how does experience interact with overconfidence and naivete? In our baseline treatment SN (show nothing), we implement the AST game as descried in 2.1. After each round, subjects are told
their partners’ actions, their partners’ signals, the state of the world, and their payoffs, but do not receive any additional information to mitigate the roles of overconfidence or naivete.

**You own a Green Ticket: Submit a trading choice for each clue pair**

<table>
<thead>
<tr>
<th>Your Clue</th>
<th>Partner’s Clue</th>
<th>Your Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Green</td>
<td>Trade for Blue Ticket</td>
</tr>
<tr>
<td>Green</td>
<td>Blue</td>
<td>Trade for Blue Ticket</td>
</tr>
<tr>
<td>Blue</td>
<td>Green</td>
<td>Trade for Blue Ticket</td>
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<tr>
<td>Blue</td>
<td>Blue</td>
<td>Trade for Blue Ticket</td>
</tr>
</tbody>
</table>

Figure 3: Choice Interface for Treatment SS

In order to disentangle these two behavioral traits, we implement additional treatments between-sessions. Our approach is to “help” subjects by showing them information (about signal accuracies or about signal realizations) they might otherwise have to deduce via introspection or updating through feedback. In treatment SA (show accuracies), we focus on the role of strategic naivete by informing subjects of their signal accuracies and their partners’ signal accuracies. That is, each round, we remind every subject of her signal’s accuracy and inform her about the signal accuracy of her partner for that round. In our analysis, we focus in particular on cases in which two subjects with high-accuracy signals are paired together, as willingness to trade can no longer be rationalized via overplacement. Analogously, in treatment SS (show signals), we show subjects both their own signals and their partners’ signals, in order to understand the role of overplacement. We continue to implement trade via the strategy method, so that in our choice interface, subjects must choose whether to trade for each combination of signal realizations—see Figure 3. Trading may no longer be attributed to strategic naivete, as subjects no longer need to link hypothetical signal combinations to the contingency of trade. Specifically, in our analysis, we focus on the case in which each subject in a pair receives the signal matching the other’s ticket (third row in Figure 3). In this scenario, each subject understands that her partner’s signal contradicts her own, and thus willingness to trade suggests a subject believes her signal to be more accurate than her partner’s. In our final treatment, SAS (show accuracies and signals), we show subjects both types of information (signal accuracies, their partners’ signals), so neither overplacement nor strategic naivete should motivate subjects to trade. Thus, any residual willingness to trade may serve as a benchmark by which to compare willingness to trade in other treatments.

Table 1: Treatment Summary

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Own Signal Accuracy</th>
<th>Partner’s Signal Accuracy</th>
<th>Own Signal</th>
<th>Partner’s Signal</th>
</tr>
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<tbody>
<tr>
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<td>SS</td>
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<td>Not Shown</td>
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<tr>
<td>SAS</td>
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</tbody>
</table>
2.4 Eliciting Beliefs

We elicit subjects’ beliefs about signal accuracies in order to evaluate initial overconfidence and to study how overconfidence changes as subjects experience feedback. We elicit beliefs twice: once after the guessing task but before the AST game and second after the AST game. In each round of elicitation, each subject chooses a number $b^{\text{self}}$ between 0 to 100 on a slider to rate how likely they were to have submitted a correct report in the final round of the guessing task—i.e. a subject would choose 100 to indicate 100% likelihood of a correct report. Subjects then choose a second number $b^{\text{others}}$ between 0 and 100 to rate the percentage of other subjects in the session who reported correctly in the final round of the guessing task. For treatments SA and SAS, we only elicit beliefs about others in the second round of elicitation, as they are directly told their own signal accuracies during the AST game.

We incentivize subjects to report correct beliefs using the quadratic scoring rule. For each subject $i$, let $g_i = 100$ if the subject’s reported correctly in the guessing task and 0 otherwise, and let $\rho_i$ be the percentage of other subjects who reported correctly—i.e. $\rho_i = 100$ if 100% of other subjects reported correctly. For each round of elicitation, we randomly select $q \in \{\text{self}, \text{others}\}$ and pay subjects according to the quadratic distance between $b^q$ and $c(q)$, where $c(\text{self}) = g_i$ and $c(\text{others}) = \rho_i$. Specifically, we pay subjects $s(q)$ dollars, such that

$$s(q) = 4 - \frac{(b^q - c(q))^2}{5000}.$$

2.5 Implementation Details

Our experiment is conducted over Zoom with 160 subjects recruited from NYU’s undergraduate population. We run four sessions of each treatment, with sessions consisting of between 8 to 12 subjects. In addition to their earnings from the other tasks (the guessing task and the two belief elicitation tasks), subjects are paid for one randomly chosen round of the AST game. Payment information is revealed only after the experiment concludes, and subjects earn $22.82 on average.

Instructions for the experiment are distributed in sequence, so that subjects do not receive instructions for a task until all preceding tasks have been completed. We distribute instructions in two ways to ensure subjects have access to the instructions during the experiment and are engaged while the instructions are being presented. First, we provide a Dropbox link that enables subjects to view the instructions during the course of the experiment. Second, we open a PDF copy of the instructions on

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9We elicit beliefs about guessing task performance instead of directly about signals so that we may elicit beliefs before introducing the AST game.
10See Schotter and Trevino (2014).
11The software for the experiment was written in oTree (Chen et al., 2016), and subjects were recruited via hroot (Bock et al., 2014).
12We disable downloading from the link, so our instructions cannot be dispersed outside the experiment.
the experimenter’s computer, which we then share via Zoom’s screen-sharing function. The instructions are then read aloud, and likewise, questions are asked (and repeated if necessary) and answered aloud so that all subjects can hear.

3 General Findings

We first explore general features of the aggregate data. We discuss our belief elicitation results, which show that: (1) our guessing task induces over-placement, such that the average subject initially believes herself more successful than others; and (2) subjects understand the link between the guessing task and the AST game. We then provide a taxonomy of signal configurations to organize situations in which subjects make trading decisions and use it to show that (3) subjects generally choose to trade only when their signals match their partners’ assets. Finally, we explore how willingness to trade evolves over the course of the experiment, finding that (4) in our baseline treatment, SN, average willingness to trade actually increases with experience and (5) willingness to trade generally increases (decreases) among subjects with high (low) accuracy signals across all treatments. In particular, we note that the rates at which subjects choose to trade in treatment SN converge to those in treatment SA.

3.1 Elicitation Results

Recall that signal accuracy in subjects’ signal accuracies in the AST game are determined by their performances in the final round of the guessing task. Thus, we proxy for subjects’ initial and final beliefs about signal accuracies using the subjective likelihoods we elicit from subjects about whether their

![Figure 4: Elicited Likelihoods of Guessing Correctly](image)

Recall that signal accuracy in subjects’ signal accuracies in the AST game are determined by their performances in the final round of the guessing task. Thus, we proxy for subjects’ initial and final beliefs about signal accuracies using the subjective likelihoods we elicit from subjects about whether their
responses were correct. To study over-placement, we analyze initial likelihoods (elicited prior to the AST game) from all treatments and final likelihoods (elicited after the AST game) from treatments SN and SS only. Consistent with past experiments (e.g. Moore and Healy 2008), we find that, on average, subjects exhibit over-placement across treatments. Additionally, we provide evidence that the subjective likelihoods we elicit are appropriate proxies for subjects’ beliefs about signal accuracies. In particular, we show that subjects who guess correctly (incorrectly) increase (decrease) their estimates of themselves after playing the AST game and that the magnitude of subjects’ estimate changes is positively correlated to the frequency with which their signals match the state in the AST game.

Figure 4 reports the average elicited likelihoods of responding correctly in the guessing task. For each treatment, the average subject initially believes her own likelihood of guessing correctly is greater than that of other subjects. The better-than-average belief is more pronounced for subjects who guess correctly, suggesting subjects’ private information about their own skill at the guessing task is at least somewhat informative. After the AST game, subjects update beliefs about their own likelihoods in the correct direction; in treatments SN and SS, subjects who were correct (incorrect) in the guessing-task report higher (lower) likelihoods of being correct after the AST game. This dichotomy suggests that subjects internalize the relationship between their performances in the guessing-task and their signal accuracies in the AST game.

Figure 5 provides additional evidence that subjects diverge in their estimates after playing the AST game. Each observation shows a particular subject’s estimate of her own and others likelihood of guessing correctly. Initially, both correct and incorrect subjects display relative overconfidence—located below the 45 degree line—but after playing the game, relatively overconfident subjects are predominantly those who were correct in the guessing task. Note, however, movement across the 45 degree line is mostly horizontal. Subjects who were correct (incorrect) increase (decrease) their estimates of themselves, but estimates of others is largely static.

We further explore the relationship between subjects’ signals in the AST game and their elicited likelihoods in Table 2. Our dependent variables \( \text{change}_\text{self}, \text{change}_\text{others} \) measure the change in estimates after the AST game, and our independent variables \( \text{accuracy}_\text{avg} \) and \( \text{accuracy}_\text{others.avg} \) record the frequency with which the signals of a subject and her partner match the state during the AST game.

We note three patterns. (1) In both treatments, subjects’ estimates are highly responsive to the empirical accuracy of their own signals—\( \text{change}_\text{self} \) is almost one-to-one with \( \text{accuracy}_\text{avg} \)—so that subjects whose signal realizations match the state more often report higher estimates of their performance.

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13 The rate of correct responses is roughly consistent across treatments, with around 60% of subjects responding correctly and 40% of subjects responding incorrectly.

14 In treatments SA and SAS, we elicit only beliefs about others, as subjects are informed of their own accuracy.
in the guessing task. (2) In both treatments, subjects’ estimates of others are far less sensitive to data from the AST game. (3) While subjects from treatment SN, on average, do not update their estimates of others accuracies, those from treatment SS do in fact respond in the correct direction to feedback about their trading partners—albeit not to the extent to which they respond to feedback about themselves.

3.2 A Taxonomy of Trade

Before discussing subjects’ trading behavior, we note that subjects make trading decisions in response to up to four different signal configurations. A subject’s signal may be green or blue—indicating whether her ticket or her partner’s ticket is likelier to pay out the high reward of $14—and likewise, a subject’s
partner’s signal may be green or blue. In treatments SS and SAS, in which subjects also observe their partners’ signals, subjects thus make four different choices each round (as we elicit full strategies). We first provide a taxonomy of signals for these two treatments and then describe our taxonomy for treatments SN and SA, in which subjects observe only their own signals.

- We first address configurations in which both subjects in a pair receive different signals. We say a signal configuration is crossing when each subject in a pair receives the signal that matches the color of her partner’s ticket. For example, if a subject endowed with the green ticket receives a blue signal and her partner (endowed with the blue ticket) receives a green signal, we say the subjects receive crossing signals. In the reverse case, in which each subject receives the signal matching her own ticket, we say the subjects receive reverse crossing signals.

- There are then two cases in which both subjects receive the same signal. Take a subject as given. If her signal and her partner’s signal match her ticket—e.g., the subject is endowed with a green ticket and both signals are green—we say the signal configuration is same-own for the subject. However, when her signal and her partner’s signal match her partner’s ticket—e.g., the subject is endowed with a green ticket and both signals are blue—we say the signal configuration is same-partner.

- In treatments SN and SA, a subject can only observe whether her signal matches her own ticket or her partner’s ticket. For these treatments, we broaden our definition of crossing to mean all cases in which a subject’s signal matches her partner’s ticket. Likewise, when a subject’s signal does not match her partner’s ticket, we describe the situation as no crossing.

The motivation of using both a broad (for SN and SA) and narrow (for SS and SAS) definition for crossing is that we are interested in (1) whether subjects trade when their own signal indicates they should trade and (2) whether observing partners’ signals affects this decision. That is, we are interested in the extent to which subjects trade according to their signals because they undervalue the possibility that their partners receive the opposite signals. Our treatment-dependent definition of crossing facilitates this analysis by allowing us to compare subjects’ trading behavior when they receive a signal matching their partners’ asset (SN and SA) and the narrower situation in which they also learn that their partners receive the opposite signal (SS and SAS).

Table 3 below decomposes the frequency with which subjects choose to trade—that is, willingness to trade—across our categories of situations. In treatments SN and SA, subjects rarely trade “against” their own signals, as the frequency of trade in no crossing situations is low and decreases over the course of the experiment—suggesting subjects understand the relationship between signals and ticket payouts. In a similar vein, frequency of trade is low in same-own situations and high in same-partner

\[15\text{Recall that the likelihood of a particular ticket paying out the high reward is weakly higher when a signal matches its color.}\]
situations: a subject in treatment SS or SAS is unlikely (likely) to trade when both signals match her (partner’s) ticket. Additionally, the data show subjects are moderately willing to trade in reverse crossing situations; this is primarily driven by low-accuracy subjects who are matched with higher accuracy partners and thus trade according to their partners’ signals. Finally, notice that by the end of the experiment, (1) trading rates in crossing situations are lower in treatments SS and SAS than in SN and SA and (2) in treatments SS and SAS, trading rates in same-partner configurations are higher than those in crossing configurations. These observations suggest that strategic naivete plays an important role in generating trade, as we learn that subjects are less likely to trade when they know their partners hold an opposite signal and are much likelier to trade when they learn their partners hold the same signal.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crossing</th>
<th>No Crossing</th>
<th>Reverse Crossing</th>
<th>Same-Own</th>
<th>Same-Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN</td>
<td>0.52 (0.03)</td>
<td>0.17 (0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>0.58 (0.02)</td>
<td>0.16 (0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>0.47 (0.02)</td>
<td>0.21 (0.02)</td>
<td>0.11 (0.02)</td>
<td>0.65 (0.02)</td>
<td></td>
</tr>
<tr>
<td>SAS</td>
<td>0.57 (0.03)</td>
<td>0.26 (0.02)</td>
<td>0.10 (0.02)</td>
<td>0.76 (0.02)</td>
<td></td>
</tr>
</tbody>
</table>

(a) First 10 Rounds

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crossing</th>
<th>No Crossing</th>
<th>Reverse Crossing</th>
<th>Same-Own</th>
<th>Same-Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN</td>
<td>0.59 (0.03)</td>
<td>0.09 (0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>0.51 (0.02)</td>
<td>0.14 (0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>0.46 (0.02)</td>
<td>0.25 (0.02)</td>
<td>0.07 (0.01)</td>
<td>0.73 (0.02)</td>
<td></td>
</tr>
<tr>
<td>SAS</td>
<td>0.48 (0.03)</td>
<td>0.31 (0.02)</td>
<td>0.05 (0.01)</td>
<td>0.75 (0.02)</td>
<td></td>
</tr>
</tbody>
</table>

(b) Last 10 Rounds

Table 3: Trade Frequencies by Situation

For the remainder of our analysis, we will focus on subjects’ trading behavior when they are faced with a crossing situations (unless otherwise specified), and additionally, we focus on willingness to trade. As such, we will use “trade rate” to describe the frequency with which subjects choose to trade in crossing situations. Furthermore, recall that in the base treatment, SN, our two theories of overtrading suggest that a subject trades in crossing situations if (1) she is overconfident about the relative accuracy of her signal or (2) she is strategically naive and ignores the selection bias implied by trade. Thus, for treatment SA and SAS—in which subjects observe accuracy information—we drop observations for high-accuracy subjects when they are matched with low-accuracy subjects; in such pairings, trading in crossing situations is weakly optimal for high-accuracy subjects.

### 3.3 Evolution of Trade

We now turn our attention to our experiment’s main question: do subjects trade less with experience? We find, surprisingly, that subjects have a tendency to trade more as they accumulate experience. Figure 6 plots the evolution of trade rates and shows that in our base treatment (SN), subjects choose to trade more frequently in later rounds than they do in earlier rounds.\(^\text{16}\) This trend disappears when we

\(^{16}\)We bin observations across rounds, and the vertical lines represent standard errors.
introduce controls for overconfidence (SA) or strategic naivete (SS) and reverses when we introduce both controls (SAS). Note that initially, trade rates are lower in treatment SS than in treatment SA, suggesting strategic naivete is a greater contributor to overtrading than overconfidence is. We also note that in all treatments other than SAS, average trade rates remain high (close to 50%) by the end of the experiment, indicating that even with controls for behavioral motivations to trade, the tendency to engage in speculative trade is robust and fairly persistent.

Figure 6 decomposes trading rates by subjects’ signal accuracies and shows that accuracy plays an important role in determining trading behavior. In all treatments, subjects with high-accuracy signals trade at substantially higher rates than those with low-accuracy signals and that this gap generally grows with experience, suggesting that subjects are quick to internalize their signal accuracies—even in treatments in which it is not revealed. Moreover, in treatment SN, we find the trend of increasing
trade rates is driven purely by the behavior of subjects with high-accuracy signals; trade rates for low-accuracy subjects remain stable around 40% throughout the experiment. In fact, by the end of the experiment, willingness to trade in treatment SN closely approximates that in treatment SA. We note two additional features of the data. First, while low-accuracy subjects choose to trade less than high-accuracy subjects do, they still trade at fairly high rates toward the end of the experiment. This finding is especially notable in treatment SA, as trading is a weakly dominated strategy for low-accuracy subjects. We speculate that this tendency to trade may in part be explained by experimenter demand effects. Second, trade rates are persistently high among high-accuracy subjects in treatment SAS—in which both behavioral motivations for trade are accounted for. While, we believe this phenomenon is closely linked to tendencies driving behavior in treatments SN and SA—namely, subjects’ preoccupation with their own signal accuracies—we defer further analysis to our discussion in Section 5 but include treatment SAS in our presentation of results for the sake of completeness.

4 Role of Experience

To better understand the main findings discussed in Section 3, we now investigate the role of experience on subjects’ trading behavior in more detail. In particular, we examine whether subjects are more or less willing to trade as they learn more about (1) their own signal accuracies, (2) others’ signal accuracies, and (3) others’ strategies. We first establish theoretical predictions in subsection 4.1, highlighting how fully rational subjects to should respond to information that is provided through feedback. Next, in subsection 4.2, we test these predictions against our data—finding that subjects in our base treatment SN under-respond to data about other subjects’ strategies and signals. In subsection 4.3, we evaluate the optimality of subjects’ trading behavior, given past feedback, finding that while subjects respond optimally to feedback in aggregate, high-accuracy subjects generally over-trade as a consequence of ignoring other subjects’ strategies.

4.1 Theoretical Predictions

In this subsection, we study subjects’ incentives in crossing situations with the aim of understanding how feedback should affect willingness to trade. We begin by first expressing conditional expected payoffs for a subject $i$ from trading and keeping, represented respectively as $\pi_T$ and $\pi_K$—conditional on her partner $-i$ being willing to trade.\footnote{Subjects may suspect they should trade, given they are participating in a trading experiment.} We express payoffs in terms of subject $i$’s own signal accuracy $\alpha_i$, the conditional accuracy of her partner $\mu_{-i}$, and a selection bias statistic, $\beta$.

Let $\omega \in \{B, G\}$ represent the state of the world, such that the ticket paying the high-reward
is identified by \( \omega \). We define \( \mu_{-i} \equiv \Pr[S_{-i} = \omega | a_{-i} = T] \) such that it is the likelihood that \(-i\)'s signal is correct, conditional on \(-i\) being willing to trade. To define \( \beta \), first let \( t_i \in \{B, G\} \) represent the color of subject \( i \)'s ticket. We then let \( \beta \equiv \Pr[S_{-i} = t_i | a_{-i} = T] \), such that conditional on subject \(-i\) being willing to trade, \( \beta \) is the likelihood that subject \(-i\) holds a signal matching the ticket of subject \( i \). Observe that when \( \beta = \frac{1}{2} \), \(-i\) trades at random, and when \( \beta = 1 \), \(-i\) follows the naive strategy of trading-with-signal, leading to full selection bias. In the basic AST game (implemented in treatment SN and SA), subjects’ incentives to trade are expressed in the equations below, such that \( \Delta = \pi_T - \pi_K \) is a subject’s expected gain from trading over keeping.

\[
\begin{align*}
\pi_T &= \beta \frac{12 \alpha_i (1 - \mu_{-i}) + 2 \mu_{-i} (1 - \alpha_i)}{\alpha_i (1 - \mu_{-i}) + \mu_{-i} (1 - \alpha_i)} + (1 - \beta) \frac{12 \alpha_i \mu_{-i} + 2 (1 - \mu_{-i}) (1 - \alpha_i)}{\alpha_i \mu_{-i} + (1 - \mu_{-i}) (1 - \alpha_i)} \\
\pi_K &= \beta \frac{4 \alpha_i (1 - \mu_{-i}) + 14 \mu_{-i} (1 - \alpha_i)}{\alpha_i (1 - \mu_{-i}) + \mu_{-i} (1 - \alpha_i)} + (1 - \beta) \frac{4 \alpha_i \mu_{-i} + 14 (1 - \mu_{-i}) (1 - \alpha_i)}{\alpha_i \mu_{-i} + (1 - \mu_{-i}) (1 - \alpha_i)} \\
\Delta &= \beta \frac{8 \alpha_i (1 - \mu_{-i}) - 2 \mu_{-i} (1 - \alpha_i)}{\alpha_i (1 - \mu_{-i}) + \mu_{-i} (1 - \alpha_i)} + (1 - \beta) \frac{8 \alpha_i \mu_{-i} - 2 (1 - \mu_{-i}) (1 - \alpha_i)}{\alpha_i \mu_{-i} + (1 - \mu_{-i}) (1 - \alpha_i)} \tag{GT}
\end{align*}
\]

A subject \( i \) must weight expected payoffs under two contingencies: (1) her partners hold the opposite signal and (2) her partner holds the same signal. Thus, the first term on the right hand side of (GT) expresses the expected gain from trading for \( i \) when \( i \) and \(-i\) indeed hold opposite signals—i.e. \( i \) receives a signal matching \(-i\)'s ticket and vice versa—weighted by the likelihood \( \beta \). The second term, weighted by \( 1 - \beta \), expresses the expected gain when both subjects receive the signal matching \(-i\)'s ticket. Note that in our parameterization of the AST game, the gain from trading for \( i \) is weakly decreasing in \( \beta \), as signal accuracies are always at least \( \frac{1}{2} \). Additionally, observe that while the incentive for \( i \) to trade is increasing in her own signal accuracy \( \alpha_i \), it may be decreasing or increasing in the conditional signal accuracy of her partner \( \mu_{-i} \).

Recall that in our treatments featuring the augmented AST game (SS and SAS), in which subjects observe their partners’ signals, crossing situations imply that both subjects receive signals matching the other’s ticket, and so \( \beta = 1 \) by construction. Thus, in treatments SS and SAS, \( \Delta \) is increasing in \( \alpha_i \) and decreasing in \( \mu_{-i} \).

**Proposition 5** Suppose that subject \( i \) receives a signal matching the ticket of subject \(-i\). Conditional on subject \(-i\) being willing to trade, subject \( i \)'s expected gain \( \Delta \) from trading for \(-i\)'s ticket in treatments SN and SA is

- increasing in \( \alpha_i \), her own signal accuracy;
- weakly decreasing in the conditional likelihood that \(-i\) holds the opposite signal, \( \beta \);
- decreasing in the signal accuracy of \(-i\), \( \mu_{-i} \), when \( \beta > \frac{1}{2} \), and increasing in \( \mu_{-i} \), when \( \beta < \frac{1}{2} \).
In treatments SS and SAS, $\Delta$ is increasing in $\alpha_i$ and decreasing in $\mu_{-i}$.

### 4.2 Empirical Responses to Feedback

We now assess whether the comparative statics outlined in subsection 4.1 are reflected in our data. We pursue the following approach to test the predictions of Proposition 5. For each round and each subject, we construct proxies ($\alpha_i, \mu_{-i}, \beta$) for our three variables ($\alpha_i, \mu_{-i}, \beta$) by computing empirical averages. That is, we define $\alpha_i$ to be the frequency with which subject $i$’s signal has matched the high-reward ticket in all past rounds and $\beta$ to be the past frequency with which subject $i$’s partner has held the signal matching $i$’s ticket, conditional on subject $i$’s partner being willing to trade.

Table 4: Effect of Feedback on Willingness to Trade

<table>
<thead>
<tr>
<th></th>
<th>SN</th>
<th>SA</th>
<th>SS</th>
<th>SAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_i$</td>
<td>0.58***</td>
<td>0.71***</td>
<td>0.76***</td>
<td>0.87***</td>
</tr>
<tr>
<td></td>
<td>(0.22)</td>
<td>(0.13)</td>
<td>(0.03)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>$\mu_{-i}$</td>
<td>-0.34***</td>
<td>-0.23</td>
<td>-0.52**</td>
<td>-0.14</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.16)</td>
<td>(0.22)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.10</td>
<td>0.29**</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.36)</td>
<td>(0.13)</td>
<td>(0.16)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.34</td>
<td>-0.03</td>
<td>0.26**</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
<td>(0.14)</td>
<td>(0.10)</td>
<td>(0.30)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,396</td>
<td>1,217</td>
<td>1,577</td>
<td>1,068</td>
</tr>
</tbody>
</table>

Note: *p < 0.1; **p < 0.05; ***p < 0.01
Standard errors clustered at session level

Table 4 reports a linear regression of subjects’ willingness to trade on our three proxy variables.\(^{20}\) That is, for each round, we regress a subject’s choice of whether to trade in a crossing situation on the proxies constructed for that round.\(^{21}\) The results in Table 4 lead us to conclude that subjects not only suffer from strategic naivete but are also unable to become more strategically sophisticated through experience. Notably, subjects in treatments SN do not trade less as selection bias ($\beta$) increases and those in SA trade more. On the other hand, subjects do seem to respond to information about signal accuracies in the predicted direction: subjects in treatments SN and SS are more willing to trade if

\(^{19}\)Note that empirical accuracy levels may actually be higher or lower than 80% or 50%, respectively. However, we simply use empirical averages as it bypasses the need for estimating priors and our accuracy averages quickly converge to subjects’ true accuracies—see Appendix.

\(^{20}\)We include results for treatment SAS for completeness. As expected, subjects do not respond to information about past rounds, as they are told both signal accuracies and their partners’ signals. In a similar vein, subjects in SA do not respond to information about signal accuracies of past partners ($\alpha_{-i}$) and those in in SS do not respond to information about selection bias ($\beta$).

\(^{21}\)We do not include controls for subject fixed-effects or true signal accuracies, as both are heavily correlated with our measure of empirical signal accuracy $\alpha_i$.  

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their past signal accuracies are higher and are less willing to trade when their past partners have had more accurate signals. Interestingly, we also find that strategic sophistication interacts with subjects’ responses to others’ accuracies, as subjects in treatment SN are less responsive to others’ accuracies than in treatment SS, in which selection bias is artificially “revealed” to subjects.

(a) Low-Accuracy Subjects

<table>
<thead>
<tr>
<th></th>
<th>SN</th>
<th>SA</th>
<th>SS</th>
<th>SAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\bar{\pi}_{-i})</td>
<td>-0.66***</td>
<td>-0.04</td>
<td>-0.55***</td>
<td>-0.61**</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.14)</td>
<td>(0.20)</td>
<td>(0.25)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.81***</td>
<td>0.34***</td>
<td>0.71***</td>
<td>0.72***</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.10)</td>
<td>(0.13)</td>
<td>(0.19)</td>
</tr>
<tr>
<td>Observations</td>
<td>509</td>
<td>624</td>
<td>527</td>
<td>642</td>
</tr>
</tbody>
</table>

Note: *p<0.1; **p<0.05; ***p<0.01

(b) High-Accuracy Subjects

<table>
<thead>
<tr>
<th></th>
<th>SN</th>
<th>SA</th>
<th>SS</th>
<th>SAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\bar{\pi}_{-i})</td>
<td>-0.10</td>
<td>-0.30</td>
<td>-0.59*</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.32)</td>
<td>(0.32)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.76***</td>
<td>0.89***</td>
<td>0.97***</td>
<td>0.56***</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.23)</td>
<td>(0.29)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Observations</td>
<td>887</td>
<td>929</td>
<td>1,050</td>
<td>795</td>
</tr>
</tbody>
</table>

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5: Effect of Others’ Accuracies on Willingness to Trade

In Table 5, we investigate further how subjects respond to information about others’ accuracies by running separate regressions for subjects with low and high-accuracy signals and find further evidence that subjects’ perceptions of their own accuracies affects the manner in which they respond to feedback.\(^{22}\) Specifically, in treatment SN, subjects with low-accuracy signals trade less when their feedback suggests others are likely to have high-accuracy signals, but those with high-accuracy signals do not respond to feedback about others’ signals.

We note that the dichotomous response of SN subjects to information about others’ signals accuracy strongly resembles the aggregate behavior of subjects in treatment SA. When told both their their and their partners’ signal accuracies, subjects with high-accuracy signals not only choose to trade

\(^{22}\)We present regressions featuring only \(\bar{\pi}_{-i}\) as a dependent variable for the sake of presentation, but results do not change when including \(\pi_{i}\) and \(\bar{\pi}\)—see Appendix.
more frequently than those with low-accuracy signals, but also do not discriminate based on the on the signal accuracies of their partners. That is, high-accuracy subjects in treatment SA choose to trade just as often when paired with a high-accuracy partner as when paired with a low-accuracy partner. In keeping with the dichotomy noted for SN, however, low-accuracy subjects learn to trade less when paired with a high-accuracy partner. Thus, in both treatments SN and SA, a subject’s own signal accuracy plays an important role in whether subjects adjust for accuracy information about others (feedback in SN, presented outright in SA).

![Figure 8: Willingness to Trade by Partner Accuracy (Treatment SA)](image)

4.3 Optimality of Behavior

In this subsection, we evaluate whether subjects behave sub-optimally as a consequence of the patterns documented in subsection 4.2. Substituting our proxies for accuracies $\left(\tilde{\tau}_i, \tilde{\mu}_{-i}, \tilde{\beta}\right)$ into equation GT, we compute subjects’ expected gain from trading over keeping ($\Delta$). For treatments SA, SA, and SAS, we substitute values known to subjects when possible. That is, for treatments SA and SAS, we use subjects’ true accuracies (shown to them) in place of our proxies $\left(\tilde{\tau}_i, \tilde{\mu}_{-i}\right)$, and for treatment SS and SAS, we set $\beta = 1$. Figure 9 examines the rate at which subjects trade in crossing situations, decomposed by whether $\Delta$ is positive or negative.

In aggregate, we find that subjects generally trade for their partners’ tickets when the gain from trading is positive (around 70% of the time) and keep their own tickets when the gain is negative (roughly 60% of the time). However, upon closer examination, we find that high-accuracy subjects—with the exception of those in SS—choose to trade close to as often when expected gain from trading is negative as when it is positive. In other words, the tendency of subjects with high-accuracy signals to under-respond to the accuracies and strategies of others, as documented in subsection 4.2 seems to drive them to choose to trade when doing so is unprofitable in expectation.
We note that the pattern evident in panel 9b persists when we evaluate profitability of trade by averaging past profitability of trading. That is, we construct an alternative measure of profitability by averaging the ex-post profit to trading in crossing situations (controlling for the accuracy of subjects’ partners in treatments SA and SAS) and examine the rate at which subjects choose to trade. Figure 10 displays the result of this exercise for subjects with high-accuracy signals, and again we find that subjects choose to trade just as often (if not more often) when the expected gains to trading are negative as when they are positive. Only in treatment SS are subjects less willing to trade when the expected gains are negative.
5 Discussion

Our aggregate findings for treatment SAS (see Figure 7) are surprising, as subjects with high-accuracy signals persistently choose to trade with their high-accuracy partners (around 80% of the time). Thus, after removing overconfidence by showing subjects’ their partners’ signal accuracies, subjects trade more relative to treatment SS. We note that this result, while unexpected, is consistent with our finding that subjects with high-accuracy signals tend to be more strategically naive in treatment SA. We speculate that inexperienced subjects have strong heuristics regarding signal accuracy, such that they believe they should trade when their own signal accuracy is high. Driven by this heuristic, subjects are more likely to ignore information about their trading partners available in treatment SAS and thus actually trade more than they might if they were not initially made aware that they possess high-accuracy signals.

6 Conclusion

Evidence from the field shows that, in general, retail investors lose money by engaging in speculative trade. We study the persistence of this phenomenon by analyzing the effect of experience on experimental subjects participating in a simple no-trade game. Our design focuses on two leading explanations for speculative trading—overconfidence and strategic naivete—by revealing subjects’ information quality and the information of their trading partners.

We find that strategic naivete is the more important behavioral hurdle investors face. When we reveal signal quality, subjects receiving high-accuracy signals continue to trade with partners receiving equally accurate signals; on the other hand, when we reveal their partners’ signal realizations, subjects choose to trade less as their perception of their partners’ signal quality improves. Additionally, our anal-
ysis reveals an important interaction between information quality and strategic sophistication. Subjects with higher information quality are less sensitive to the information quality of their partners, appearing more strategically naive when they have more accurate signals. This effect appears to be so strong that it can override the experimental features in place to alleviate strategic naivete. In treatment SAS, in which both signal realizations and signal accuracies are revealed, subjects who are told they receive high-accuracy signals consistently choose to trade with partners who also receive high-accuracy signals. We find that as a result their strategic naivete, subjects frequently choose to trade when the expected payoff from keeping their assigned tickets is greater than that of trading for their partners’ ticket. Only in treatment SS, in which we reveal only partners’ signal realizations and thus alleviate selection bias, do subjects trading decisions correlate with their expected gains from trading.

References


Appendices

A Figures

Figure 11: Evolution of Average Accuracy
Figure 12: Selection Bias in Accuracy

Figure 13: Signal Accuracy Conditional on Choice (Last 10 Rounds)
Figure 14: Evolution of Selection Bias ($\bar{\beta}$)

Figure 15: Selection Bias in Treatment SA
B Instructions

Instructions are made available both through a no-download Dropbox link and via the experimenter’s Zoom interface. After distribution, instructions are read aloud, and subjects ask questions aloud, so that all other subjects could hear them, and likewise, questions are answered for all subjects to hear.

In the following pages, we include the instructions we use for our baseline treatment SN. Instructions for our remaining treatments are similar (with minor variations) and can be found on our Online Appendix. We distribute our instructions in parts, so that after completing a task, subjects receive instructions for the next task. The correspondence of parts to task is detailed below.

- **Part 1** explains the color-guessing task.
- **Part 2** explains the belief elicitation task (occurring before the AST game).
- **Part 3** explains the AST game.
- **Part 4** re-explains the belief elicitation task (occurring after the AST game).
INSTRUCTIONS

1. You are about to participate in an experiment on decision-making. What you earn depends partly on your decisions, partly on the decisions of others, and partly on chance. Please turn off cell phones and close any unrelated software or tabs on your computer.

2. Please do not talk or in any way try to communicate with other participants.

3. We will start with a brief instruction period. If you have any questions during this period, please ask and your question will be answered so everyone can hear.

4. This experiment has four parts.
Part 1

*These instructions are for the first part. Once this part is over, instructions for the next part will be given to you.*

This part will consist of four rounds. The first three rounds will be for practice; **you will be paid** for your response in the fourth and final round.

In each round, you will be shown an image of 400 green and blue dots—similar to the one below. You will be asked which color is more common. **In the payment round,** you will earn $10 if you are correct, and $5 if you are incorrect.

![Image of green and blue dots](image.png)

Which is more common?

- Green Dots More Common
- Blue Dots More Common

You will have ten seconds to respond. If you fail to do so, your response will automatically be counted as incorrect.
Part 2

*These instructions are for the second part. Once this part is over, instructions for the next part will be given to you.*

In this part, you will estimate (1) the likelihood that your final response in the payment round of the Part 1 was correct and (2) the percentage of others’ final responses that were correct. Note that everyone was shown the exact same arrangement of green and blue dots.

For each estimate, you will select a number between 0% and 100% on each of the sliders, as shown below.

![Sliders](image)

One of these estimates will be randomly chosen for payment, which is calculated in the following way.

$$
Payment = $4 - \frac{(Your\ Estimate - Correct\ Answer)^2}{5000}
$$

**In words, your payment for the chosen estimate will be higher when it is closer to the correct answer.** The correct answer for the first question is 100% if your final response was correct and 0% if your final response was incorrect. For the second question, the correct answer is the percentage of other subjects whose final responses were correct.
Part 3

In this part of the experiment, you will make trading decisions over 40 rounds. In each round, you will be paired with a random trading partner. You will start every round with a colored ticket (Green or Blue), and your trading partner will start with the other colored ticket. After each round, one ticket will pay out a reward of $14, and the other ticket will pay out a reward $4. Therefore, either:

- The Green ticket pays $14, and the Blue ticket pays $4, or
- The Green ticket pays $4, and the Blue ticket pays $14.

Note: you will start with the same ticket color in all rounds.

Trading

During a round, you choose to either (1) keep your assigned ticket or (2) trade for your partner’s ticket. Trading costs a fee of $2 and only occurs if both you and your partner agree to trade for each other’s tickets. That is:

- If you choose to trade tickets and your partner chooses to keep his/her ticket, you each keep your tickets.
- If your partner chooses to trade tickets and you choose to keep your ticket, you each keep your tickets.
- If both you and your partner choose to trade tickets, you will trade tickets, and a fee of $2 will be subtracted from each of your rewards.

Clues

Before you trade (or not), you will receive a clue—either Green or Blue—as to which ticket pays out the high reward. You and your partner may receive different clues. The likelihood your clue matches the high-reward ticket is determined by your final response from Part 1.

- If your final response was correct, your clue will match the high-reward ticket 80% of the time.
- If your final response was incorrect, your clue will match the high-reward ticket 50% of the time.
Submitting a Trading Decision

Your clue will be automatically generated by the software. Before the clue is revealed, you will submit a trading plan to specify how you would like to trade depending on the clue you receive. That is, you choose (1) whether you’d like to trade if your clue is Green and (2) whether you’d like to trade if your clue is Blue. After you submit these two choices, the software will reveal your clue and will implement a trading decision based on your clue and your trading plan.

The two examples below illustrate how submit a trading plan. In the first example, you start with a Green ticket, and in the second example, you start with a Blue ticket. In both examples, if your clue is Green, your trading decision will be determined by your choice in the “Green clue” row, and if your clue is Blue, your trading decision will be determined by your choice in the “Blue clue” row. To submit your trading plan, simply click on the choice you’d like to take for each clue.

**You own a Green Ticket: Submit a trading choice for each clue**

<table>
<thead>
<tr>
<th>Clue</th>
<th>Your Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Trade for Blue Ticket</td>
</tr>
<tr>
<td>Blue</td>
<td>Trade for Blue Ticket</td>
</tr>
</tbody>
</table>

**You own a Blue Ticket: Submit a trading choice for each clue**

<table>
<thead>
<tr>
<th>Clue</th>
<th>Your Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Trade for Green Ticket</td>
</tr>
<tr>
<td>Blue</td>
<td>Trade for Green Ticket</td>
</tr>
</tbody>
</table>
Interface

You submit your choices on the left side of the interface shown below.

1. After you submit your trading plan, you will be shown your clue and trading decision.
2. Clicking next will reveal your partner’s clue, trading decision, and the trading outcome.
3. The final page in a round will reveal the high-reward ticket and your earnings.

At the bottom of the interface, you will see a history table. Each column displays the following information:

- The first column “Round” of a row displays the round the data is drawn from;
- The second column “Trade” indicates if you and your partner traded;
- The third column “Your Clue” shows your clue;
- The fourth column “Your Choice” shows whether you decided to trade or keep;
- The fifth column “Partner’s Clue” shows your partner’s clue;
- The sixth column “Partner’s Choice” shows whether your partner decided to trade or keep;
- The seventh column “High Reward” shows which ticket paid out the high reward of $14;
- The final column “Your Earnings” shows your earnings from the round.

Payment

Your earnings from a round will equal the reward from the ticket you hold at the end of the round, minus the $2 trading fee if you and your partner traded. One round will be randomly selected for payment at the end of the experiment.
Summary

- Either your ticket or your partner’s ticket will pay out a high reward of $14, and the other ticket will pay out $4;
- Both you and your partner will receive potentially different clues that are more likely to match the high-reward ticket if your final responses from Part 1 were correct;
- Your decision for each round is whether or not to trade tickets with your partner, depending on the clue you receive;
- If you and partner both choose to trade tickets, you will each pay a trading fee of $2;
- You will be randomly rematched to a partner each round.
Part 3

In this part of the experiment, you will make trading decisions over 40 rounds. In each round, you will be paired with a random trading partner. You will start every round with a colored ticket (Green or Blue), and your trading partner will start with the other colored ticket. After each round, one ticket will pay out a reward of $14, and the other ticket will pay out a reward $4. Therefore, either:

- The Green ticket pays $14, and the Blue ticket pays $4, or
- The Green ticket pays $4, and the Blue ticket pays $14.

*Note: you will start each round with the same ticket color.*

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**Trading**

During a round, you choose to either (1) keep your assigned ticket or (2) trade for your partner’s ticket. Trading costs a fee of $2 and only occurs if both you and your partner agree to trade for each other’s tickets. That is:

- If you choose to trade tickets and your partner chooses to keep his/her ticket, you each keep your tickets.
- If your partner chooses to trade tickets and you choose to keep your ticket, you each keep your tickets.
- If both you and your partner choose to trade tickets, you will trade tickets and will each pay a fee of $2.

**Clues**

Before you trade (or not), you will receive a clue—either Green or Blue—as to which ticket pays out the high reward. You and your partner may receive different clues. The likelihood your clue matches the high-reward ticket is determined by your final response from part 1.

- If your final response was correct, your clue will match the high-reward ticket 80% of the time.
- If your final response was incorrect, your clue will match the high-reward ticket 50% of the time.
Part 4

These instructions are for the last part of the experiment.

In this part, you will again estimate (1) the likelihood that your final response in the payment round of the Part 1 was correct and (2) the percentage of others’ final responses that were correct. Note that everyone was shown the exact same arrangement of green and blue dots.

For each estimate, you will select a number between 0% and 100% on each of the sliders, as shown below.

One of these estimates will be randomly chosen for payment, which is calculated in the following way.

\[
Payment = 4 - \frac{(Your \ Estimate - Correct \ Answer)^2}{5000}
\]

In words, your payment for the chosen estimate will be higher when it is closer to the correct answer. The correct answer for the first question is 100% if your final response was correct and 0% if your final response was incorrect. For the second question, the correct answer is the percentage of other subjects whose final responses were correct.