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Professional trader discipline and trade disposition ☆

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Abstract

Recent evidence indicates irrational behavior among retail investors. They hold onto losses and sell winners in a manner consistent with the disposition effect. Market professionals often use the term "discipline" to indicate trading strategies that minimize potential behavioral influences. We investigate the nature of trading discipline and whether professional traders are able to avoid the costly irrational behaviors found in retail populations. The full-time traders in our sample hold onto losses significantly longer than gains, but we find no evidence of costs associated with this behavior. The successful floor futures traders in our sample exhibit trading

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behavior characterized as rational and disciplined. Moreover, measures of relative trading discipline have predictive power for subsequent trading success.

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1. Introduction

The behavioral finance literature suggests that certain market anomalies are consistent with the presence of irrational trading by investors (e.g., Bernartzi and Thaler, 1995).[1] Recent evidence, for example, Odean (1998a) and Grinblatt and Keloharju (2000), suggests that various populations of traders exhibit irrational behavior. Odean (1998a) finds that winning stocks sold by a sample of retail traders subsequently outperform the losers that they continue to hold, evidence he attributes to the disposition effect.[2] Grinblatt and Keloharju (2000) find that Finnish retail investors are reluctant to realize losses, after controlling for trading style (which Odean does not) and many other factors. They also find significant differences in trading styles between Finnish retail investors and foreign institutions, as does Grinblatt and Keloharju (2001), suggesting that professionals could differ from retail customers. However, little evidence has been offered as to whether the disposition effect influences the decisions of professional traders.[3]

Is it surprising that small retail investors have eccentric and potentially costly trading patterns? Evidence of irrationality, including the disposition effect or overconfidence (e.g., Odean, 1998b), is certainly consistent with conventional wisdom and anecdotal evidence. Generic trading advice literature typically warns against the type of trading patterns described by the disposition effect and proposes instead disciplined approaches, through which investors are advised to use predetermined trade exit points (times or prices) to mitigate any potential behavioral

[1] Barberis and Thaler (2002) define behavioral finance as the study of how irrational behavior could influence market prices, driving them from their fundamental values.

[2] Ranguelova (2001) shows that evidence of the disposition effect in Odean's sample is found only in highly capitalized stocks and that it could be mitigated by analyst coverage, suggesting informational explanations for the patterns. Fama (1998) discusses some of the pitfalls in interpreting empirical results as evidence of irrationality. In Shefrin and Statman (1985), the disposition effect is costly because of overpayment of taxes. Additional support for the behavioral basis for the disposition effect and associated costs is provided by Kahneman and Tversky (1979), Kahneman et al. (1990), Heisler (1996), Weber and Camerer (1998), Barber and Odean (2000, 2001) and Shapira and Venezia (2001). Other research, including Shefrin and Statman (1985) and Ferris et al. (1988), looks at volume patterns for stocks conditioned upon prior price changes. In an experimental setting, Kirchler et al. (2002) find a framing effect, as well as an apparent disposition effect, though this is mitigated by positive framing.

[3] Coval and Shumway (2005) examine behavior on the Chicago Board of Trade. Haigh and List (2005) find, in an experimental setting, that a small self-selected sample of 54 professional traders are *more* prone to show symptoms of myopic loss aversion than 64 undergraduate students.

costs from irrational mental accounting or overconfidence. (Dozens of trading advice books have been published, many during the day trading boom of the latter 1990s.) The conventional wisdom among professional traders is that disciplined trading, or the avoidance of behavioral biases, is the key to success, as the following quotations illustrate.

> To be a successful trader, I must love to lose money and hate to make money. The first loss is the best loss; there is no better loss than the first loss. Trading is a discipline.
> *From* "*EEK*" (*memoirs of Chicago Board of Trade member Everett Klipp*, *1995* (*EEK represents his trading floor badge ID*))
> One of the critical criteria I use in judging my traders is their ability to take a loss. If they can't take a loss, they can't trade.
> *John Mack*, *Morgan Stanley chief executive officer* (*CEO*), *in a 1991 deposition.*
> If you have bad inventory, mark it down and sell it quickly.
> *Attributed to Bear Stearns chairman Alan* "*Ace*" *Greenburg*, *describing his penchant for quickly selling losing trades*, *in the* Wall Street Journal ("*If Wall Street were Olympian*, *He'd Ace the Marathon*," *March 8, 1999*)
> So, as our discipline requires, we sold.
> *J. Stowers*, *CEO*, *American Century Funds*, *in a December 10, 1999 letter to investors*
> Never meet a margin call. (In other words, if the market is going against you, concede defeat quickly and liquidate before you really lose your shirt.)
> *James Grant*, *editor*, Grant's Interest Rate Observer, *quoted in* BusinessWeek ("*Failed Wizards of Wall Street*," *September 21, 1998*)

If professional traders' discipline minimizes behavioral costs, then models of trader irrationality describe only small numbers of investors or lightly capitalized investors whose behavior has little impact on price formation. In particular, the irrational practice of treating stocks differently depending on their history (e.g., gains versus losses) could be an annoying but essentially harmless anomaly, with the cure (yet again) being buy and hold, particularly in the absence of momentum. Evidence that professional traders are undisciplined or exhibit costly irrationality would heighten support for behavioral approaches to asset pricing and also to other areas.[4]

Using high-frequency transactions data, we study the trading behavior of professional futures traders on the Chicago Mercantile Exchange (CME), where trades are typically offset in a matter of minutes. These traders depend on the profitability of their trading to meet the direct (exchange seat lease) and indirect (opportunity) costs of trading in the pit. We examine approximately 300 traders active in four CME commodities during 1995. Much of the analysis is based on the first six months of 1995, with the second six months held for out-of-sample testing.

[4]See, for example, the models of Barberis et al. (1998), Barberis et al. (2001), and Daniel et al. (1998, 2001). Grinblatt and Han (2002) suggest that the disposition effect drives observed momentum in stock returns.

We investigate the relation between discipline and future success using two measures of trading discipline that are consistent with indicators of futures trading success described in Silber (1984). The first is trading speed, or how quickly trades are offset. This fits with our interpretation of trader discipline as the outcome of rational decisions to exit trades once informational advantages dissipate, using the metric of time instead of price change as the predetermined constraint. In the context of high-frequency trading environments such as the futures pits, orderflow-related informational advantages, which are described as semi-fundamental information by Ito et al. (1998), are likely to be short-lived and should result in relatively quick trade exists if disciplined traders use a time metric. The second measure of discipline is exposure, determined by the magnitude of paper losses per contract on trades held for a long time. Disciplined traders presumably resist holding onto large potential losses that they hope will turn around. Whether discipline is defined as adhering either to preset exit prices or to predetermined offset intervals, disciplined traders will be less likely to sit on large paper losses. We then examine the relation between these discipline measures and subsequent trader success in out-of-sample data.

We find that the two discipline measures are positively related to subsequent success. Traders who offset trades quickly are more successful in the future.[5] In addition, traders who are more prone to hold onto large paper losses are less likely to be successful in the future. This second result could indicate that less successful traders are subject to the disposition effect and hold large losses beyond the rational exit time, impairing their chances of success. However, we find that the speed at which traders offset winning trades is just as helpful in predicting success as the speed at which they close losses.[6] Therefore, while a lack of time-based discipline is costly (in terms of a lower probability of future success), this cost does not appear to be associated with the disposition effect.

We offer alternative explanations for the relation between excessive retention of large losses and a subsequent lack of success. Consider trades entered on the basis of some Bayesian prior, with new information continually entering into the decision to close the trade and thereby realize a gain or loss. If we characterize as overconfident a trader who places too much weight on the prior (a common definition), then overconfident traders could be most likely to retain losing trades, ignoring negative new information for too long. If our discipline measures are related to overconfidence, then our finding that less disciplined traders are subsequently less successful is consistent with Odean (1998b), as well as Daniel et al. (2001), who find that overconfident traders take excessive risk and underperform rational traders.[7]

The discipline/success results suggest that trading speed is an important factor in profitability. Our data also allow us to investigate the offset speed of winners versus

[5]This bolsters the limited finding regarding trade time in Silber (1984), who suggests that dealer informational advantages could be extremely short lived, so that trade profitability is highly correlated with the speed of offset.

[6]We thank the referee for suggesting this decomposition.

[7]Biais et al. (2002) also find that overconfidence diminishes profitability in an experimental setting. In a different framework, Bernardo and Welch (2001) show that overconfident traders could survive if their trading has positive externalities.

losers using methodology similar to Odean (1998a). We first examine the entire population of traders and find that traders consistently hold losing trades for significantly longer periods of time than winning trades. However, we fail to find costs associated with this behavior, in direct contrast to Odean (1998a). Nor do we find a contemporaneous relation (within the first six-month period) between trader success and the tendency to hold losers longer.

Our inability to find costs associated with the tendency to hold losers longer than winners contrasts with evidence of costly behavior provided by Coval and Shumway (2005). Coval and Shumway find that traders with midday losses subsequently exhibit increased risk taking and poorly executed trades, results they attribute to prospect theory, and that the losing positions are held longer than gains, a result they interpret as consistent with loss aversion. Differences between our findings and those of Coval and Shumway are possibly the result of different datasets (their data are for the Chicago Board of Trade in 1998) but more likely are driven by important methodological differences, particularly regarding the time frame and trade aggregation. Similar to Odean (1998a), we examine behavior on a trade-by-trade basis, with our trades occurring over time horizons measured in minutes. Coval and Shumway (2005) define gains and losses via temporal aggregation, not on a trade-by-trade basis, examining the role of cumulative morning gains or losses on afternoon trading, an approach also taken by Locke and Mann (2003). Despite substantial differences in methodology (and exchanges), both of those papers provide evidence that morning losses lead to greater risk taking in the afternoon.[8] For the Coval and Shumway evidence to be consistent with loss aversion, trader behavior must depend on the mental accounting of gains and losses in a cumulative sense, instead of on a trade-by-trade basis. If so, then the trade-level results that we observe, i.e., no apparent costs of holding losses longer than gains, could be subsumed as gains or losses accumulate.

Our failure to find any immediate costs associated with otherwise apparent loss aversion (holding losses longer than gains) led us to examine the sensitivity of the apparent loss aversion to the choice of benchmark. We identify other reasonable benchmarks for gains and losses, somewhat akin to using a market model to identify excess returns. While the zero benchmark is intuitive and clear, it is also reasonable to assume that professional traders focus on net gains or losses. When we benchmark gains and losses on the basis of an expected profit, we find little evidence that traders hold net losers longer.

The paper's remaining structure is as follows. Section 2 describes the futures trading data and general methodology. In Section 3 we present the results, and Section 4 concludes.

[8]Locke and Mann (2003) examine cross-sectional variation in the documented income-related temporal shifts in exhibited risk tolerance, finding that successful traders are significantly less likely to increase risk exposure after suffering losses than are their less successful counterparts.

2. Data and methodology

The futures trading pit that forms our data-generation mechanism has been described in some detail. Kuserk and Locke (1993) describe the high-frequency trading of futures floor traders trading for their own account, and Silber (1984) examines several such traders. Manaster and Mann (1996, 1999) delve further into inventory management and sources of profits for futures floor traders. Together, the evidence in these papers suggests that a large group of floor traders trade frequently for their personal accounts, making small but positive revenue per trade, on average, and rarely holding overnight positions. From this environment we seek evidence of the disposition effect and relative discipline among floor traders.

2.1. The data

We use transactions data from the Chicago Mercantile Exchange, supplied by the U.S. Commodity Futures Trading Commission. We examine the first and second six-month periods of 1995 for the two most active currencies (deutsche marks and Swiss francs) and the two most active nonfinancial commodities (live cattle and pork bellies). We use the first six months of data to show trader behavior and the second six months to examine the relation between measures of trader discipline and subsequent trader success.

We select all traders who executed at least five trades for their personal account on at least ten different days during the 1995 calendar year, resulting in a sample of 334 traders. The selected traders were responsible for 99.5% of the personal account volume traded in these contracts during this period. The excluded traders are either much more transient or, more likely, were offsetting brokerage error trades.

Table 1 provides descriptive statistics for the traders and the volatility of the instruments for each six-month period. The typical daily dollar trading range (measured for the most active contract month each day) is consistently higher for the currency contracts across each period. Alternatively, when we compare trading ranges as a percentage of contract notional value, we see that pork bellies exhibit the highest percentage volatility, while the deutsche mark exhibits the least. Describing, for convenience, only the first six months, we see that the $1,229 mean daily price range for a futures contract for the Swiss franc (based on 125,000 francs per contract) is almost 100 times the minimum price increment, or tick, of $12.50, but that the mean daily percentage range is 1.17%, much smaller than the typical percentage range for pork bellies, which averages 3.12%. While cattle futures have the smallest typical daily price ranges, the mean daily range, at $353, is still over 35 times the tick, and the percentage range (1.31%) is slightly higher than that of the franc.

In addition to volatility statistics, Table 1 provides statistics on income and volume for personal trades included in the sample. The number of selected traders in the first and second six-month periods are presented. As these traders are under no obligation to trade, and most could trade any commodity at any time, there is some degree of exit and entrance. Slightly fewer traders are active in the second six-month

Table 1
Sample descriptive statistics. Data are for floor traders on the Chicago Mercantile Exchange, for the first and second six months of 1995. The sample contains all traders who executed at least five personal account trades on at least ten different trading days in 1995. The price range statistics are calculated for each commodity using the contract month with the highest volume for any given day, while other statistics combine all contract months. Income figures are based on daily trader incomes calculated by marking any end-of-day positions to market with contract settlement price.

Statistic	Deutsch mark		Swiss franc		Live cattle		Pork bellies	
	January–June	July–December	January–June	July–December	January–June	July–December	January–June	July–December
Mean daily price range (dollars)	906	660	1,229	905	353	283	512	563
Median daily price range (dollars)	788	544	1,119	775	330	240	480	540
Mean notional contract value (dollars)	87,324	87,792	105,063	107,829	26,880	26,326	16,397	21,789
Mean range as percent of mean value	1.04	0.75	1.17	0.84	1.31	1.07	3.12	2.59
Number of traders	109	100	86	84	98	95	36	35
Trader mean total contracts traded	12,344	9,549	10,187	7,722	7,770	6,842	3,806	3,279
Daily mean contracts traded per trader	121	97	104	85	79	70	37	37
Mean revenue per contract, all traders (dollars)	6.49	6.32	8.93	6.20	5.64	4.88	15.53	20.50
Total trader gross trading income (dollars)	8,744,641	6,030,949	7,819,764	4,025,140	4,293,790	3,175,152	2,128,527	2,352,982
Trader mean daily trading incomes								
Lower quartile trader (dollars)	−32	42	51	2	31	11	182	181
Median trader (dollars)	510	381	440	431	218	154	494	552
Upper quartile trader (dollars)	1,070	728	1,395	1,012	629	397	964	1,023

period across the four commodities. The highest number of traders is in the deutsche mark contract, and the fewest in bellies.[9] Traders earn a small amount per contract on a round-trip basis, about one tick (a minimum price change) or less across all four commodities. The table reports the aggregate income for the sample of floor traders. In a sense this is a measure of the gross value added of the exchange. Also presented in the table are the quartiles for mean daily income across traders, illustrating the substantial heterogeneity in terms of income across these trader groups.

2.2. Trade histories and accounting

This section describes the trade accounting methodology we use to determine a trader's daily trading history. We construct trade sequences for each trader (and also for each different contract delivery month in which the trader executes personal account trades) for each trading day during the entire 1995 sample period. We use only the first six months to test for evidence of discipline and the disposition effect and then use the second, hold-out six-month sample to examine the relation between discipline and future success. The data provide trades sequenced to the minute. For each minute of the trading day (for each contract) we determine the quantity of contracts that traders buy and sell. In addition, we calculate certain market statistics by minute. We assume that all trades are closed out at the end of each day, so traders carry no overnight position. Kuserk and Locke (1993) and Manaster and Mann (1996) present evidence that floor traders rarely hold overnight positions.

Sometimes a trader executes multiple trades in the same minute, which we are unable to sequence because the time indicator reveals only the minute of the trade. If a trader buys contracts at two different prices during a minute, we consolidate the trades and use the quantity-weighted mean price as the trader's purchase price for that minute. We treat sales analogously so that, for each minute, we track each trader's buy volume and mean purchase price as well as the trader's sell volume and mean sales price.

We develop a methodology for revenue and timing accounting. Trading language typically refers to how much was made or lost on "a trade." For a simple trade, in which something is purchased and then later sold (or vice versa), the trade is easy to define, as are any revenues associated with it. But floor trader histories typically exhibit much more complicated trade sequences. Therefore, we use average cost to allow trades, and their associated revenues, to be defined without resorting to either specific identification accounting (attempts to match specific contract purchases with specific sales) or a LIFO/FIFO (last in, first out/first in, first out) scheme. This method parallels Silber (1984). We employ analogous methods to calculate the length of time that positions are held. A complete description of this methodology, with a numerical example, is provided in the Appendix.

[9]Generally, traders are free to migrate among these and other CME pits, although Kuserk and Locke (1993) find little evidence of frequent pit-hopping. Chang et al. (1994) find evidence of pit-specific trading skills, consistent with the existence of pit-specific semi-fundamental (order flow) information.

The trading *cost* for each contract in a trader's position at the beginning and the end of each minute is defined as the quantity-weighted average price for the position. We use trading cost in a generic sense: Long position cost is the average purchase price and short position cost is the average sale price. At any particular time, a trader's position is either long or short, or the trader has no position. When trades augment an existing position (e.g., long traders buy or short traders sell), average per contract cost is adjusted. When a trader reduces a position (e.g., long traders sell or short traders buy), the per contract average cost of the remaining position is unchanged.

We calculate the *holding time* for all trades in a manner analogous to the cost basis. The holding time for a trade increases by one minute at the start of each minute. As a trader adds to a position, the holding time associated with each existing contract in the position is reduced to reflect the shorter holding time of the newest contracts. As positions are reduced but not eliminated, the holding time of the remaining position increases because additional time has passed.

A *roundtrip* describes the purchase and sale, in either order, of one contract. For a particular trade, the number of roundtrips is the quantity of contracts in a sale that offset prior purchases or the number of purchased contracts that offset a prior sale. Thus, roundtrips indicate the number of contracts involved in a completed trade.

Existing positions can be characterized by their unrealized trading gains or unrealized trading losses. We calculate the sequence of each trader's unrealized revenues by marking the trader's positions to market each minute, performing this calculation for all minutes that they trade as well as all minutes between trades. We mark positions to market by comparing the cost of the position with the average pit price each minute. The average pit price is the quantity-weighted average transaction price for all trades within the minute. If the average pit price is higher than a long position's cost, then the position has an unrealized gain and a positive mark-to-market. A positive mark-to-market indicates that, at that time, the position could be closed for a gain; a negative mark-to-market indicates that the position would probably be closed at a loss.

In addition to a running mark-to-market, we count the minutes that a trader has the opportunity to complete a trade with an outcome similar to the eventual outcome but does not. For example, consider a trade that is held for 20 minutes and subsequently completed with a gain. If, over the 20 minutes that the position was held, the position was marked to market at a gain for 12 minutes and at a loss for eight minutes, then for that trade we count 12 *potential exit* minutes. Each losing trade's potential exit minute statistic represents the number of prior opportunities to take a loss; potential exit minutes for gains represent the number of prior opportunities to take a gain. For trades that are offset within a minute, we treat potential exit minutes as undefined.

We also calculate for each trade the position size and mark-to-market for each of these potential exit minutes. For trades resulting in losses, we evaluate position size (number of contracts held) and the mark-to-market for only those minutes in which the mark-to-market is negative, with corresponding calculations for trades resulting in gains. Finally, for each trade, we calculate the average position and

mark-to-market across those potential exit minutes to complement the simple count of potential exit opportunity minutes.

In sum, for every trade, we record the revenue, cost, holding time, the current mark of the trader's position, the count of potential exit minutes, and the average position and mark over those potential exit minutes. We also calculate the maximum and minimum marking to market over the trade's history. The gross *revenue* from a trade is the sale price or cost of the short position minus the purchase price or cost of the long position. The sequence (buy first and sell later, or vice versa) is irrelevant to futures market accounting.

We also calculate several proxy measures of net revenue. For these, we assume that traders lease the seat that allows them to trade and that they bear an opportunity cost (e.g., daily salary) by being physically present in the pit to trade. These two costs are, unfortunately, unobservable. Instead, we rely on measures of expected income per trade as proxies for lease, wage, and other costs (described in Section 3.1).

2.3. Intraminute trades

In this section we describe the characteristics of the subset of trades that are offset within a minute (i.e., buys and sells with the same time stamp). Our goal is to make inferences about trader decision processes regarding existing positions. However, a cursory examination of the data reveals that traders frequently execute offsetting transactions (buys and sells) during a minute while leaving their basic position unchanged. Sometimes traders change their positions while executing some intraminute offsetting trades as well. The data do not allow a sequencing of these intraminute trades, making some inferences from these trades problematic.[10] Because of this uncertainty, we isolate these trades for our cost and time accounting, imposing no changes to the holding times or average costs of existing positions. We do, however, include the trades in our analysis, and the revenue and holding times are calculated accordingly. The revenue for an intraminute trade is the quantity traded times the difference between the sale price and the purchase price. The holding time for an intraminute trade is zero. Because these trades are a significant fraction of all trades, we describe them in some detail relative to other trades. Table 2 provides summary statistics for these intraminute trades compared with other trades in the January-to-June sample.

The results in Table 2 indicate that intraminute trades constitute roughly 20% of all trades for each of the four pits, ranging from a high of 25% for the deutsche mark to a low of 18% for pork bellies. Comparing these offset trades with other trades that are held longer, we note three results in particular. First, intraminute trades are much more likely to be executed with realized revenues equal to zero (scratch trades)

[10]Consider a trader holding an open position of one contract long at the end of a minute. Suppose that, during the next minute, the trader buys one contract and sells one contract. While the intraminute sequence of the buy and sell trades is unavailable, we do know that the trader is still long one contract at the end of that minute.

Table 2
Descriptive statistics for intraminute trades compared with trades held at least one minute (others). Intraminute trades are those roundtrips in which the purchase and sale occur in the same minute, with unknown sequence. The quantity of intraminute roundtrips is the minimum of the quantity bought and the quantity sold during a minute. If there are only purchases or sales but not both within a minute, then there are no intraminute trades for that minute. Trades in the "others" category are round-trip transactions (contracts bought and sold) in which the position is held at least one minute.

Statistic	Deutsch mark		Swiss franc		Live cattle		Pork bellies	
	Intraminute	Others	Intraminute	Others	Intraminute	Others	Intraminute	Others
Number of round-trip trades	70,184	213,960	52,361	168,456	28,396	104,840	7,966	36,081
Percent intraminute	24.7		23.7		21.3		18.1	
Mean trade size (contracts)	4.2	4.4	3.4	3.8	4.1	4.3	2.1	2.1
Mean revenue per contract (dollars)	6.34	6.71	10.88	8.87	4.40	7.16	13.60	17.92
Quantity-weighted								
Mean revenue per contract (dollars)	7.69	7.15	13.14	7.49	5.45	8.19	16.13	19.38
Median revenue per contract (dollars)	5.83	6.57	12.50	12.50	1.67	9.46	10.00	20.00
Gain/loss interquartile range (dollars)	15.00	62.50	25.00	100.53	10.00	56.15	28.33	120.00
Percentage of round-trip								
Trades with zero revenue	23.8	6.1	17.7	3.6	38.5	4.3	34.8	3.7
Percentage of nonzero								
Trades with positive revenue	66.7	57.7	71.5	58.1	73.6	59.8	80.9	60.4

than are trades that are held at least one minute (other trades). For example, 24% of deutsche mark intraminute trades are scratch trades (zero income), compared with only 6% of other deutsche mark trades. Second, considering only trades that exhibit a gain or a loss, we see that intraminute trades are predominantly gains to a much greater extent than are trades with longer holding times. For example, the proportion of gains for intraminute offsets ranges from 67% (deutsche mark) to 81% (bellies), in contrast to 58% (deutsche mark) and 60% (bellies) for trades held longer.[11] Third, as a somewhat mechanical result, trades that are held longer exhibit more revenue volatility than do the intraminute trades. The interquartile range of per contract gains and losses is three to five times wider for trades held for a minute or longer than for the intraminute trades.

3. Empirical results

We first present evidence on the nature of trading discipline and trading success. After developing empirical measures for discipline and success, we present evidence indicating a positive relationship between relative discipline and relative success. We then investigate the possibility that relative discipline is driven by relative irrationality, focusing on the possible existence of the disposition effect. We find little support for costly irrationality among the traders in our sample.

3.1. Discipline and success

In this section we present our evidence on the relation between measures of discipline and trading success. It is reasonable to assume that futures floor traders operate on the basis of short-lived information, given the high frequency of trading that we observe. Manaster and Mann (1999) posit that order flow contains information signals observed to some extent by floor traders, an aspect of what Ito et al. (1998) describe as semi-fundamental information. If this information is short-lived, any positions taken on the basis of such information should also have a short holding time. We consider the relative speed at which traders open and close positions to be a measure of their trading discipline, given that the longer a position is held, the more likely it is that the position has outlived the informational basis for the trade, as described by Silber (1984). We investigate success and discipline by comparing the profitability of trades for various holding times across trader success groupings.

To determine whether trading success is related to trading behavior, we require a working definition of trading success. Intuitively, trading success ought to be directly related to trading revenue. However, the degree of risk undertaken to achieve short-term revenue is vital to long–run survival. We therefore use two related measures of success. The first is total income for each six-month sample period. The second,

[11]All differences significant at a 1% level (two-sample binomial test for equal proportions, normal approximation).

which we label "risk-adjusted performance" or RAP, measures a trader's daily return on an amount related to the economic capital required to cover potential losses that could result from trading during the period. The RAP measure gives low rankings to traders who are successful in terms of income, but who expose themselves to relatively higher risk in the process of generating that income.

We estimate a trader's economically required capital by considering the trader's marked-to-market position for each minute of each day that the trader trades. We define the maximum exposure for each trader on each day as the absolute value of the trader's maximum loss exposure (negative mark-to-market) that day. In some cases this could be the largest loss taken by a trader but more generally will represent the largest potential loss. We define an ex post value-at-risk (VaR) measure as the 95th percentile daily maximum exposure for the trader. If a trader trades for 100 days, we take the trader's fifth largest potential loss over the 100 days as the ex post VaR.

Given our VaR estimates of trading capital requirements, we define the RAP as average daily income divided by the VaR. Table 3 reports distributional statistics for RAP rankings during the first six months. Traders with similar average trading incomes vary widely in the amount of risk they take to earn that income. The first two columns report median incomes and median 95th percentile potential losses for the traders within each quartile. The median trader in the highest RAP quartile for the deutsche mark earned a daily average of $1,101, and the 95th percentile potential loss for that trader was $3,398.

The last column of Table 3 provides the RAP for the median trader within each quartile. The median deutsche mark trader in the highest RAP quartile has an RAP of 0.36. A natural interpretation of the RAP is the relation between income and potential loss. In this sense, traders with an RAP of 0.20 risk at least five times their average daily trading income around once every 20 days. Table 3 indicates that low-RAP traders expose themselves to much more risk for a given level of income. For example, the median deutsche mark trader in the third quartile has an RAP of 0.06, indicating that the trader risks about 17 times his or her mean daily income every 20 days.

Table 4 reports mean revenue per contract for trades classified by holding times across trader success quartiles. The first five columns report average income per contract for traders ranked by risk-adjusted performance and the next five columns present the same statistics using trader ranks determined by total income. As the table shows, profitability remains relatively constant across holding times for higher-ranked traders, in marked contrast to the lowest-ranked traders. For example, deutsche mark traders in the lowest RAP quartile earn $8.63 per contract on average for trades held less than one minute, but they lose $11.52 on average for trades held longer than ten minutes. In contrast, deutsche mark traders in the highest RAP quartile have comparable revenue per contract of $8.44 and $14.87, respectively.

These results are illustrated clearly in Figs. 1 and 2. The lowest-ranked traders earn revenues comparable to their more successful peers for holding times of up to ten minutes. But trades held longer than ten minutes are especially unprofitable for less successful traders. If discipline is defined as the propensity to trade quickly when

Table 3
Risk-adjusted performance (RAP) for the first six months of 1995. RAP is trader mean daily income divided by the trader's 95th percentile potential loss, which is based on the distribution of the largest negative marking to market on each day the trader traded in the sample. The 95th percentile of the distribution of these daily statistics is the 95th percentile potential loss.

Pit (Number of traders)	Mean daily income for the median trader within the quartile (dollars)	Ninety-fifth percentile potential loss for the median trader within the quartile (dollars)	RAP for the median trader within the quartile
Deutsche mark (109)			
Lowest quartile RAP	(205.09)	4,523.38	(0.05)
Below median RAP	518.57	9,231.49	0.06
Above median RAP	472.06	3,223.28	0.14
Highest quartile RAP	1,100.50	3,398.11	0.36
Swiss franc (86)			
Lowest quartile RAP	(240.07)	5,148.33	(0.02)
Below median RAP	300.69	7,752.35	0.04
Above median RAP	1,048.57	6,609.09	0.15
Highest quartile RAP	1,518.79	3,593.09	0.40
Live cattle (97)			
Lowest quartile RAP	(68.65)	2,355.45	(0.02)
Below median RAP	336.51	3,447.36	0.09
Above median RAP	372.68	2,002.80	0.17
Highest quartile RAP	559.93	1,334.18	0.38
Pork bellies (35)			
Lowest quartile RAP	33.30	5,780.00	0.02
Below median RAP	1,212.45	5,798.79	0.15
Above median RAP	750.26	2,995.61	0.26
Highest quartile RAP	549.51	1,014.52	0.55

a position is not likely to be profitable, then the evidence in this section is consistent with the notion that discipline is related to success. The strategy followed by successful traders on average is consistent with the short-lived information hypothesis.

The relation between discipline and contemporaneous success is subject to a mechanical bias, however, because profitability is essentially a component of both measures. All else equal, low income traders are more likely to earn less on their trades, which take longer to offset, hence they are undisciplined and low income by definition within the same sample. In particular, the simultaneous relation between success and discipline is most evident for trades held a long time, because trades must generally be held a long time to lose a considerable amount of value. To address the simultaneity problem, we develop several proxies for relative discipline and examine the relation between these proxies and subsequent, instead of simultaneous, trading success. We also expand the data set to include the second six-month period for our

success measurements, after establishing relative discipline for the first six-month period.

Traders with less discipline should exhibit longer holding times for their trades. Therefore, as one set of proxies for relative discipline, we use trader mean and median holding times. For each trader, we calculate holding times for each trade completed from January through June 1995 and then calculate mean and median holding times for that trader, combining winner trades with losers. We report all results using statistics for holding times of gains and losses combined.[12]

As alternative measures of discipline, we use each trader's mean and median potential loss exposure for trades held more than ten minutes during the first six months of the sample. For each trader, we collect all completed trades held more than ten minutes, along with the minute-by-minute mark-to-market history for each trade. We define the loss exposure for each trade as the largest potential loss (the absolute value of the most negative mark-to-market exposure) per contract during the trade history. We employ exposure for trades held a long time as a measure of discipline, using each trader's mean and median potential exposure for all losses held more than ten minutes during the first six months of the sample.

Given proxy measures for relative discipline, we examine via correlation and tabulation the relation between relative discipline, or a trader's rank in terms of discipline relative to other traders, and subsequent success. Table 5 provides ordinary (Pearson) and rank (Spearman) correlations between first-period holding times and the two measures of subsequent success. The significance of the correlations versus a null hypothesis of no correlation is measured by the *p*-values presented in italics below each correlation. Table 5 shows that first-period discipline is positively correlated with subsequent success. Our discipline indicators are the speed at which positions are offset and the tendency to avoid holding onto trades with a large exposure (negative mark-to-market), so that a negative correlation with either discipline measure implies a positive correlation with discipline. Using the two correlation measures and two discipline measures for the four commodities provides 16 correlations, all of which are negative and significant in the case of RAP. Correlations between first-period holding times and subsequent gross income are of mixed sign, with seven negative and nine positive, and with low significance levels. The results indicate that less discipline in the first period is associated with lower subsequent success, particularly as measured by return on economically required capital, or RAP.

The final two columns of Table 5 provide correlations between our measure of potential loss exposures and subsequent success. Traders that expose themselves in the first period to larger potential losses per contract, on average, appear to have lower subsequent success. All 16 correlations between first-period exposure and subsequent RAP are negative, and 12 of these have significance levels less than 10%. Consistent with the hold time measure, correlations between exposure and

[12]We have replicated the results provided in Tables 5–7 with alternative measures based on decomposing the holding times for gains from the losses, with no qualitative differences in the reported results. Tables are available from authors.

Table 4
Income and holding times across contemporaneous trader success rankings. The table reports the mean gain per contract for trades, sorted by holding times, for traders grouped by their rank based on success. The table reports mean gains for trader risk-adjusted performance (RAP) ranks based on total income for the six-month sample period and the mean gains for trader ranks based on risk-adjusted income (mean daily income divided by ex post 95th percentile value-at-risk).

Pit	Holding time: τ (minutes)	Trader RAP ranks, contemporaneous (mean revenue per contract in dollars)				Trader income ranks, contemporaneous (mean revenue per contract in dollars)				Lowest RAP traders
		Highest RAP traders	Above median traders	Below median traders	Lowest RAP traders	Holding time: τ (minutes)	Highest RAP traders	Above median traders	Below median traders	
Deutsche mark										
	$\tau<1$	8.44	9.26	5.19	8.63	$\tau<1$	7.91	8.64	4.03	8.73
	$1\leqslant\tau<2$	9.17	11.08	7.36	6.99	$1\leqslant\tau<2$	9.26	9.83	6.69	6.90
	$2\leqslant\tau<3$	8.02	9.02	5.84	8.33	$2\leqslant\tau<3$	8.01	7.50	5.80	8.45
	$3\leqslant\tau<5$	6.78	6.75	5.66	7.13	$3\leqslant\tau<5$	6.71	6.28	4.97	6.31
	$5\leqslant\tau<10$	4.90	4.68	3.56	5.57	$5\leqslant\tau<10$	5.01	3.36	0.15	4.49
	$10\leqslant\tau$	14.87	5.14	5.94	(11.52)	$10\leqslant\tau$	9.11	4.35	19.42	(19.45)
Swiss franc										
	$\tau<1$	13.67	12.36	10.70	18.52	$\tau<1$	12.67	13.54	13.96	19.14
	$1\leqslant\tau<2$	14.30	14.75	20.91	14.38	$1\leqslant\tau<2$	14.04	18.13	15.02	13.59
	$2\leqslant\tau<3$	12.08	10.40	22.05	17.87	$2\leqslant\tau<3$	10.96	16.44	16.37	16.44

	$3 \leqslant \tau < 5$	12.52	11.99	21.09	7.38	$3 \leqslant \tau < 5$	12.61	14.87	9.01	7.93
	$5 \leqslant \tau < 10$	7.49	7.71	13.69	8.28	$5 \leqslant \tau < 10$	8.15	10.44	3.86	7.40
	$10 \leqslant \tau$	7.87	7.59	5.19	(15.99)	$10 \leqslant \tau$	11.78	(0.40)	(1.21)	(18.04)
Live cattle										
	$\tau < 1$	5.09	6.74	6.32	6.19	$\tau < 1$	5.79	5.65	5.92	6.46
	$1 \leqslant \tau < 2$	7.05	10.11	11.02	10.00	$1 \leqslant \tau < 2$	8.39	9.75	8.20	9.11
	$2 \leqslant \tau < 3$	7.87	8.42	11.84	6.26	$2 \leqslant \tau < 3$	8.80	8.70	7.71	4.46
	$3 \leqslant \tau < 5$	6.79	10.38	11.34	5.60	$3 \leqslant \tau < 5$	8.74	8.87	4.52	7.51
	$5 \leqslant \tau < 10$	7.97	9.00	10.48	7.52	$5 \leqslant \tau < 10$	9.00	7.81	7.97	8.29
	$10 \leqslant \tau$	12.39	6.25	5.84	0.78	$10 \leqslant \tau$	8.09	3.55	5.12	0.95
Pork bellies										
	$\tau < 1$	17.24	17.72	16.25	15.93	$\tau < 1$	16.04	17.83	19.16	13.03
	$1 \leqslant \tau < 2$	24.45	31.22	30.99	33.09	$1 \leqslant \tau < 2$	31.73	25.39	42.62	8.96
	$2 \leqslant \tau < 3$	24.32	26.78	27.56	18.15	$2 \leqslant \tau < 3$	24.92	25.59	25.27	21.88
	$3 \leqslant \tau < 5$	26.31	24.05	33.57	35.73	$3 \leqslant \tau < 5$	29.46	24.33	44.38	22.61
	$5 \leqslant \tau < 10$	23.16	23.96	28.00	33.83	$5 \leqslant \tau < 10$	23.29	21.08	48.24	23.19
	$10 \leqslant \tau$	20.41	18.12	17.68	(4.26)	$10 \leqslant \tau$	17.24	17.19	9.11	(2.61)

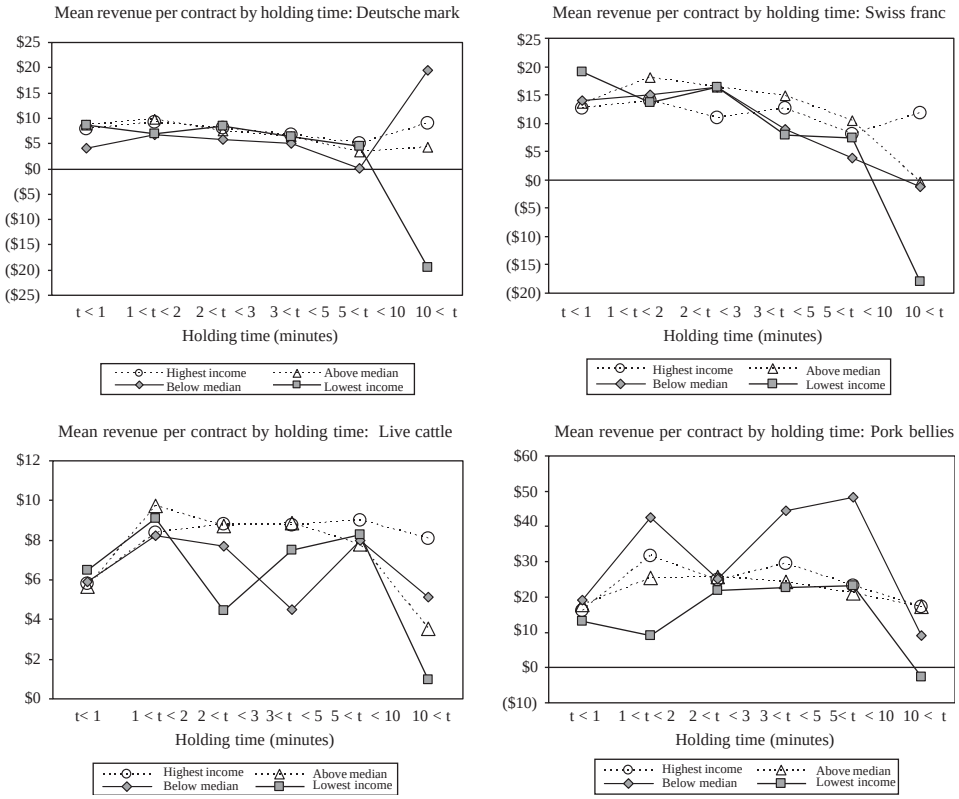

Fig. 1. Mean revenue per contract by holding times for trade. Traders ranked into quartiles based on total income.

subsequent income are less conclusive. While 11 of the correlations are negative, only four are significant at the 10% level, and two are positive and significant.

To supplement the correlations, we examine the relation between success and discipline in tabular format. We rank traders into quartiles on the basis of first-period discipline and then examine measures of subsequent success across the discipline quartiles. Table 6 provides mean and median second-period success statistics for traders within each first-period discipline quartile, where we measure discipline by median potential loss exposure. Consistent with Table 5, only weak evidence exists of a negative relation between first-period exposure and subsequent income. However, strong evidence emerges of a positive relation between first-period exposure and subsequent VaR, defined ex post. The VaR here is the potential loss in the subsequent period (second six months), measured again by 95th percentile daily exposure. The strong positive relation between first-period exposure and subsequent VaR, combined with the weak negative relation between first-period exposure and subsequent income, leads to a negative relation between first-period loss exposure and subsequent RAP.

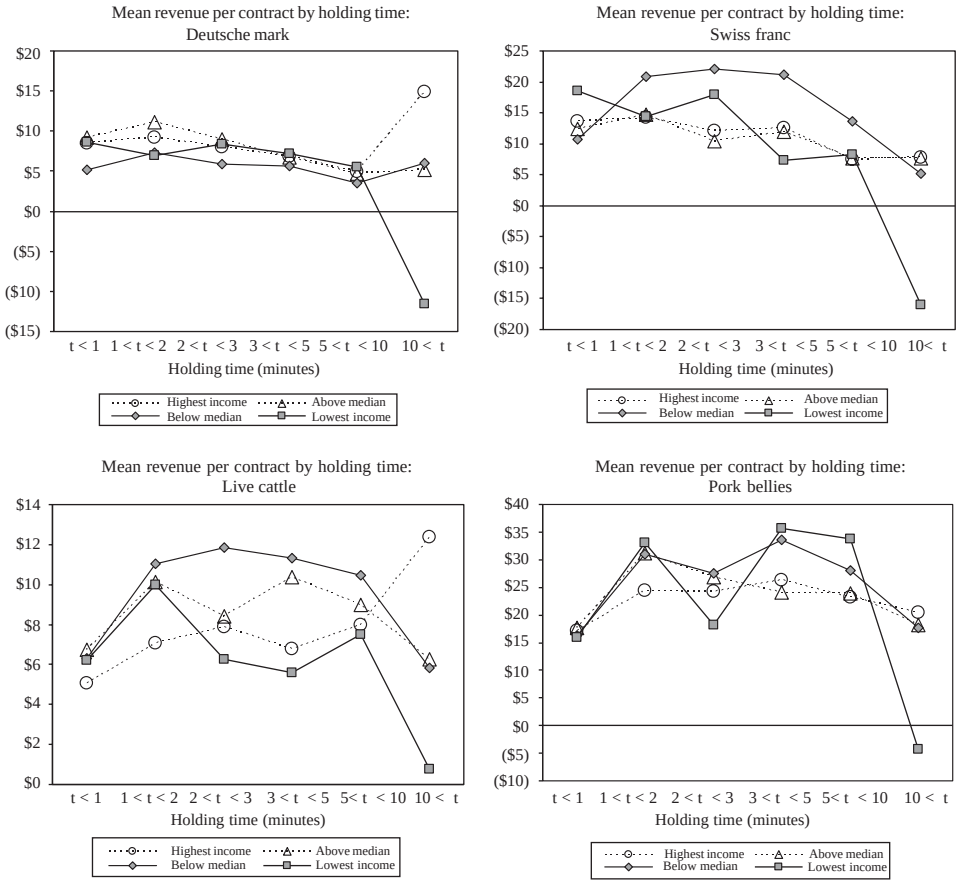

Fig. 2. Mean revenue per contract by holding times for trade. Traders ranked into quartiles based on risk-adjusted performance (RAP).

Table 7 provides mean and median second-period success statistics for traders within each first-period holding time quartile, where relative discipline is measured using median trade holding time. These results are similar to those in Table 6. The least disciplined traders in the first six months, or those with the longest median holding times, generally have lower subsequent incomes, higher subsequent risk exposure (VaR), and lower subsequent RAP than do traders with more discipline.

The results of this section are consistent with the notion that floor traders have access to short-lived information, such as signals about incoming orders, and that the more successful traders are those who interpret and act on these signals and then offset their positions quickly, whether their interpretation was correct or not. On average, all trades (losses as well as gains) are offset more rapidly by more successful floor traders, although traders at all success levels hold losses longer than gains. We also observe that traders who ride losses are less likely to be successful in the future.

Table 5
Correlations between trader discipline characteristics and subsequent success. The table reports correlations between measures of trading discipline based on trading during the first six months of 1995 and success measures based on trading for the second six months of 1995, for the traders active during both six-month periods.

Pit	Number of traders in both samples (trading in each six-month period)	Second period success measure	Correlation type	Correlation between second-period success measure and first-period trade holding times			Correlation between second-period success measure and first-period potential loss on trades held more than ten minutes		
				Mean holding time	Gain mean holding time	Loss mean holding time	Median holding time	Mean exposure	Median exposure
Deutsche mark	100	RAP	Pearson	−0.36	−0.33	−0.36	−0.24	−0.26	−0.23
			(*p*-value)	0.00	0.01	0.01	0.01	0.01	0.02
			Spearman	−0.58	−0.55	0.55	−0.43	−0.36	−0.26
			(*p*-value)	0.00	0.00	0.00	0.00	0.00	0.01
		Income	Pearson	−0.24	−0.23	−0.24	−0.13	−0.17	−0.11
			(*p*-value)	0.02	0.02	0.02	0.19	0.08	0.27
			Spearman	−0.39	−0.38	−0.34	−0.21	−0.21	−0.15
			(*p*-value)	0.00	0.00	0.00	0.03	0.03	0.14
Swiss franc	82	RAP	Pearson	−0.08	−0.09	−0.08	−0.07	−0.05	−0.01
			(*p*-value)	0.47	0.41	0.48	0.55	0.64	0.93
			Spearman	−0.50	−0.45	−0.53	−0.49	−0.28	−0.16
			(*p*-value)	0.00	0.00	0.00	0.00	0.01	0.15
		Income	Pearson	−0.13	−0.12	−0.18	0.00	−0.11	0.00
			(*p*-value)	0.25	0.29	0.10	0.96	0.33	1.00
			Spearman	−0.32	−0.28	−0.34	−0.25	−0.14	−0.01
			(*p*-value)	0.00	0.01	0.00	0.02	0.20	0.94

Live cattle	91	RAP	Pearson	−0.25	−0.26	−0.18	−0.21	−0.26	−0.27
			(*p*-value)	0.01	0.01	0.01	0.04	0.01	0.01
			Spearman	−0.28	−0.29	−0.24	−0.20	−0.18	−0.22
			(*p*-value)	0.01	0.01	0.02	0.05	0.09	0.04
		Income	Pearson	0.05	0.05	0.03	0.07	−0.22	−0.19
			(*p*-value)	0.65	0.65	0.77	0.49	0.04	0.07
			Spearman	0.08	0.07	0.07	0.14	−0.06	−0.14
			(*p*-value)	0.43	0.49	0.53	0.19	0.54	0.20
Pork bellies	32	RAP	Pearson	−0.46	−0.46	−0.38	−0.46	−0.31	−0.29
			(*p*-value)	0.01	0.01	0.03	0.01	0.09	0.11
			Spearman	−0.54	−0.51	−0.54	−0.53	−0.23	−0.13
			(*p*-value)	0.00	0.01	0.00	0.00	0.20	0.47
		Income	Pearson	0.01	0.04	−0.11	0.06	0.22	0.42
			(*p*-value)	0.95	0.83	0.55	0.75	0.22	0.02
			Spearman	0.03	0.09	−0.06	0.09	0.22	0.38
			(*p*-value)	0.88	0.64	0.75	0.64	0.24	0.03

Table 6
Subsequent success of traders ranked on first-period discipline characteristics. The table reports mean and median measures of trader success in the second six months of 1995 for traders ranked into four quartiles on the basis of the trader's median exposure (maximum potential loss) per contract on trades held longer than ten minutes during the first six months of 1995. Total gain is the gross trading profit (dollars) for each trader during the second six-month period. VaR = Value-at-risk. RAP = Risk-adjusted performance.

Pit	First period (January–June) trader ranking for the median potential loss per contract on trades held longer than ten minutes	Traders in first period/ traders remaining in second period	Subsequent success							
			July–December total gain for traders in quartile		July–December daily gain for traders in quartile		July–December VaR (95% potential loss for traders in quartile)		July–December RAP for traders in quartile	
			Mean total gain	Median total gain	Mean daily gain	Median daily gain	Mean VaR	Median VaR	Mean RAP	Median RAP
Deutsche mark										
	1 – lowest exposure	27/26	47,894	29,494	409	400	2,265	1,465	0.215	0.164
	2 – next lowest exposure	28/24	60,565	42,397	570	430	6,494	2,307	0.189	0.095
	3 – next highest exposure	27/25	75,401	27,894	789	273	6,737	4,088	0.133	0.106
	4 – highest exposure	27/25	50,909	4,782	573	97	7,560	5,450	0.100	0.046

Swiss franc										
	1 – lowest exposure	21/20	36,658	14,121	371	308	2,789	2,085	0.201	0.176
	2 – next lowest exposure	22/20	84,802	84,855	830	774	5,372	2,596	0.219	0..171
	3 – next highest exposure	22/22	44,544	24,815	358	522	5,405	4,038	1.831	0.096
	4 – highest exposure	21/20	40,384	15,488	494	181	19,443	7,564	0.069	0.031
Live cattle										
	1 – lowest exposure	24/22	43,122	12,657	335	213	3,610	1,508	0.206	0.116
	2 – next lowest exposure	25/25	60,088	22,383	622	219	3,330	2,312	0.219	0.211
	3 – next highest exposure	24/24	25,392	15,361	270	249	2,265	1,468	0.118	0.118
	4 – highest exposure	24/20	18,534	6,279	225	182	2,963	2,390	0.093	0.067
Pork bellies										
	1 – lowest exposure	9/8	34,139	20,353	392	338	1,488	1,254	0.437	0.182
	2 – next lowest exposure	9/8	60,459	50,526	593	457	3,219	2,416	0.307	0.179
	3 – next highest exposure	9/8	72,631	52,521	318	463	2,143	2,320	0.096	0.262
	4 – highest exposure	8/8	96,246	89,150	1,131	1,014	6,173	5,544	0.201	0.176

Table 7
Subsequent success of traders ranked on first-period discipline characteristics. The table reports mean and median measures of trader success in the second six months of 1995 for traders ranked into four quartiles on the basis of the trader's median holding time (minutes) per contract during the first six months of 1995. Because ties in median holding time, the number of traders in each group for the first six months is somewhat uneven, particularly for the Deutsche mark traders. Many traders in the shortest time group had a median holding time of four minutes. Total gain is the gross trading profit (dollars) for each trader during the second six-month period. VaR = value-at-risk. RAP = risk-adjusted performance.

Pit	First-period (January–June) trader ranking for median trade holding time	Traders in first period/ traders remaining in second period	Subsequent success							
			July–December total gain for traders in quartile		July–December daily gain for traders in quartile		July–December VaR (95% potential loss for traders in quartile)		July–December RAP for traders in quartile	
			Mean total gain	Median total gain	Mean daily gain	Median daily gain	Mean VaR	Median VaR	Mean RAP	Median RAP
Deutsche mark										
	1 – shortest time	31/29	76,769	54,080	693	477	2,507	2,185	0.298	0.240
	2 – next shorter time	21/20	55,002	18,998	525	411	3,301	1,671	0.219	0.140
	3 – next highest time	30/26	74,824	8,666	757	121	8,353	4,210	0.076	0.059
	4 – longest time	27/25	23,391	4,817	324	123	8,651	9,006	0.038	0.044

Swiss franc										
	1 – shortest time	24/22	77,024	73,086	822	866	3,033	2,311	0.322	0.298
	2 – next shorter time	20/20	36,410	3,291	208	222	4,292	2,779	1.987	0.096
	3 – next highest time	21/21	56,232	36,970	668	641	13,951	5,425	0.074	0.056
	4 – longest time	21/19	32,275	12,559	289	226	11,866	5,842	0.038	0.044
Live cattle										
	1 – shortest time	24/23	28,891	4,161	328	149	1,722	561	0.227	0.273
	2 – next shorter time	25/23	35,537	17,028	359	180	2,069	1,207	0.196	0.095
	3 – next highest time	25/23	34,787	28,131	361	313	3,043	2,324	0.114	0.136
	4 – longest time	24/22	50,748	12,020	436	261	5,293	2,816	0.121	0.091
Pork bellies										
	1 – shortest time	9/9	51,099	42,926	505	413	1,515	1,177	0.389	0.351
	2 – next shorter time	9/9	74,967	66,649	455	784	2,639	2,808	0.389	0.275
	3 – next highest time	9/6	55,078	47,938	712	487	4,102	3,542	0.153	0.147
	4 – longest time	8/8	80,342	51,337	821	684	5,273	4,477	0.050	0.135

Thus, we find that both measures of discipline are directly related to future relative success. If the variation we observe in the observed willingness to hold large losses arises from irrational considerations, then relative discipline could be associated with a relative mitigation of potentially costly behavioral effects.

3.2. Testing for trade asymmetry

In this section we compare holding times for gains and losses to see whether professional traders exit these two types of trades asymmetrically. The designation of a gain or loss indicates positive or negative gross revenue (as defined in Section 2). Again we use the first six months of the data for the analysis, so that the results can be compared with the contemporaneous success and discipline analysis. We compare holding times for all gains and all losses in aggregate as a first pass and then compare the empirical distribution of gains and losses, as the distribution of *sizes* of gains and losses can differ. We select rough distribution parameters on the basis of the absolute revenue per contract for the trade. The categories are for illustrative purposes, and the following break points for absolute gross revenue are arbitrary, chosen on the basis of intuition and sufficient sample size: zero (no gain or loss); less than \$10 per contract; at least \$10 but less than \$25; at least \$25 but less than \$50; at least \$50 but less than \$100; and any trades with absolute gross revenue of at least \$100 per contract.

Table 8 provides descriptive statistics for gross revenues aggregated (all gains and all losses) in Panel A and broken down by absolute revenue category in Panel B. Both panels provide the raw number of trades with gains and losses (first two columns), the number of round trips (second two columns), the percentage of trades with gains versus losses, the mean trade size, and the mean revenue per contract for gains and losses. For example, Panel A shows that mean trade sizes are virtually identical for gains and losses, that roughly 60% of all trades with nonzero revenue are gains, and that average losses are significantly larger in magnitude than average gains for trades in all commodity markets. Panel B reports statistics for the rough empirical distribution of trades by absolute revenue per contract. Instead of reporting percentages of gains versus percentages of losses *within* each absolute revenue category, Panel B reports the percentage distribution of gains and losses *across* the absolute revenue categories, providing a rough frequency distribution across gain and loss magnitudes.

Examination of the Panel B columns labeled "percent of trade totals "reveals why the average loss is larger in magnitude than the average gain: the *percentage* of large losses is higher than the percentage of large gains. For example, consider trades with absolute revenues over \$100 for the deutsche mark. While the average loss is slightly larger than the average gain (\$227 compared with \$225), the percentage of large losses (15%) exceeds the percentage of large gains (12%).[13]

[13]Using the two-sample binomial test for equal probabilities (normal approximation), the percentage of large losses is significantly greater (at the 1% level) than the percentage of large gains for all commodities but pork bellies.

Table 9 reports holding time comparisons. Panel A reports comparisons without regard to absolute revenue magnitude, and Panel B compares gain and loss holding times for trades with similar absolute revenues. The median holding times range from three to 23 minutes across the four commodities. These numbers might appear somewhat high given the suggestion by Silber (1984) that holding a trade longer than two minutes will result in an expected loss. The difference could be the result of the different time periods and different exchanges. However, our sample is comprehensive, analyzing entire trading populations over a six-month period, not selected individuals.

The evidence in Table 9 comparing gain and loss holding times is striking. Panel A shows that, in aggregate, professional traders hold losses significantly longer than gains for all four commodities. Median and average holding times for losses range from 35% to 133% longer than corresponding holding times for gains. The differences in times are most noticeable in the two agricultural commodities, especially pork bellies. Panel B provides overwhelming evidence that trading gains are realized more quickly than trading losses regardless of the magnitude of the absolute gain or loss. We were concerned that gains and losses might be treated differently depending on absolute revenue. We tested for such differences using the gross revenue categories developed for Table 8. For example, the median holding time for $10–25 losses on pork bellies is nine minutes, compared with about two minutes for $10–25 gains. Similar differences exist across most categories, with some exceptions such as the one-minute median times for gains and losses for francs and deutschemarks in the $10–25 range. However, across all revenue categories, losses are held significantly longer than gains. Using gross trade revenues as a measure of gains and losses, the professional traders in our sample as a group hold losing trades longer than winning trades.

3.3. *Are there costs associated with holding losses longer than gains?*

The evidence of longer holding times for losses does not imply inferior trade quality for those exit trades, especially given the short (intraday) time frame, but could simply be a benign characteristic of trader behavior instead of evidence of a disposition effect. In the spirit of Odean (1998a), we identify certain measures of the quality of the decision to terminate a trade. Odean finds costs associated with investors holding their losses longer than their winners, and it is such costs that give credence to the disposition effect: The presence of these costs, if they are not sample specific, allows one to make a strong normative argument regarding trading strategies. A failure to find such costs suggests that traders do not suffer from the disposition effect but instead appear to be trading in a manner that generates patterns consistent with the disposition effect. We examine exit trade quality by defining several measures of post-trade potential revenues and one measure of pre-trade potential and comparing these quality measures for trades that result in gains versus those that result in losses.

The forward-looking measures compare prices obtained for position-reducing trades to three alternative subsequent potential exit prices. We term these "what if"

Table 8
The table reports statistics for traders in these four commodities on the Chicago Mercantile Exchange for the first six months of 1995. A trade is the completion of a buy–sell combination in any order. The number of roundtrips in the trade is the number of contracts offset at the time of the completion of the trade. Revenues per contract is the income generated by the trade divided by the number of roundtrips for the trade.

Panel A. Trades with nonzero revenues

	Number of trades		Number of roundtrips		Percent of trade totals		Mean trade size		Mean revenue/Contract (dollars)	
Pit	Gains	Losses	Gains	Losses	Gains	Losses	Gains	Losses	Gains	Losses
Deutsche mark	151,609	102,793	681,317	460,460	59.7	40.3	4.5	4.5	53.14	−60.08
Swiss franc	125,067	80,411	466,903	303,533	60.6	39.4	3.7	3.8	71.66	−85.78
Live cattle	72,805	44,953	320,366	196,944	61.9	38.1	4.4	4.4	36.49	−39.61
Pork bellies	25,170	14,754	53,728	31,672	62.9	37.1	2.1	2.1	75.95	−78.40

Panel B. Revenue categorized by the magnitude of revenue per contract

Absolute revenue (y) per contract	Number of trades		Number of roundtrips		Percent of trade totals		Mean trade size		Mean revenue/Contract (dollars)	
Pit (dollars)	Gains	Losses	Gains	Losses	Gains	Losses	Gains	Losses	Gains	Losses
Deutsche mark										
$y>100$	17,913	14,868	90,207	74,633	11.8	14.5	5.0	5.0	224.56	−227.30
$50<y\leqslant100$	23,156	17,837	101,883	79,323	15.3	17.4	4.4	4.4	72.15	−72.37
$25<y\leqslant50$	31,559	21,645	137,760	93,875	20.8	21.1	4.4	4.3	38.55	−3856
$10<y\leqslant25$	61,356	34,676	249,409	135,482	40.5	33.7	4.1	3.9	17.08	−17.29
$0<y\leqslant10$	17,625	13,767	102,058	77,147	11.6	13.4	5.8	5.6	5.60	−5.20
$y=0$		29,742		101,309				3.4		

Swiss franc										
$y>100$	22,803	19,386	97,066	86,040	18.2	24.1	4.3	4.4	234.54	−240.29
$50<y\leqslant100$	23,932	16,373	89,065	61,232	19.1	20.4	3.7	3.7	72.86	−73.47
$25<y\leqslant50$	27,694	15,944	100,849	56,386	22.1	19.8	3.6	3.5	39.07	−39.09
$10<y\leqslant25$	40,545	21,083	134,485	67,485	32.4	26.2	3.3	3.2	18.04	−17.65
$0<y\leqslant10$	10,093	7,625	45,438	32,390	8.1	9.5	4.5	4.2	5.60	−5.40
$y=0$		15,339		39,691				2.6		
Live cattle										
$y>100$	4,945	3,784	26,605	19,705	6.8	8.4	5.4	5.2	157.17	−158.67
$50<y\leqslant100$	10,645	7,513	52,100	35,036	14.6	16.7	4.9	4.7	70.57	−70.65
$25<y\leqslant50$	17,240	10,366	74,620	45,389	23.7	23.1	4.3	4.4	36.48	−36.52
$10<y\leqslant25$	19,318	10,634	84,396	45,117	26.5	23.7	4.4	4.2	18.12	−17.82
$0<y\leqslant10$	20,657	12,656	82,645	51,697	28.4	28.2	4.0	4.1	7.24	−6.43
$y=0$		15,478		47,270				3.1		
Pork bellies										
$y>100$	6,010	3,743	14,915	9,107	23.9	25.4	2.5	2.4	187.48	−190.48
$50<y\leqslant100$	6,126	3,638	12,722	7,737	24.3	24.7	2.1	2.1	73.61	−73.56
$25<y\leqslant50$	5,942	3,115	11,857	6,235	23.6	21.1	2.0	2.0	38.10	−37.73
$10<y\leqslant25$	4,743	2,541	9,261	5,070	18.8	17.2	2.0	2.0	19.02	−18.47
$0<y\leqslant10$	2,349	1,717	4,973	3,523	9.3	11.6	2.1	2.1	7.43	−6.79
$y=0$		4,123		7,404				1.8		

Table 9
The table reports trade holding times. The holding time for a position increases by one minute at the start of each minute. As a trader adds to a position, the average hold time for each contract in the position is reduced to reflect the shorter holding time of the newest contracts. As positions are reduced but not eliminated, the hold time of the remaining position increases because additional time has passed. Intraminute trades have a hold time of zero and do not change the average holding times of previously existing positions.

Panel A. Holding times for trades with nonzero revenues: gains versus losses

Pit	Median trade holding time		Average trade holding time		*t*-statistic	Wilcoxon
	Gain	Loss	Gain	Loss		
Deutsche mark	2.00	3.60	9.77	13.18	−29.9	−55.9
Swiss franc	2.00	4.33	10.12	14.93	−36.7	−68.7
Live cattle	6.00	12.00	20.42	28.13	−35.5	−46.9
Pork bellies	9.00	21.00	25.51	36.91	−27.2	−36.4

Panel B. Holding times for trades: gains versus losses by size of revenue per contract

Pit	Absolute per contract trade revenue ($y)	Median trade holding time		Average trade holding time		*t*-statistic	Wilcoxon
		Gain	Gain	Gain	Loss		
Deutsche mark							
	$y>100$	13.20	18.00	35.52	40.62	−8.6	−15.6
	$50<y\leqslant100$	5.00	6.72	12.68	15.26	−9.8	−20.4
	$25<y\leqslant50$	2.34	4.00	7.38	9.60	−12.8	−23.6
	$10<y\leqslant25$	1.00	1.00	3.58	5.02	−17.0	−28.2
	$0<y\leqslant10$	1.57	2.03	5.66	7.03	−7.4	−10.6
	$y=0$	0.00		1.88			
Swiss franc							
	$y>100$	11.00	16.48	28.96	34.13	−11.2	−25.0
	$50<y\leqslant100$	3.50	6.00	9.96	13.65	−15.3	−27.5
	$25<y\leqslant50$	2.00	3.00	6.06	9.08	−17.1	−30.5
	$10<y\leqslant25$	1.00	1.00	3.34	5.36	−18.1	−30.3
	$0<y\leqslant10$	1.70	2.45	6.25	7.56	−5.4	−9.1
	$y=0$	0.00		1.78			
Live cattle							
	$y>100$	50.18	57.23	59.28	65.69	−5.9	−6.7
	$50<y\leqslant100$	20.00	29.88	34.44	43.14	−13.9	−16.0
	$25<y\leqslant50$	8.67	14.79	20.81	28.57	−18.3	−23.1
	$10<y\leqslant25$	4.00	8.67	14.11	20.88	−19.3	−27.2
	$0<y\leqslant10$	1.00	4.00	9.47	13.73	−15.9	−24.7
	$y=0$	0.00		3.12			
Pork Bellies							
	$y>100$	30.81	48.80	45.28	59.85	−5.9	−6.7
	$50<y\leqslant100$	12.00	24.00	25.98	37.38	−13.9	−16.0
	$25<y\leqslant50$	5.50	14.22	17.71	28.72	−18.3	−23.1
	$10<y\leqslant25$	2.00	9.09	14.03	22.09	−19.3	−27.2
	$0<y\leqslant10$	4.00	9.00	16.60	22.66	−15.9	−24.7
	$y=0$	0.00		4.18			

profits *forgone income*. For positions reduced by selling, forgone income is defined as the benchmark potential exit price less the actual sale price. For position reductions via purchase (i.e., covering a short position), forgone income is defined as the purchase price less the benchmark price. Thus, for both purchases and sales, forgone income measures the dollars that were lost by executing a trade at the actual time and price, not at a particular later time and price. Positive forgone income indicates that the position-reducing trade was, in effect, poorly timed (looking forward to the alternate benchmark). Negative or zero forgone income indicates that the trade was, ex post, well timed. The existence of momentum, for example, would lead to positive forgone income by selling winners prematurely or holding losers that continue to decline.

The three forward-looking potential exit price benchmarks implicitly embed various assumptions about the ability of traders to time their trades. The first measure looks forward ten minutes to examine the quality of the trade vis-à-vis an estimate of contract value shortly after the close of the trade. For this we use the average pit price in the tenth minute after the completion of a trade, which can be viewed as an unbiased ex post predictor of the intrinsic value of the contract at the time that the trader offsets his or her position. The second measure uses the closing price for the day. These two measures define the same benchmark price for purchases and sales. Thus, if a trader closes a position by selling at the ask or buying at the bid, we would expect negative forgone revenues versus the ten-minute-ahead price or the closing price, which serve as proxies for the contemporaneous intrinsic value. We employ these two benchmarks to allow for the possibility that trader compensation for liquidity provision accrues from longer-term liquidity swings in addition to, or even instead of, the higher-frequency bid-ask bounce. Finally, we use a *perfect foresight* benchmark, looking forward from the time the trade is offset to the end of the day and searching for the best subsequent price (highest price for offsets by sales, lowest for offsets by purchases).

To complement the forward-looking trade quality measures, we use a retrospective measure of trade quality for position reductions, which we label the "percentage realized." This measure is comparable to the measure developed by Odean (1998a). For trades with gains, the percentage realized is defined as the actual revenue divided by the maximum potential (marked-to-market) revenue available on the trade. For losses, the percentage realized is defined as the absolute revenue per contract divided by the maximum absolute potential loss per contract over the time the trade was held open. For gains, if a trader receives the best price for the trade (looking back), then 100% of gains are realized; if not, the percentage realized is less than 100. For losses, if the trader receives the worst price for the trade (looking back), then 100% of the losses are realized; if not, then the percentage realized is less than 100. Finding that a greater percentage of gains than losses are realized would be evidence ostensibly consistent with the disposition effect.

Table 10 presents trade quality statistics comparing the three forgone income measures and percent realized statistics for gains and losses (aggregated across all trades for each commodity). The first column gives the number of trades used in calculating the statistics, with two rows for each commodity representing positive

Table 10
Forward- and backward-looking measures of position-reducing trade quality. Forgone revenue represents potential regret on the part of the trader. For example, when a trader buys to offset an existing short position and the benchmark price is lower than the price of the offset, the trader forgoes the opportunity to offset the trade at the lower price. A negative value for forgone revenue indicates that the trader offset the trade at a price better than the benchmark. We report forgone income using three alternative benchmark prices: the closing price of the day, the market price ten minutes after the trade, and a perfect foresight price, which is the best possible price that could have been obtained subsequent to the trade on the same day. Percentage of revenue realized is a measure of what could have occurred had the trade been offset earlier and is bounded by 0% and 100%, formed by the ratio of the gain (loss) on a trade relative to the maximum (minimum) mark-to-market. For gains (losses), if they close out at the peak (trough), the percent realized is 100. If there was a higher (lower) mark-to-market during the life of the trade, then the percent realized for the gain (loss) is less than 100%.

Trade sign	Foregone revenues (in dollars)								
	Benchmark	Closing price		Ten minutes ahead		Perfect foresight		Percentage of revenue realized	
	Number of Trades	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Deutsche mark									
Positive	115,903	−6.08	−5.18	0.65	0.00	294.23	178.63	72.97	87.97
Negative	84,983	−7.99	1.68	−1.80	0.83	300.18	189.06	67.23	76.47
		t-statistic	0.97		4.71		−3.82		39.25
		Wilcoxon	−4.06		−4.64		−8.80		41.75
Swiss franc									
Positive	94,281	−9.28	−9.72	−0.35	−2.03	390.75	233.33	72.83	87.71
Negative	68,118	−19.76	0.00	−2.58	0.00	388.20	243.71	66.16	74.10
		t-statistic	3.46		2.91		1.12		41.08
		Wilcoxon	−1.71		−6.15		−4.56		44.38
Live cattle									
Positive	59,955	3.65	0.00	−2.41	0.00	97.55	60.03	75.14	95.75
Negative	40,338	−8.72	−2.17	−1.07	0.00	89.65	59.00	69.73	83.33
		t-statistic	12.54		−4.54		11.55		25.78
		Wilcoxon	10.71		−7.95		6.05		25.68
Pork bellies									
Positive	20,973	−16.29	−5.88	−8.80	−5.00	145.17	100.85	76.14	98.30
Negative	13,760	−2.76	0.00	−2.15	0.00	153.12	116.01	72.49	91.14
		t-statistic	−5.45		−7.53		−4.89		10.39
		Wilcoxon	−4.79		−13.10		−6.92		9.60

revenue trades and negative revenue trades. The remaining columns present the trade quality measures: forgone income using the closing price, forgone income using the ten-minute-ahead price, forgone income using perfect foresight, and the percentage of possible revenue realized. For each measure we present the mean and the median for winning and losing trades for each commodity. Below the row of means and medians for each commodity we present two statistics to test the hypothesis that the position-reducing winning trades have the same quality as losing trades. The statistics are a simple *t*-test for equal means and a nonparametric Wilcoxon test for equal distributions.

The trade quality results are somewhat contradictory in that many of the statistics are significant, although the signs change. Simply comparing the means and medians reveals that the numbers are relatively close for most measures. This is especially true for the perfect foresight measure, in which forgone losses and gains are nearly identical. For example, for the deutsche mark, an average of $390 per trade is left on the table when a gain is offset, and $388 is left on the table when a loss is offset, relative to the best price obtainable the rest of the day. Nonetheless, the number of observations is high and leads to many instances of statistical significance for even small differences.

In contrast to the striking difference between holding times for gains and losses, the forgone income measures exhibit no systematically significant variation between gains and losses. Slightly stronger evidence exists that traders realize a higher percentage of their possible gains than they do their losses, but the overall message of the comparisons of exit trade quality is ambiguous. The evidence suggests that the current mark-to-market of a trade (whether it is a gain or a loss) has no systematic impact on the quality of trader decisions to close trades. Traders hold onto losses longer, but we find no evidence of costs associated with the relative timing of offsetting gains and losses, in contrast to Odean (1998a). This finding, combined with a positive revenue stream, suggests that this trading pattern need not be aberrant but could be a side consequence of some information-based trading strategy.

Because futures traders have no obligation to trade, they generally enter positions with expectations of favorable price movements (these expectations are rational, as average trader revenue is positive). Both pure market-making techniques (revenue generated via a bid-ask bounce) and floor-based informational advantages can generate conditions such that traders have opportunities to realize gains more rapidly, on average, than losses. We investigate this possibility by following the history of a trade, specifically identifying the opportunities to realize a loss or gain prior to the actual realization of a loss or gain for each trade.

If traders hold losses longer because gain opportunities occur more rapidly than loss opportunities, then there should be no difference in prior realization opportunities between gains and losses. However, evidence that traders pass up more opportunities to take a loss, on average, than they do for gains is inconsistent with the notion of differential opportunity. For all trades other than intraminute offsets, we calculate the potential exit minutes, or the number of opportunities to realize a gain (loss) prior to actually realizing a gain (loss). Section 2.2 provides a more complete explanation.

As the results presented in Table 11 show, traders pass up more opportunities to exit losing trades at a loss than they do winning trades. The first two columns of Table 11 report mean and median potential exit minutes for gains and losses. For all four commodities, trades that eventually result in a loss are preceded by significantly more prior opportunities to realize that loss than similar opportunities for winning trades. For example, deutsche mark losses averaged 22 prior minutes with opportunities to offset at a loss, significantly higher than the 17 minutes' average opportunity to realize gains for trades that eventually resulted in gains (median potential exit minutes for deutsche mark trades were six for losses and four for gains, with the Wilcoxon statistic indicating that the distributions are significantly different).

Potential losses also exhibit larger average magnitudes (absolute income per contract) and position sizes than potential gains, as shown in the remaining columns of Table 11. In each case (position size and value of potential gain or loss) across the four commodities, trades that result in a loss exhibit greater exposure. Based on the evidence, we reject the hypothesis that traders hold onto losses longer due to differential opportunities. Traders hold losses longer than gains, hold onto larger losses, and pass up more opportunities to take losses than opportunities to take gains.

3.4. Alternative benchmarks for measuring gains and losses

In this section we analyze the importance of the choice of the gain/loss reference point, using alternative benchmarks based on expected profitability or net revenues. Kahneman and Tversky (1979), in the original presentation of prospect theory, discuss the critical nature of the benchmark used by individuals to internally define gains and losses. They give the example of a falling stock market, when losing less than others could be something to brag about. Further, traders have different capitalizations and likely react differently to a given loss, so that any internal benchmarks are probably idiosyncratic.

Our basic measure (as in Table 9) is the simple tallying of a gain or loss on a trade. While zero is a natural and clear benchmark, these floor traders do not operate in a zero-sum environment. Traders pay to lease (or own) a seat and also forgo wages by taking the time-at least four to six hours a day-to stand in the futures pit. In this more general framework, a trader's view of the gain from a trade would be the revenue earned on the trade less some measure of the costs of the trade, or the expected net revenue.[14] We use three measures to proxy for a trader's expectation of the costs of trading. The first is the aggregate average gain per contract across all trading in that commodity for the prior trading day, reflecting immediate past market conditions. The second is the trader's own revenue per trade, lagged one

[14]If these traders were continuously offsetting trades completely, that is, returning to a flat position rather quickly, a reasonable benchmark could be in terms of ticks per trade. This would be something tangible for the trader, buying at 10 and hoping the price goes to 11. Unfortunately, our traders' trading patterns are more complex.

Table 11
The table provides statistics comparing intratrade activity for winning versus losing trades. All trades held at least one minute that resulted in a gain or a loss are included (intraminute trades and trades with zero profit are excluded). The first set of statistics reports the mean and median number of prior opportunities to exit trades with the same result as the eventual result (i.e., a gain or a loss). The second set of statistics reports mean and median position sizes during those potential opportunities to exit the trade with the same result. Finally, the last set of results provides the mean and median absolute mark-to-market potential loss or gain during those potential opportunities to exit the trade with the same result.

Trade revenue sign	Number of trades	Number of prior opportunities to exit trade at gain or loss		Average position size during potential exit minutes: gain versus loss		Average absolute marker-to-mark during potential exit minutes gain versus loss	
		Mean	Median	Mean	Median	Mean	Median
Deutsche mark							
Positive	115,903	17.3	4.0	11.4	5.2	$1,264	$157
Negative	84,983	22.2	6.0	13.5	6.0	1,499	203
		t-statistic	−26.1		−21.3		−3.2
		Wilcoxon	−48.1		−22.4		−34.1
Swiss franc							
Positive	94,281	17.8	4.0	9.51	4.8	$1,187	$195
Negative	68,118	25.3	7.0	11.72	5.0	1,800	272
		t-statistic	−35.14		−24.3		−10.2
		Wilcoxon	−55.57		−22.4		−37.5
Live cattle							
Positive	59,955	29.4	10.0	16.1	8.7	$1,019	$220
Negative	40,338	37.0	17.0	19.1	10.0	1,143	297
		t-statistic	−26.5		−17.4		−3.7
		Wilcoxon	−37.1		−22.3		−27.4
Pork bellies							
Positive	20,973	32.4	13.0	6.8	4.0	$624	$210
Negative	13,760	40.0	22.0	7.7	4.7	708	248
		t-statistic	−15.5		−8.8		−4.4
		Wilcoxon	−21.8		−11.2		−9.0

trading day. This is a noisier estimate of the prior-day measure but is arguably more informative about trader-specific expectations. The third measure is a moving average of the trader's revenue, using all of the trader's trading days within the last seven calendar days (typically five trading days), thus reducing the impact of anomalous days. We use each of these measures separately to adjust the trader's gains and losses, forming net revenues that reflect a trader's profit or loss on a trade after covering costs.

We repeat the analysis of Table 9, investigating holding times for trades based on the sign of the trade's net revenue. The results, presented in Table 12, are based on a benchmark of each trader's own average revenue per contract during the previous five trading days. The results using the other two alternative benchmarks (not presented) are substantially the same. Consistently across all three measures of normed gains and losses using alternative benchmarks, there is no evidence that losses are held longer. We conclude that the evidence that losses are held longer depends on the choice of the benchmark. The strong evidence that losses are held longer than gains, based on a zero benchmark, is dissipated using other reasonable expected income benchmarks.

3.5. *Contemporaneous trading success and the timing of gains and losses*

In this section we investigate the relation between the pattern of holding losing trades longer than winners and contemporaneous success. Even if the zero benchmark is appropriate and traders hold losses longer than gains, the evidence presented in Section 3.3 indicates no cost associated with this behavior, on a trade-by-trade basis, because trade quality in exiting losses is similar to that in exiting gains. In an alternative attempt to find costs associated with this trading pattern, we examine cross-sectional relations between trading behavior and trading success.

We now examine possible relations between relative trader success and the observed trading pattern. We compare gain and loss holding times across trader success levels. We normalize holding times by dividing each trade's holding time (in seconds) by the trade's absolute revenue (in dollars) for nonzero gains and losses. We restrict the analysis to trades with absolute income greater than \$10 to avoid dividing by small numbers. This time per dollar metric has a natural economic interpretation, as it measures the time it takes for the position to gain or lose a dollar. A trade held two minutes and gaining \$12 per contract generates a time per dollar of ten seconds (120 seconds divided by \$12). Table 13 reports times per dollar for gains and losses across trader success quartiles for the first six months of the sample.

Table 13 indicates that, for every commodity, traders across every success quartile hold losses longer than gains, on average. From another perspective, it takes all of these groups of traders longer to lose a dollar than to gain a dollar. Success appears unrelated to the willingness to hold losses longer than gains. Successful traders hold losses for a shorter time than their less successful compatriots; for example, for Swiss francs, a trader in the highest RAP quartile takes ten seconds to lose a dollar, while a trader in the fourth quartile takes almost 22 seconds. This contemporaneous finding is consistent with our previous results on predicting success with discipline measures.

However, successful traders also close winning trades more quickly than their peers. Again for francs, a trader in the highest RAP takes eight seconds to make a dollar, while a trader in the fourth RAP quartile takes 16 seconds.

Overall, Table 13 shows that when traders are ranked on the basis of risk-adjusted performance, successful traders close both winning and losing positions more quickly than less successful traders, indicating a relation between contemporaneous success and trade holding times. This result appears to reaffirm the findings of Silber (1984). However, when success is defined as total income, the relation between position holding time and contemporaneous success is less clear. RAP assigns low ranks to traders taking large risks to earn income. Losing positions generating large potential losses sometimes result in gains when held until a price reversal. Such a trade would be strictly positive for the total income measure but has the potential to reduce the RAP measure.

Consistent with the analysis of trade-level costs presented in Section 3.3, we find no evidence that holding losses longer than gains is detrimental to contemporaneous trader success. Quicker trading (for both gains and losses) appears to be strongly positively correlated to both contemporaneous and future success.

4. Summary and conclusion

We examine the discipline of professional traders and their tendency to exhibit the disposition effect. By discipline we mean the adherence to trade exit strategies, which we measure by either the general speed of trading or by the avoidance of riding losses: holding onto positions with large loss exposure (negative mark-to-markets). We measure the tendency to hold onto large losses for each trader as the median of the trader's maximum potential (mark-to-market) loss per contract for trades held over ten minutes. In either case, trades will be offset more rapidly by disciplined traders, as suggested by Silber (1984). We find that measures of relative discipline based on trading in the first six months of 1995 are related to trader success in the subsequent six months. Traders offsetting losses more quickly are more likely to be successful in the future, but speed in closing gains is equally useful as a success predictor. Thus, aversion to realizing losses is not driving the results. However, we also find that traders who hold onto relatively large losing trades for longer periods (more than ten minutes) are subsequently less likely to be successful.

Using the natural zero benchmark for establishing gains and losses, we find that professional futures floor traders exhibit asymmetric trading behavior with respect to gains and losses. The evidence is strong that these traders hold losing trades longer than gains. However, we are unable to discover any contemporaneous measurable costs associated with this apparent aversion to realizing losses. Thus we conclude that no evidence exists of a costly disposition effect among this group of traders.

Absent evidence of costs associated with holding losses longer than gains, we seek other explanations, following the suggestion in Fama (1998) that evidence of behavioral problems is often consistent with rational behavior. First, we find that the evidence that traders hold losses longer than gains is sensitive to the benchmark

Table 12
Gain and loss holding times, trader's own prior week benchmark. This table differs from Table 4 in that we redefine gains and losses relative to the average gain per contract for each trader's prior week (seven calendar days) of trading. If a trade results in per contract income higher than the prior week's average gain, then it is a gain, otherwise it is defined as a loss.

Panel A. Holding times for trades with nonzero revenues: gains versus losses

Pit	Median trade holding time		Average trade holding time		*t*-statistic	Wilcoxon
	Gain	Loss	Gain	Loss		
Deutsche mark	2.00	2.00	10.22	10.13	0.9	−2.4
Swiss franc	2.00	3.00	10.72	11.89	−10.0	20.7
Live cattle	11.00	5.00	28.30	18.71	39.7	46.0
Pork bellies	9.47	11.94	26.09	28.72	−7.2	5.9

Panel B. Holding times for trades: gains versus losses by size of revenue per contract

Pit	Absolute per contract trade revenue ($y)	Median trade holding time		Average trade holding time		*t*-statistic	Wilcoxon
		Gain	Gain	Gain	Loss		
Deutsche mark							
	More than 100	13.45	15.00	36.20	36.34	−0.2	−6.8
	50–100	4.86	5.00	12.77	12.52	1.1	−4.9
	25–50	2.00	2.15	7.53	7.22	2.1	1.0
	10–25	1.00	1.00	4.92	4.70	2.1	−7.1
	0–10	1.00	0.00	3.60	3.52	0.9	8.2
	0	3.00		11.55			

Swiss franc							
	More than 100	10.99	13.70	29.04	30.64	−3.7	−15.2
	50–100	3.50	4.00	10.29	11.35	−5.0	−0.7
	25–50	2.00	2.00	6.34	6.56	−1.5	4.5
	10–25	1.00	1.00	4.47	4.95	−3.9	1.5
	0–10	1.00	0.00	3.84	3.96	−1.1	−1.8
	0		3.00		9.20		
Live cattle							
	More than 100	12.14	5.00	30.97	18.20	32.4	37.9
	50–100	13.00	4.00	30.82	17.93	23.7	30.1
	25–50	9.40	5.66	25.80	19.97	9.7	11.6
	10–25	8.49	6.25	24.24	21.16	4.5	5.6
	0–10	7.21	7.50	22.18	23.10	−1.1	−0.9
	0		6.08		20.07		
Pork bellies							
	More than 100	31.33	41.07	45.70	54.54	−9.3	11.2
	50–100	13.00	17.00	27.55	31.57	−5.4	6.9
	25–50	6.75	8.94	19.73	23.02	−4.8	5.0
	10–25	3.33	3.00	14.71	15.13	−0.7	−2.3
	0–10	2.00	1.00	13.74	12.24	2.3	3.7
	0	18.10		35.65			

Table 13
Holding times for trades across contemporaneous trader success rankings. Trade times are calculated holding time in seconds per absolute dollar gain per contract for the trade Trades with absolute gains of less than $10 are not included. RAP = risk-adjusted performance.

Pit	Trader RAP quartile	Quartiles defined by RAP ranking							Trader income quartile	Quartiles defined by income ranking						
		Mean time per dollar (seconds)			Difference from first quartile					Mean time per dollar (seconds)			Difference from first quartile			
					Gains		Losses						Gains		Losses	
		Gains	Losses	t	Difference	t	Difference	t		Gains	Losses	t	Difference	t	Difference	t
Deutsche mark																
	First (highest)	9.54	12.07	16.4					First (highest)	13.55	16.53	13.2				
	Second	17.33	21.03	10.5	7.80	33.5	8.96	29.2	Second	12.41	16.34	15.4	−1.14	−5.8	−0.19	−0.7
	Third	16.38	19.71	8.7	6.84	23.0	7.64	27.6	Third	17.33	21.04	6.3	3.78	10.2	4.51	8.9
	Fourth (lowest)	38.73	42.00	1.3	29.19	16.4	29.93	17.4	Fourth (lowest)	30.88	35.20	2.5	17.33	15.5	18.67	13.5
Swiss franc																
	First (highest)	7.75	10.18	16.0					First (highest)	10.64	15.18	16.7				
	Second	14.24	18.79	12.4	4.70	28.5	6.72	26.3	Second	9.71	12.30	11.2	−0.93	−4.8	−2.88	−9.6
	Third	11.78	15.74	10.9	2.25	19.0	3.67	16.7	Third	12.77	16.87	12.0	2.13	8.6	1.60	4.2
	Fourth (lowest)	16.05	21.62	9.4	6.52	22.9	9.55	23.2	Fourth (lowest)	16.40	22.42	9.2	5.76	14.2	7.24	12.5
Live cattle																
	First (highest)	24.03	33.55	14.6					First (highest)	43.44	56.76	17.2				
	Second	50.07	65.33	14.3	26.04	37.8	31.80	30.4	Second	37.85	52.63	12.9	−5.59	−7.4	−4.13	−3.6
	Third	42.16	52.80	10.9	18.13	27.3	19.25	19.8	Third	43.00	56.16	10.8	−0.44	−0.5	−0.60	−0.5
	Fourth (lowest)	71.45	84.61	6.6	47.42	36.0	51.06	30.9	Fourth (lowest)	49.51	60.32	5.3	6.07	2.0	3.56	4.7
Pork bellies																
	First (highest)	18.08	24.08	11.0					First (highest)	35.19	49.53	12.3				
	Second	29.51	43.95	12.8	11.43	15.0	15.91	12.9	Second	24.63	37.53	10.6	−10.56	−11.6	−12.00	−8.4
	Third	37.24	54.46	10.0	19.16	18.4	26.42	16.0	Third	18.95	30.63	9.5	−16.24	−17.7	−18.90	−13.3
	Fourth (lowest)	41.89	52.08	4.4	23.81	16.0	24.04	12.1	Fourth (lowest)	37.99	50.20	5.4	2.80	1.9	0.67	0.3

choice. While the zero benchmark is natural, and evidence using the zero benchmark indicates that traders hold losses longer than gains, the strength of the evidence dissipates using expected income benchmarks. Regardless of the benchmark, we find no evidence of contemporaneous costs associated with holding losses longer. Second, we find no evidence that success is contemporaneously related to a tendency to hold losses longer than gains. The effect appears to be prevalent across trader success groups. We conclude that no evidence is available of a costly disposition effect among professional futures traders, but that a relative lack of discipline in realizing both gains and losses promptly is harmful to the probability of success.

Appendix. Trade accounting methodology

To provide an example of the accounting methodology, Table A1 details a trade history for an imaginary trader, Trader Z.

Trader Z opens a position at 9:10 by buying a contract at \$100; the end-of-minute *average cost* of the position is \$100. In each of the next two minutes, Z adds to the position, buying one contract each minute at declining prices. The average per contract cost declines with each trade. After 9:12 (the third minute), the average cost is \$99 which is the average price of the three purchased contracts (the price of each trade weighted by trade quantity). As Trader Z liquidates the position by selling, the average cost of the remaining position is unchanged until 9:18, when the trader switches positions, moving from long (positive) to short (negative). At that point, the end-of-minute average cost is adjusted to the average sale price of the new short position, \$102.

Table A1 illustrates *intraminute* trades in minutes 9:13 and 9:19. At 9:13, Z buys one contract at \$96 and sells one at \$97. Z starts the minutelong three contracts and ends the minutelong three contracts. We consider the intraminute trades as distinct from the existing position and therefore the offsetting trades do not change the position average cost. Intraminute trades could sometimes be concurrent with a position change, as at 9:19. In situations such as this, we define the minimum of intraminute buy and sell quantities as the intraminute offset trades and adjust the average cost only for the net change in position. In the example, Z's trades at 9:19 result in an (absolute) increase in the short position. The mean sales price is 103, so the cost basis is adjusted to reflect one contract (the preexisting position) sold at 102 and one new contract (the net change in position) sold at 103, for an end-of-minute position cost basis of 102.5.

We calculate *realized revenues* as the sale price less the purchase price times the number of *roundtrips*. The term roundtrips means the number of contracts in a completed trade. In the example, the 9:13 intraminute offsets result in realized revenue of 1 (97 less 96) for one roundtrip. For position reductions (absolute), we calculate realized revenues as the difference between the trade price when the offset occurs and the average cost of that trade, multiplied by the number of roundtrips. Trader Z generates a loss of \$3 and a single roundtrip at 9:14 and a gain of \$3 (\$1.5

Table A1
Hypothetical trade history for Trader Z

Time	Trade	Price	Position average cost		Mean hold time (minutes)		Realized revenue	Round trips	End of minute marking to market		
			Start	End	Start	End			Pit price	Total mark	Mark/contract
9:10	Buy 1	$100		$100.00		0			$100	0	0
9:11	Buy 1	99	$100.00	99.50	1.0	0.5			99	−$1.00	−$0.50
9:12	Buy 1	98	99.50	99.00	1.5	1.0			98	−3.00	−1.00
9:13	Buy 1	96	99.00	99.00	2.0	2.0	1.00	1	97	−6.00	−2.00
	Sell 1	97									
9:14	Sell 1	96	99.00	99.00	3.0	3.0	−3.00	1	96	−6.00	−3.00
9:15			99.00	99.00	4.0	4.0			93	−12.00	−6.00
9:16			99.00	99.00	5.0	5.0			98	−2.00	−1.00
9:17	Sell 1	100	99.00	99.00	6.0	6.0	1.00	1	100	1.00	1.00
9:18	Sell 2	102	99.00	102.00	7.0	0.0	3.00	1	102	0	0
9:19	Buy 1	102	102.00	102.50	1.0	0.5	1.00	1	103	−1.00	−1.00
	Sell 2	103									
9:20	Buy 2	101	102.50		1.5		3.00	2	101		

per contract) on two roundtrips at 9:20, with both of these trades being position reductions, one via sale at 9:14 and one via purchase at 9:20.

Table A1 also contains *holding time* calculations. For examples at the end of minute 9:11, Trader Z has a long position of two contracts, one that was purchased at 9:11 and one purchased at 9:10. The first contract has been held one minute and the second has just been purchased, so the mean contract holding time is 0.5 minutes. As Trader Z sells to reduce the (absolute) position (beginning at 9:14), the hold time continues to increase, because position reductions do not affect the time that the remaining position has been held.

Table A1 illustrates the *marking-to-market technique*. At 9:15, Trader Z has a long position of two contracts with a cost basis of \$99. The 9:15 average pit price is \$93, so Z's unrealized loss is \$6 per contract, and the end-of-minute position mark-to-market for the two contracts is a \$12 unrealized loss. Position marks are indicative of unrealized revenues at a particular time. Rapid price changes can lead to observed unrealized losses becoming realized gains, and unrealized gains can become realized losses. In Table A1, Trader Z enters the minute 9:17 with an unrealized loss on the long position, but rapid increase in the pit price allows Z to liquidate some of the position at a gain.

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