Are Investors Really Reluctant to Realize Their Losses? Trading Responses to Past Returns and the Disposition Effect

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We examine how investor preferences and beliefs affect trading in relation to past gains and losses. The probability of selling as a function of profit is V-shaped; at short holding periods, investors are more likely to sell big losers than small ones. There is little evidence of an upward jump in selling at zero profits. These findings provide no clear indication that realization preference explains trading. Furthermore, the disposition effect is *not* driven by a simple direct preference for selling a stock by virtue of having a gain versus a loss. Trading based on belief revisions can potentially explain these findings. (*JEL* G11, G12, G14)

What makes individual investors trade, and how do they trade in relation to their past gains and losses? Several studies have examined aspects of these fundamental questions by testing whether the probability of selling (or of buying additional shares) differs depending on whether the investor experienced a previous gain versus a loss. For example, the literature on the disposition effect reports that investors are more likely to sell winners than losers. A leading explanation that has been offered is that investors are reluctant to realize their losses, either because of a direct disutility from doing so (which we call *realization preference*), or for more complex reasons arising from prospect theory preferences.

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Investors' trading in relation to gains and losses could derive from various sources, such as direct preferences toward realizing gains and losses, beliefs about future performance of the stock, tax considerations, margin calls, and portfolio rebalancing incentives. By far the dominant interpretations of the stylized facts in the literature have centered on imperfectly rational investor preferences. We explore here how individual investors trade in response to the size as well as the sign of profits (gains or losses), to explore how preferences and beliefs affect trading patterns. Using this approach, we test preference and belief-revision explanations for both the disposition effect and more general patterns in investor trading.

We begin by testing for a specific form of preference over realizations, *sign realization preference*. It is simplest to first define a special case of this, *pure* sign realization preference—a preference for realizing gains over losses without regard to their magnitudes. Pure sign realization preference implies a preference discontinuity at zero, so that investors are more prone to selling small winners than small losers.

In addition to being intuitively simple, pure sign realization preference is interesting because it offers a possible motivation for existing tests of the disposition effect (as we discuss later). The more general concept of sign realization preference (without the "pure") combines a jump in utility at zero with a utility component that increases smoothly with realized profit (positive or negative).[1]

To identify the effect of the discontinuity in sign realization preference, we test whether the probability that an investor sells a stock is higher when profits are just above, rather than just below, zero. A key advantage of this discontinuity approach is that it controls for other possible effects, such as tax incentives or trading based on belief revisions, that can affect the decision to sell. Such effects are likely to be correlated with the profit being realized, but there is no reason to expect such effects to vary discontinuously at zero profit.

For example, if an investor has traded based on private information about a firm's prospects, rational variations in beliefs will in general be correlated with profits. However, the rational inference from events that lead to a tiny loss should be approximately identical to the inferences associated with a tiny gain. Thus, our threshold discontinuity tests focus on the pure effect on investors' selling propensity of having a loss versus a gain.[2]

In the full sample, the evidence for a discontinuity at zero is minimal; point estimates for the jump are of small magnitudes and often statistically

[1] The model of Barberis and Xiong (2011) accommodates sign realization preference. Their model allows for both a utility component that depends discretely on the sign of profit, and a smooth component that depends on the magnitude of profit.

[2] We use both simple discontinuity tests and regressions. The regression discontinuity approach (e.g., van der Klaauw 2008) has been increasingly popular in economics and other fields as a way of identifying causal effects of a treatment variable that may be correlated with other causal variables.

insignificant. We use two methods to estimate the jump: (1) by comparing the abnormal probability of selling in regions just above and just below zero (i.e., the averages of residuals within a gain region just above zero, and within a loss region just below zero, from a single polynomial fit to the probability of selling over both regions); and (2) performing regression discontinuity tests.

Using the residuals method, we find no evidence of a jump for short-term prior holding periods (1 to 20 days since purchase). For selling in intermediate and long prior holding periods, point estimates of the jump range from 1.5% to 3.2% of the unconditional probability of selling. Pooling across all prior holding periods, point estimates of the jump range from 4.1% to 5.7% of the unconditional probability of selling. Although these estimates are statistically significant, they are economically minor. Using the regression discontinuity method, our estimates for the discontinuity have point estimates ranging from zero to 6.4% of the unconditional probability of selling, and are not statistically significant.

Subsample analysis reinforces the conclusion that it is hard to find the tracks of sign realization preference in the data. Looking across different categories of trades and investors defined by position amount, trade frequency, and gender, we do not detect a statistically significant or economically important sign realization preference.

Regardless of whether there is any jump in utility at zero from realizing gains versus losses, we call a situation where utility from realizing a (positive or negative) profit is strictly increasing with the profit *magnitude realization preference*. Magnitude realization preference implies that investors will be more likely to realize large gains than small ones, and small losses than large losses.[3] Unlike tests of sign realization preference, tests of magnitude realization preference tend to be confounded by other effects, such as taxes and belief-revision based trading, which can cause the probability of selling to depend on the size of the gain or loss. Nevertheless, as we will see, documenting the probability of selling as a function of profits provides insight into whether realization preference is a major determinant of selling schedule.

A stylized fact about the trading responses of U.S. investors to profits in our tests is that the probability of either selling or buying has a V-shaped relation to profits, with a minimum at zero (see Figure 1). This probability-of-selling schedule (henceforth, the selling schedule) indicates that investors are less likely to sell per unit time for small gains or losses, and most likely to sell as the

[3] In the realization utility model of Barberis and Xiong (2011), investors who enjoy realizing profits are more likely to sell as the gain increases; sales of losers never occur unless investors are forced to sell by liquidity shocks. So, the model implies an increasing probability of selling winners and a flat relation between selling and the magnitude of losses. More broadly, if liquidity considerations were non-absolute so that investors could trade them off against realization utility, it seems intuitive that in a similar setting magnitude realization preference would cause a greater realization of small losers than large ones. Henderson (2012) and Ingersoll and Jin (2012) provide models based on prospect theory in which investors "give up" on losers and thus have a higher likelihood of selling extreme losing positions.

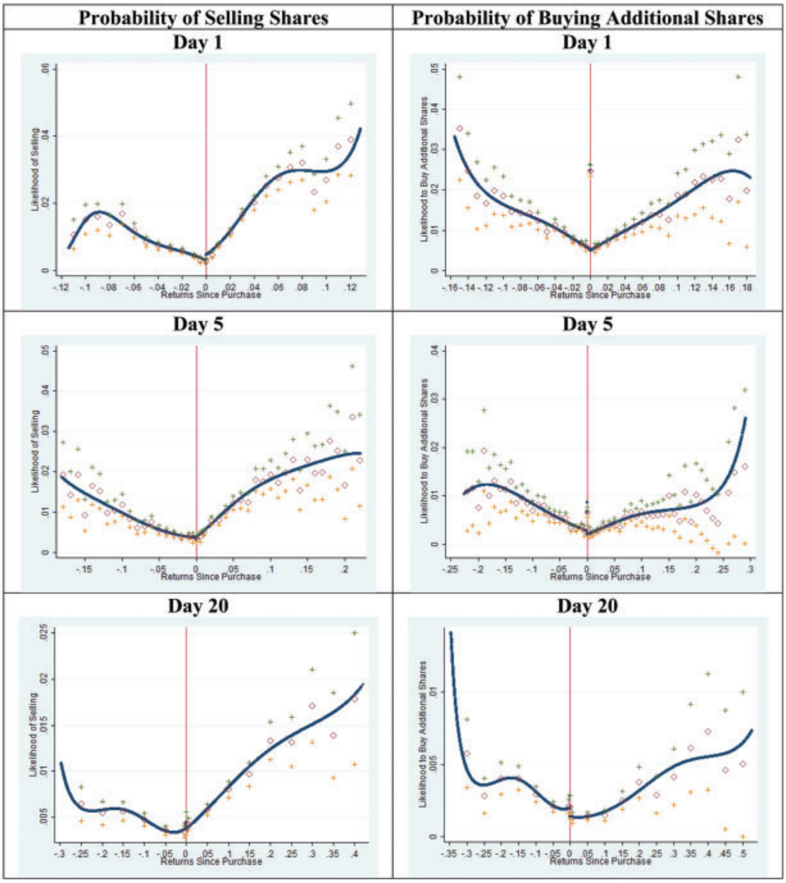

Figure 1
V-shapes in the probability of selling or buying additional shares

gain increases and (up to 10 days after purchase) as the absolute loss increases as well. The V is strongest for short prior holding periods. For example, the one-day probability of selling a stock that had an absolute price move of 5% or less after one day of prior holding is 1.57%, whereas the probability of selling if the move was more than 5% is about double in size: 3.03%.

The V-shape in the likelihood of selling bears upon the hypothesis that prospect theory explains investor trading behavior in relation to gains and losses. In the model of Meng (2010), owing to loss aversion, prospect theory predicts that investors have a greater probability of selling risky positions when the returns are close to zero. Under prospect theory, the kink in the value function at zero makes it concave in the neighborhood of the origin.

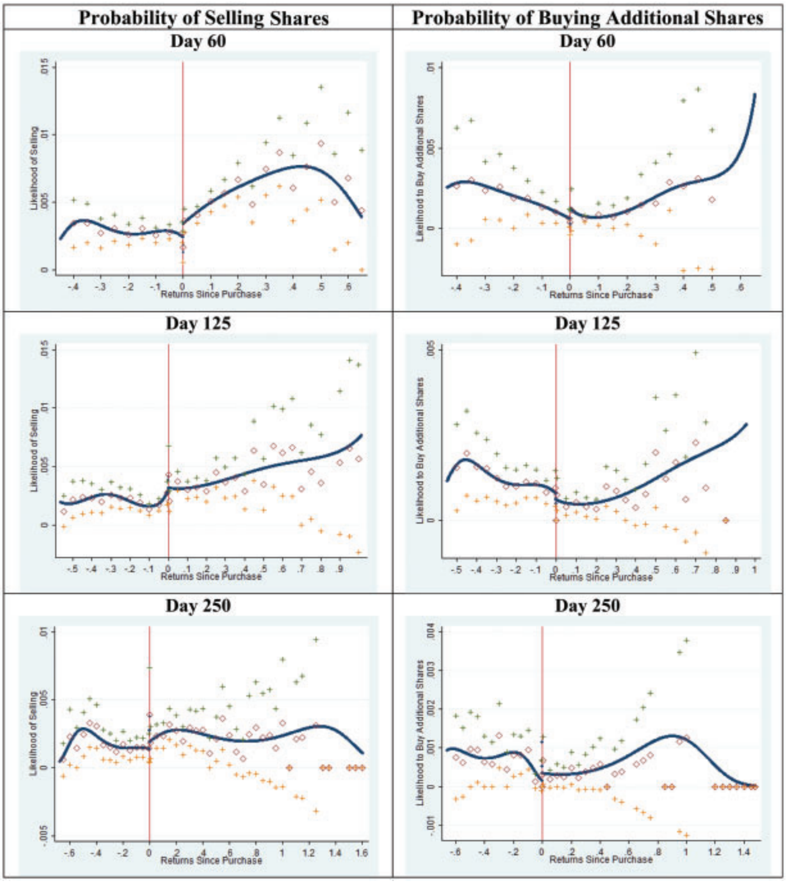

Figure 1
Continued
The charts present the estimated probabilities of selling stock or buying additional shares as a function of the returns since the initial purchase. The sample used in each chart is restricted to stocks that were purchased exactly before the stated number of days (as stated above each chart) and in which logged gross returns are within 3 standard deviations from the mean. The diamond markers present the local average frequency of selling stock or buying additional shares, at return intervals of 1% or 5% (for Day 20 onward). The fitted curve is based on a 3rd-degree polynomial fitted with separate parameters for the positive and negative regions. + markers indicate ±2 standard errors from the local means.

So, investors sell the security to reduce risk. The finding that zero returns is the point with lowest probability of selling opposes this prediction.

Importantly, the V is asymmetric: the right branch is steeper than the left branch. Indeed, for prior holding periods of greater than 10 days, the selling schedule becomes flat in the loss region. As we will later discuss, this asymmetry is the main source of the well-known disposition effect.

There is a similar V-shape in additional purchases of stocks that are already held in the investor's portfolio. For example, for the one day prior holding period, the probability of buying additional shares is low, 0.86%, when returns since purchase are within the ±5% range, and high, 1.76%, when returns since purchase are outside this range. However, the asymmetry of the buying schedule is opposite of that of the selling schedule; the buying schedule is steeper in the loss region.

The downward slope of the selling schedule in the loss region for short prior holding periods indicates that investors are more likely to sell big losers than small losers—the opposite of what is implied by immediate magnitude realization preference. At no prior holding period is there any indication of the expected effect—selling decreasing with the size of the loss. This does not prove that the magnitude realization preference is nonexistent; it could be present, but canceled or reversed by other effects. However, these findings strongly suggest that other motives, such as tax avoidance, the desire to profit from perceived market mispricing, or other preference effects, are more important determinants of trading behavior.

The speculative motive for trading (trading based upon beliefs) offers a possible explanation for the V-shapes of both the selling and buying schedules. Previous research suggests that individual investors trade aggressively (Odean 1998, 1999; Barber and Odean 2000), presumably in the hope of profit. Speculative investors think they know better than the market what a stock is worth; they place trades and then update their positions by selling or buying more in response to news. The speculative motive could be associated with genuinely superior information, or could derive from overconfidence.

To see how the speculative motive could generate V-shaped trading schedules, suppose first that subsequent to purchase there has been little news and price change, so that the gain or loss is close to zero. Then a speculator has little reason to update beliefs and trade, implying a low probability of trading near the center of the V. In contrast, when news arrival induces a substantial gain or loss, a speculator is likely to revise his beliefs about (1) whether the market has now impounded his private information, and (2) whether his original viewpoint was correct. Such belief updating will in general induce buying or selling, which implies higher probabilities of trading at the extremes of the V. We sketch this argument in greater detail in Subsection 3.4 [4]

Overconfidence-driven speculation can also potentially explain the asymmetry in the tilt of the V-shape between selling (for which the V is steeper in the positive region) and buying additional shares (V steeper in the negative region). Consider the incremental effect of overconfidence in the reasoning above. For selling, overconfident investors may more readily sell winners, because the run-up they expected has occurred, but (incrementally) be less willing to sell losers, because they remain confident that the run-up will eventually occur.

[4] In that section, we also discuss a version of the speculative trading argument based on the idea that big gains and losses grab investor attention and cause reexamination of the portfolio, and we consider how speculative trading might potentially induce asymmetry in the V-shape and thereby the disposition effect.

For additional buying, overconfident investors may readily "double down" on their bets when stocks decline in value, but have relatively weak reason to invest more when the run-up that they were expecting has already occurred.

We provide several cross-sectional tests to further explore the sources of the V-shape. Past research has provided evidence suggesting that overconfidence in investing is associated with males and with frequent trading (Odean 1999; Barber and Odean 2000, 2001). This suggests that belief-revision-based trading should be more important in these categories. To test this, we focus on the Vs for selling and for buying additional shares of stocks that are already owned given a 1–20-day prior holding period.

Consistent with the importance of speculation for the V-shape, we find that the Vs for both selling and buying are steeper for frequent traders, and for male investors. These findings are consistent with the speculative motive for trade as a contributor to the V. We also consider other possible explanations for the V. We find little evidence that tax-loss selling steepens the left branch in the last quarter or last month of the year. Nor do we find evidence that margin calls (proxied by value weight of the stock in the portfolio) affect the V in the predicted direction.

Perhaps the most prominent trading anomaly in financial economics is the disposition effect (Shefrin and Statman 1985)—the stylized fact that investors are on average more likely to sell a winner (an asset in which the investor has a gain relative to purchase price) than a loser (for which the investor has a loss). The disposition effect has been confirmed both experimentally (Weber and Camerer 1998) and in the field over different time periods, time horizons, assets classes, investor types, and countries.[5] It has also been viewed as an important window into investor psychology.[6] It has also served as the basis for theoretical modeling, as well as an explanation for return anomalies (Grinblatt and Han 2005; Frazzini 2006; Shumway and Wu 2006).

The concept that originally motivated disposition effect tests is that investors have a "disposition to sell winners too early and to ride losers too long" (from the title of Shefrin and Statman 1985), or a reluctance to realize their losses (Odean 1998). In other words, the literature has almost always attributed the disposition effect to investor *preferences* rather than beliefs (see, however, Dorn and Strobl 2010).

For example, the disposition effect is often ascribed to investor realization preference. Shefrin and Statman (1985, pp. 778, 782) use the term "disposition"

5 Studies that have documented the disposition effect in various contexts include Shefrin and Statman (1985), Ferris, Haugen, and Makihija (1988), Odean (1998), Weber and Camerer (1998), Grinblatt and Keloharju (2000), Shapira and Venezia (2001), Locke and Mann (2005), Kumar (2009), Kaustia (2010a), and Jin and Scherbina (2011).

6 Several papers have assumed or tested the idea that the disposition effect reflects investor irrationality (usually presumed to derive from prospect theory or realization preference). Some papers test this idea by seeing whether the disposition effect differs between more versus less sophisticated traders (Locke and Mann 2005; Shapira and Venezia 2001; Calvet, Campbell, and Sodini 2009; Dhar and Zhu 2006; Grinblatt, Keloharju, and Linnainmaa 2011). Others examine whether trading experience cures the disposition effect (Feng and Seasholes 2005).

as a shorthand for the desire to defer the pain of realizing losses, and to advance the pleasure of realizing gains. Similarly, in an overview of the field, Barber and Odean (1999) attribute the disposition effect to "the human desire to avoid regret." Such realization preference is sometimes viewed as arising from the loss aversion feature of prospect theory (Kahneman and Tversky 1979) together with mental accounting (Thaler 1985).

Another preference-based explanation is that the dual risk preference feature of prospect theory (Kahneman and Tversky 1979) implies a willingness to maintain a risky position after a loss, and to liquidate a risky position after a gain. As with the realization preference approach, prospect theory explanations require that investors derive utility as a function of gains and losses rather than the absolute level of consumption.

The realization preference explanation is an especially important contender for several reasons. First, it provides a possible motivation for performing disposition effect tests.[7] Second, theoretical analysis has raised doubts about whether prospect theory implies the disposition effect (Barberis and Xiong 2009). Third, there are measurable neural effects of realizing gains in experimental trading (Frydman et al. 2011). Finally, recent modeling shows that direct realization preference (without assuming prospect theory) can potentially explain the disposition effect (Barberis and Xiong 2011).[8]

Our findings that there is little evidence of sign realization preference in the general sample, and that there is an asymmetric V-shape in selling and buying, cast a new light on the disposition effect. These findings indicate that the disposition effect should *not* be interpreted as proof of a direct investor preference for realizing gains versus losses. The relatively weak sign realization preference in our general sample tests indicates that simple sign realization preference does not explain the disposition effect.

Specifically, based on point estimates, sign realization preference accounts for from about zero to 3.8% of the magnitude of the disposition effect up to a prior holding period of a year. So, an increase in return from just below to just above zero increases the probability of selling by at most a tiny fraction of the difference between the probabilities of selling a winner versus a loser (gains and losses not necessarily close to zero). For longer prior holding periods, the disposition effect is weaker, so sampling error causes greater variation in estimates of realization preference as a fraction of the disposition effect.

7 If the purpose of such tests is to distinguish hypotheses about investor trading preferences, it is not immediately clear why a binary conditioning on gain versus loss would be enlightening, unless gains of different sizes all have the same effect on utility, and losses of different sizes similarly all have the same effect on utility. Pure sign realization preference has this property.

8 A belief-revision-based explanation for the disposition effect is also occasionally mentioned, that belief in mean reversion induces pessimism about winners and optimism about losers. However, we argue in Subsection 3.5.3 that this explanation is unsatisfactory; certainly preference-based explanations have a higher profile in the literature.

Point estimates of realization preference range from −5.2% to 29.4% of the disposition effect, all statistically insignificant. In other words, the disposition effect is not a consequence of a selling discontinuity around zero.

These findings indicate that a simple concern by investors for the sign of their profits is at best a minor contributor to the disposition effect. This in large part removes "disposition"—the inherent preference for realizing gains over losses—from the disposition effect.

It follows that disposition effect tests are not clean tests of pure sign realization preference—almost all of the disposition effect derives from other sources. Unfortunately, disposition effect tests do not seem to be clean tests of any other simple psychological or economic hypothesis either. They are not tests of magnitude realization preference, as they measure probabilities of selling conditioning only upon the sign of profits (the winner vs. loser dichotomy), not the magnitudes of these profits. Nor are they clear tests of prospect theory (see Barberis and Xiong 2009).

The problem with disposition effect tests is that they are severely confounded by various possible factors affecting trading. The outcome of disposition effect tests will be influenced by any economic or psychological factor that (1) influences trading, and (2) is correlated with profits. In this regard, some specific interfering effects are well recognized, such as the tax incentive to realize losses, the effect of margin calls, and the fact that investors may believe that prices are mean-reverting.

More generally, the *speculative motive for trade* can induce either the disposition effect or its opposite. When an investor takes a position in a stock in the hope of profit, under almost any reasonable model (rational or otherwise), the resulting realized gains or losses will be correlated with belief revisions, and in consequence, with trades. The sign of this correlation will depend upon the relative strength of the two types of updating in response to news arrival: about how well the market now impounds the investor's initial perceived signal, versus about whether that signal was valid. So, there is no general presumption that the probability of selling winners and losers will be equal. Indeed, since speculators start out expecting positive expected profits, there is no reason to expect that, as news arrives, beliefs and trading will evolve symmetrically between gains and losses.

Two possible ways in which the disposition effect could arise are illustrated in Figure 2. In Figure 2A, investors with sign realization preference dislike realizing losses relative to gains. The jump induces a higher probability of selling in the gain region—the disposition effect. Figure 2B, in contrast, shows an asymmetric V-shape in selling, which has no such simple interpretation in terms of realization preference, but also results in the disposition effect.

Empirically, we find that the disposition effect is indeed the result of an asymmetric tilt in the selling V-shape. The greater slope of the right branch of the V causes the average propensity to sell winners to exceed the average propensity to sell losers (Figure 1, left column). However, asymmetry in the

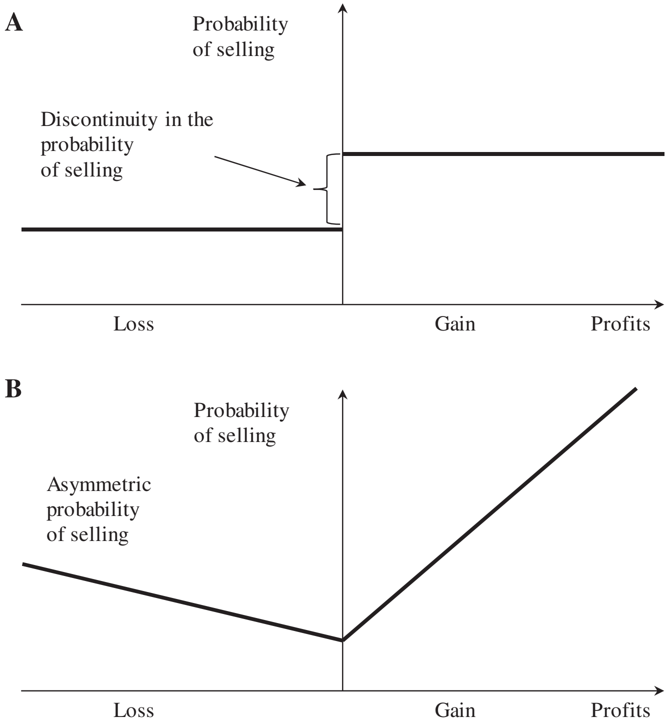

Figure 2
Potential sources of the disposition effect
Figure 2A. A jump in the probability of selling schedule
The probability of selling is constant within the loss region and within the gain region. Investors have sign realization preference (upward jump in probability of selling at zero). The distribution of profits has a zero mean.
Figure 2B. Asymmetric probability of selling schedule
The probability of selling is increasing with the magnitude of profits with asymmetric slopes in the gain and loss regions. The distribution of profits has a zero mean.

V can derive from many possible factors other than realization preference or prospect theory.

We next consider a test that does not condition on realization, in order to evaluate more directly whether factors other than realization preference can indeed induce gain/loss trading asymmetries akin to the disposition effect. The purchase of new shares of stock is not a realization, so ceteris paribus this does not directly generate any immediate realization utility. We therefore estimate the probabilities that investors *buy* additional shares of their current losers or gainers. If investors were focused only on immediate realization utility, so that other forces were minor or tended to average out in aggregate trading behavior, the probability of buying additional shares of a winner holding versus a loser holding would be approximately equal.

This is not the case, however. We find a lower slope of the right branch of the V than the left branch (see Figure 1, left column). This induces a reverse disposition effect for buying (previously documented for an earlier sample period by Odean 1998):[9] the probability of additional buying of losers is greater than the probability of additional buying of winners. The fact that something akin to the disposition effect is found even when immediate realization utility is precluded reinforces the conclusion that the disposition effect should not be interpreted as a measure or proof of the existence of realization preference.

2. Data

To explore how investors trade in relation to gains and losses, we use data on retail investor trading as used by Strahilevitz, Odean, and Barber (2011), which is similar to the data used by Odean (1998). The data set consists of trades at a large discount broker; it includes stock transactions from 77,037 unique accounts over the period from January 1990 through December 1996. Due to computational capacity limitations, for most of our tests we focus on a random sample of 10,000 accounts. As a comparison, Odean (1998) uses a sample of 10,000 accounts from 1987 to 1993. However, our tests of realization preference are based on testing for a possible jump discontinuity at zero in the relation of selling probability to returns. This requires that we maximize statistical power, so for these tests we use the full set of investors' trades while restricting returns to the neighborhood of zero ($\pm$0.5 standard deviations around zero returns, calculated for each prior holding period).

We follow several steps in cleaning and preparing the data. First, as our initial core unit is an investor-transaction, we require that all transactions associated with an investor-stock (stocks are identified by an 8-character CUSIP) will appear in CRSP on all transaction dates. Also, we retain only securities that are common shares, and remove investor-stocks if one of the entries has negative commissions (which may indicate that the transaction was reversed by the broker). To mitigate microstructure frictions, we remove all observations of any stock that had at least one day with no active trading during the previous 250 trading days (8.2% of the observations were removed). (We use CRSP to calculate stock returns, since prices in the brokerage data are not adjusted for dividends and splits. We further discuss dividends and splits at the end of Subsection 3.1.1. Our calculated returns are adjusted for bid-ask spread, but are not adjusted for brokerage commissions.) Finally, we remove from the sample investor-stocks that include short-sale transactions or that have positions that were opened before 1991.[10]

[9] However, Odean (1998) obtains an *inverted* V for buying, which is basically the opposite of the shape of the buying schedule that we document. The reason for this difference is discussed in Section 5. Strahilevitz, Odean, and Barber (2011) confirm that a reverse disposition effect also applies in a sample that includes investors at a full-service brokerage.

[10] Specifically, we accumulate share positions for each investor-stock over time. If the cumulative number of a stock's shares becomes negative at any point (owing to a purchase that occurred prior to the start of the sample period and was closed during the sample period; or a short sale), we remove the investor-stock from the sample.

Next, we use the transaction data set to construct a holding sample containing an observation for each investor-stock-day. For example, should an investor buy ACME stock on January 2, 1992, and hold it until January 16, 1992, there will be 11 observations (11 business days). We flag the days when a position is opened, when shares are sold (including a partial sale), or when additional shares of the same stock are purchased (increasing an existing position). We record purchase and selling prices (from the transaction data set), as well as closing prices from CRSP. When computing returns, we adjust for splits and dividends. In order to guard against regression results driven by outliers, we also winsorize independent variables at the 1st and 99th return percentiles within each prior holding period.

We flag an investor-stock-day as a *gain* if the current price is strictly above the purchase price (or weighted average price, in case of multiple purchases). The current price is the selling price, price of buying additional shares, or end-of-day price. Symmetrically, the *loss* indicator is one if the current price is strictly below the weighted average purchase price, and zero otherwise. If the current stock price is equal to the weighted average purchase price, then the investor-stock-day is classified as having zero-returns.

For the entire analysis, we remove the purchase day from the sample. Since the transaction data does not include intraday time stamps, we cannot separate a short round-trip from a long round-trip within the day. The effect of this adjustment on our results is negligible (purchase days are about 0.4% of all observations). After removing these observations, the data set has a total of 21.5 million investor-stock-day observations.

Table 1 presents the summary statistics for our sample. Panels A and B show the probabilities of selling and buying additional shares of stocks already owned for four prior holding periods that we consider throughout the article: up to 20 days since purchase, from 21 to 250 days since purchase, over 250 days since purchase, and the entire sample. As the time since purchase increases, the probability of selling and the probability of buying additional shares decline.

In addition, Panel A of Table 1 displays the disposition effect in the data: the probability of selling winners (PSW) is higher than the probability of selling losers (PSL). The difference is statistically significant and economically large relative to the unconditional probability of selling. Similarly, Panel B displays the unconditional and conditional probabilities of buying additional shares (PBW and PBL for probabilities conditional on gains and losses, respectively). Here, the probability of buying losers is significantly larger than the probability of buying winners. These patterns are discussed in Section 4. Panel C presents the summary statistics for the variables used in the regressions.

This procedure generally removes positions opened prior to 1991. The exception would be a situation in which a position was opened prior to 1991, then additional shares were added after 1991, and not all shares were sold prior to 1996. This trade pattern should be very rare, both because the rate of buying additional shares is very low in general, and because in over 90% of selling transactions investors sell all their shares.

Table 1
Summary statistics

Panel A: Estimated probabilities of selling stocks

	Prior holding period (days):			
	1 to 20	21 to 250	>250	All
N	1,245,126	8,829,899	11,493,943	21,568,968
Unconditional probability (%)	0.72**	0.33**	0.12**	0.24**
	(25.36)	(45.33)	(56.85)	(46.26)
PSW (%)	1.00**	0.44**	0.13**	0.29**
	(21.69)	(43.83)	(46.26)	(41.70)
PSL (%)	0.51**	0.23**	0.10**	0.18**
	(20.46)	(33.57)	(46.04)	(39.61)
Disposition effect: PSW – PSL (%)	0.49**	0.21**	0.03**	0.11**
	(11.20)	(25.04)	(8.61)	(19.22)
(PSW – PSL) / Unconditional probability (%)	67.26	62.68	21.75	44.68

Panel B: Estimated probability of buying additional shares of stocks already owned

	Prior holding period (days):			
	1 to 20	21 to 250	>250	All
N	1,245,126	8,829,899	11,493,943	21,568,968
Unconditional probability (%)	0.41**	0.11**	0.03**	0.09**
	(24.03)	(30.80)	(24.99)	(30.67)
PBW (%)	0.34**	0.09**	0.03**	0.07**
	(17.73)	(23.73)	(19.02)	(25.23)
PBL (%)	0.46**	0.13**	0.04**	0.11**
	(19.24)	(26.31)	(22.35)	(25.74)
PBW – PBL (%)	−0.13**	−0.05**	−0.01**	−0.04**
	(−4.92)	(−8.98)	(−4.41)	(−9.89)
(PBW – PBL) / Unconditional probability (%)	−31.18	−42.27	−24.86	−45.01

Panel C: Summary statistics for regression variables (means and standard deviations)

	Prior holding period (days):			
	1 to 20	21 to 250	> 250	All
N	1,245,126	8,829,899	11,493,943	21,568,968
I(ret < 0)	0.494	0.500	0.438	0.467
	[0.500]	[0.500]	[0.496]	[0.499]
I(ret = 0)	0.046	0.014	0.004	0.011
	[0.211]	[0.115]	[0.067]	[0.102]
I(ret > 0)	0.461	0.487	0.557	0.523
	[0.498]	[0.500]	[0.497]	[0.499]
Ret^-	−0.034	−0.095	−0.146	−0.119
	[0.057]	[0.148]	[0.229]	[0.195]
Ret^+	0.033	0.106	0.342	0.228
	[0.061]	[0.196]	[0.650]	[0.506]
log(Buy price)	3.030	3.014	3.067	3.044
	[0.973]	[0.991]	[1.010]	[1.000]
sqrt(Time owned)	3.046	10.523	24.232	17.397
	[1.003]	[3.156]	[5.591]	[8.771]
$Volatility^-$	0.018	0.017	0.015	0.016
	[0.022]	[0.022]	[0.021]	[0.022]
$Volatility^+$	0.014	0.014	0.014	0.014
	[0.019]	[0.018]	[0.017]	[0.017]

The table presents summary statistics about the stock transactions of retail investors. The summary statistics are based on a sample of 10,000 retail investors who trade with a large discount broker in the period from January 1991 to December 1996. Panel A presents summary statistics for the frequencies of selling and of buying additional shares of stocks currently owned, for various prior holding periods. In addition, the panel shows the probability of selling winning stocks (PSW), the probability of selling losing stocks (PSL), the probability of buying additional shares of winning stocks (PBW), and the probability of buying additional shares of losing stocks (PBL). The difference PSW – PSL is the disposition effect. *t*-statistics are in parentheses; standard errors are clustered at the investor level. *, ** denote two-tailed significance at the 5% and 1% levels, respectively. Panel B presents summary statistics (mean and standard deviation in brackets) for the variables used in regressions. Panel C presents breakpoints used to calculate quartiles in the cross-sectional analysis. Variable definitions are provided in Appendix A.

For the discontinuity tests discussed in Section 3 and for the charts of the probability schedule estimated by holding day (Figure 1), our sample is based on the trades of all investors (rather than a randomly selected subset of investors).

3. Tests of Investor Trading in Response to Gains and Losses

3.1 Tests for sign realization preference

We begin by exploring the extent to which retail investors have sign realization preference, wherein an investor has a utility component that is discretely higher for gains than for losses (even small ones). We therefore test whether there is a discontinuous increase in the probability of selling at zero profits, where profit is the return relative to the original purchase price.[11]

3.1.1 A residuals test. The first method relies on a two-stage procedure. In this analysis, to help ensure a good fit of the selling schedule in the neighborhood of zero profits, we limit the sample to investor-stock-days whose returns lie within 0.5 standard deviations of zero (where the standard deviations are computed separately for each holding day).[12] Each observation reflects an investor-stock-day for a stock held in the investor's portfolio. If a stock was sold by a particular investor in a particular day, then this trade is flagged by the selling indicator.

In the first stage, we regress a selling indicator on a single 3^{rd}- (or 4^{th}- or 5^{th}-) degree polynomial function of profits and on controls. In the second stage, we compute the residuals from the first stage and then calculate the average level of residuals for gains (*PSW residual*) and for losses (*PSL residual*). The estimated discontinuity is the difference between these variables, *PSW residual – PSL residual*. We cluster errors by investor in all regressions. By construction, this method gives the same weight to an observation that is close to zero as it does to an observation that is far from zero.

The results of the residual tests are presented in Table 2, Panel A. The explanatory variables of the first-stage probit regression include a polynomial (either 3^{rd}-, 4^{th}-, or 5^{th}-degree polynomial), and interactions of the return variables with the square root of the time since purchase. The size of the jump discontinuity is presented in the third row, labeled *PSW residual – PSL residual*.

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11 This prediction is based on the simple static intuition that when realizing a positive or negative profit becomes more attractive, the probability that an investor does so increases. Barberis and Xiong (2011) and Ingersoll and Jin (2012) show that more complex outcomes are possible in dynamic settings in which investors make realization decisions today foreseeing that this will affect their ability to take realizations in the future and possibly to reinvest. Our prediction could be viewed as the special case in which investors make myopic decisions or discount the future very heavily. Such static reasoning is implicit in intuitive arguments made throughout the empirical literature on gains, losses, and investor trading.

12 It is important to maximize power when testing for jump discontinuities, as the estimation depends strongly on the subsample of return realizations that are close to zero. For these tests, we therefore use the *entire* set of investors in the database rather than a random subset. This is computationally feasible as we restrict the sample here to returns since purchase that are within 0.5 standard deviations of zero for each holding day. This leads to a total of close to 70 million observations. (As discussed in Section 2, for computational reasons it is impossible for us to use the full sample in all tests.) We will show that these tests do have sufficient power to identify economically substantial effects, should they exist.

All estimates show a positive discontinuity, which ranges from about zero to 5.7% of unconditional probability of selling, and from about zero to 14.5% of the disposition effect. In general, as the degree of the polynomial increases, the estimated size of the discontinuity decreases.

On psychological grounds it can be argued that realization preference will be strongest for short prior holding periods, when the original purchase price is likely to be most salient as a reference point. On the other hand, an investor's self-esteem may be more closely linked to investment success in a stock he has held for a long time. However, the more important consideration is that investors are less likely to even recall the original purchase price of a stock that was purchased many months ago.

Column 1 in Table 2, Panel A, shows, however, that for the shortest range—the 1–20-day prior holding periods—the discontinuity is not statistically significant for any of the specifications. Furthermore, its magnitude is small from about zero to 0.6% of the unconditional probability of selling, and up to 1.0% of the disposition effect.

In Columns 2 and 3 in Table 2, Panel A, for the prior holding periods of 21–250 days and >250 days, some of the estimated effects are statistically significant at the 1% level but economically minimal. For these mid-range and long prior holding periods, the point estimates for the magnitudes of the effects range from 1.5% to 3.2% of the unconditional probabilities of selling.[13]

Table 2
Measuring the discontinuity around zero gains

Panel A: Difference in residuals around zero: ±0.5 standard deviation

		Variable: Residuals of I(Sell stock)			
	Prior holding period (days):	1 to 20	21 to 250	> 250	All
1st stage polynomial		(1)	(2)	(3)	(4)
	N	4,368,415	29,924,997	36,404,390	70,697,802
3rd degree	(PSW residual – PSL residual) (%)	0.003	0.007**	0.003**	0.013**
		(0.22)	(2.73)	(2.72)	(8.15)
	(PSW res – PSL res) / Uncond. probability (%)	0.4	2.2	3.2	5.7
	(PSW res – PSL res) / Disposition effect (%)	0.6	3.6	14.5	12.8
4th degree	(PSW residual – PSL residual) (%)	0.005	0.007**	0.002	0.010**
		(0.33)	(2.90)	(1.72)	(6.05)
	(PSW res – PSL res) / Uncond. probability (%)	0.6	2.4	2.0	4.2
	(PSW res – PSL res) / Disposition effect (%)	1.0	3.8	9.2	9.5
5th degree	(PSW residual – PSL residual) (%)	0.000	0.005	0.002	0.009**
	(PSW residual – PSL residual)	(−0.03)	(1.84)	(1.68)	(5.86)
	(PSW res – PSL res) / Uncond. probability	−0.1	1.5	2.0	4.1
	(PSW res – PSL res) / Disposition effect (%)	−0.1	2.4	9.0	9.2

continued

[13] For the long prior holding periods, the jump ranges up to 14.5% of the disposition effect. However, at long prior holding periods, the magnitude of the disposition effect itself is economically minor relative to the full sample unconditional probability of selling. In this prior holding period range, the disposition effect is only about 22% of the unconditional probability of selling (which is itself relatively low for long time periods), as compared to around 65% for the shorter holding periods. So, observations with long prior holding periods contribute only trivially to the disposition effect as documented in previous studies that do not condition on prior holding periods.

Table 2
Continued

Panel B: Regression discontinuity (3rd-5th polynomials): ±0.5 standard deviation

	Dependent variable: I(Sell stock) × 100								
Prior holding period (days):	1 to 20			21 to 250			>250		
Degree of polynomial:	3rd	4th	5th	3rd	4th	5th	3rd	4th	5th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I(ret > 0) (%)	−0.038	0.016	0.022	0.012	−0.006	−0.001	0.007	−0.001	−0.001
	(−1.28)	(0.40)	(0.44)	(1.65)	(−0.58)	(−0.07)	(1.75)	(−0.12)	(−0.21)
I(ret = 0) (%)	−0.001	0.020	−0.024	0.008	0.002	0.003	0.008	0.002	0.003
	(−0.05)	(0.48)	(−0.53)	(0.87)	(0.23)	(0.29)	(1.28)	(0.37)	(0.42)
sqrt(Time owned)	0.009	0.012	0.010	−0.011**	−0.011**	−0.010**	−0.005**	−0.006**	−0.006**
	(0.73)	(0.99)	(0.78)	(−11.61)	(−9.46)	(−8.43)	(−14.29)	(−13.32)	(−11.35)
Include polynomials and interactions with sqrt(Time owned)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations		4,368,415			29,924,997			36,404,390	
Pseudo R^2	0.015	0.016	0.016	0.010	0.010	0.010	0.010	0.010	0.010
β(I(ret > 0)) / Uncond. probability (%)	−5.2	2.2	3.0	3.7	−1.7	−0.3	6.4	−0.5	−1.1
β(I(ret > 0)) / Disposition effect (%)	−7.7	3.3	4.4	5.9	−2.7	−0.4	29.4	−2.5	−5.2

The table presents evidence for a discontinuity in the probability of selling stocks around zero returns since purchase. The data set contains the daily holdings of retail investors who trade with a large discount broker in the period from January 1991 to December 1996. Observations are at the investor-stock-day level. The sample is limited to stocks with returns since purchase of ±0.5 standard deviations from zero (calculated separately for each holding period). Panel A presents the averages of residuals from a probit regression. In Columns 1 to 3, the regression is of returns since purchase on 3rd-, 4th-, and 5th-degree polynomials (an intercept, returns, and returns squared), interactions of the polynomial with the square root of the time owned, and on the square root of the time owned. The residuals are then averaged by whether they belong to a winning stock position (*PSW residual*) or a losing position (*PSL residual*). Panel B presents a regression discontinuity analysis (OLS) where the dependent variable is a selling indicator multiplied by 100. In addition, the regression includes two 3rd- degree (4th-degree and 5th-degree, in Columns 2, 5, and 8 and in Columns 3, 6, and 9, respectively) polynomials: one polynomial is interacted with an indicator of whether the return since purchase is positive and the other is interacted with an indicator of whether the return since purchase is negative. The regressions also include interactions of these polynomials with the square root of time since purchase. Variable definitions are provided in Appendix A. Standard errors are clustered at the investor level. *t*-statistics are presented in parentheses. *, ** denote two-tailed significance at the 5% and 1% levels, respectively.

We place little credence on the finding of apparent realization preference at the mid-range and long prior holding periods, both because the effects are economically small, and because we expect the signal-to-noise ratio in these tests to be much lower than in the short holding period test, where no significant such effect was found. Furthermore, in the regression discontinuity tests, presented in Subsection 3.1.2, we find little evidence for a discontinuity for these prior holding periods.

As pointed out by Birru (2012), investors may naïvely calculate their gains or losses relative to reference prices without adjusting for stock splits. He documents that stocks that experienced stock splits did not exhibit the disposition effect. This raises the question of whether stock splits, or dividends, might be adding noise to our tests for realization preference.

However, the daily frequency of dividends and especially stock splits for a given stock is quite low, so such events are scarce in our short holding period tests. So, the absence of realization preference in these tests does not seem derive from naïveté about splits or dividends. As discussed above, these are also the tests that we expect to have the highest power in testing for realization preference.

We also perform tests that aggregate over all prior holding periods.[14] The results in Column 4 in Table 2, Panel A, indicate that for the entire sample the jump at zero equals to 4.1% to 5.7% of the unconditional probability of selling. In unreported tests in which we allow the slopes of the probability schedule to vary with the prior holding period, the results have similar magnitudes to those reported in Column 4.

3.1.2 A regression discontinuity approach. The second approach that we use to test for a jump in selling at zero is the regression discontinuity method. This method is often applied to identify the effects of some causal treatment when the probability of an individual having the treatment takes a discontinuous jump as some continuous variable increases. The problem of identifying the effects of gain versus loss on selling is a natural application for the regression discontinuity approach.

A key assumption of the approach is the Local Continuity (LC) assumption (van der Klaauw 2008), which is that the observations with regressor values very close to the threshold are otherwise comparable. In our setting, this means that apart from the fact of having a gain or a loss (and its effect on realization preference), an investor-stock-day with a very small loss should be similar to an investor-stock-day with a very small gain.

[14] As discussed in Section 4, spurious effects are introduced when testing for the V-shape in selling, and hence the disposition effect, when aggregating over all prior holding periods. These biases are less severe for discontinuity tests that focus on a small neighborhood of zero.

To test for a discontinuity, we fit two separate polynomials: one for the positive range of returns and one for the negative range. We measure the discontinuity at zero using an indicator variable for the positive range of returns. In addition, we include the square root of time since purchase, and interactions of the polynomials with the square root of time since purchase.

In deciding about the degree of the polynomial, we face a trade-off. On the one hand, a low-degree polynomial may not be flexible enough to capture the functional form of the probability of selling with respect to returns since purchase. On the other hand, a polynomial with a high degree may be too sensitive to extreme observations and may thus mismeasure the discontinuity at zero. Ultimately, the choice of the degree of the polynomial is a matter of judgment. We use 3rd-, 4th-, and 5th-degree polynomials. In Section 3.3, we discuss the V-shape pattern that prevails in the data. The results indicate that the V-shape dissipates over time, and therefore it is important to allow for a time-varying effect. We therefore include interactions between the polynomials and the square root of time.

The results are summarized in Table 2, Panel B. The coefficients in the first row describe the discontinuity at zero. Across the polynomial specifications and the prior holding period, the jump is never significant at the 5% level (despite the large sample size), with some point estimates being positive and others negative. The strongest significance level reached is only 8%, and even the largest of the estimated economic magnitudes are quite small: only 6.4% of the unconditional probability of selling (Column 7). For all prior holding periods, estimates based on 4th and 5th polynomial degrees are statistically insignificant and economically trivial. In summary, there is no clear indication of a jump, and therefore no clear indication that realization preference is a contributor to the disposition effect.

There are important differences between the regression tests and the plots in Figure 1. The sample for Figure 1 is based on a single holding day (e.g., day 250); the test in Table 2, Panel B, Column 9, pools all investor-stock-days for prior holding periods of 250 days or more. So, the sample used in the regression contains much more information than the figure does.[15] In addition, the purpose of the figures is to display the shape of the probability of selling schedule over a wide range of returns. In contrast, the purpose of the tests of jump discontinuities is to reveal the behavior of the selling schedule in the neighborhood of zero. For this reason, the jump discontinuity tests are restricted to stocks whose returns since purchase are within 0.5 standard deviations around zero. This allows the polynomial to fit the shape of the selling frequency schedule more accurately in the neighborhood of zero without being unduly influenced by extreme returns.

[15] Aggregation has the benefit of greater sample size, but can cause regression misspecification, as each prior holding period has a different likelihood schedule for selling (e.g., a different slope for the V-shape). We address this issue by using relatively homogeneous periods (1–20, 21–250, and >250 holding days) and by including interactions of the branches of the V-shape with the square root of the holding period. The results in Table 4 show that these interactions do capture an effect of time on the relation of the probability of selling and profits.

3.1.3 Regression discontinuity tests with profits and losses measured in eighths. A possible objection to return tests for jump discontinuities is that in focusing on returns that are close to zero, we are indirectly conditioning on the firm's stock price. The minimum possible price change during our sample period was 1/8, so only high-priced firms can experience very low returns.

To put firms with different stock prices on a more level playing field, we therefore perform regression discontinuity tests that relate the probability of selling to the gain or loss measured in eighths instead of returns. The details of the analysis and results are provided in Appendix B. These results are consistent with the results measuring profits and losses with returns. We find that for cubic and quartic specifications, the discontinuity around zero profits is always statistically insignificant and economically minimal.

Overall, the results from the residuals tests and the regression discontinuity tests indicate that there is no economically substantial positive jump discontinuity at zero for any of the prior holding periods. At short prior holding periods, during which, on psychological grounds, we would expect realization preference to be strongest, the effects are small and statistically insignificant. At longer prior holding periods, depending on the specification, the effects are sometimes significant and sometimes not, but in all cases the economic magnitude of the effect is minor as a fraction of the unconditional probability of selling.[16]

3.2 Cross-sectional analysis of the discontinuity around zero gains

We examine the cross-sectional effects of trade and investor characteristics to understand better the determinants of the discontinuity around zero gains. We focus on observations within 1–20 days of prior holding, where we expect the historical purchase price to matter the most. We split the sample according to the investor's position size in the given stock, trading frequency, and gender.

We measure the discontinuity using the two-stage procedure of Subsection 3.1 (using a polynomial of 3rd degree). In Table 3, Panel A, the discontinuity around zero gains is estimated in subsamples defined by position size, measured in dollars. The results indicate that none of the groups has a significant discontinuity. In an unreported analysis, we measured position size as dollar amount scaled by total investor's portfolio size; the results are qualitatively similar.

In Table 3, Panel B, we divide the sample by trading frequency, measured as the number of new stock positions opened by investors between 1991 and

[16] A possible qualification to these conclusions relates to the lag between the decision to sell and the placement of an order. An investor with a small gain may decide to sell, delay in placing the order, and then stick to the sell decision even if the gain has changed into a small loss. This kind of behavior would add noise to a test of whether people care about potential gain versus potential loss in their tentative decisions to trade. However, an investor who delays always has the option to change his plan. So, a decision to stick to a plan of selling despite the occurrence of a small loss implies that sign realization preference was not decisive. The focus of our tests is on realization preference in actual decisions, not pre-decision plans.

Table 3
Cross-sectional determinants of the discontinuity around zero gains

Panel A: Position amount

	Position Amount ($)			
	Q1	Q2	Q3	Q4
Breakpoint	n/a	2650	4925	9750
N	1,113,152	1,113,115	1,115,169	1,115,986
PSW residual – PSL residual (%)	0.0918	0.0018	0.0008	0.0049
	(1.60)	(0.56)	(0.19)	(0.39)
(PSW res – PSL res) / Uncond. probability (%)	3.5	4.7	1.5	2.7
(PSW res – PSL res) / Disposition effect (%)	3.6	12.9	3.5	6.4

Panel B: Trading frequency and investor gender

	Trading Frequency				Gender	
	Q1	Q2	Q3	Q4	Male	Female
Breakpoint	n/a	0.006	0.015	0.036	n/a	n/a
N	1,114,394	1,114,522	1,114,455	1,114,401	313,589	39,064
PSW residual – PSL residual (%)	0.0025	0.0127	0.0162	0.0481	0.0227	0.0171
	(0.56)	(1.43)	(1.05)	(0.79)	(0.49)	(0.19)
(PSW res – PSL res) / Uncond. probability (%)	1.9	3.5	2.0	3.0	3.0	2.4
(PSW res – PSL res) / Disposition effect (%)	2.9	4.2	2.6	5.2	4.9	3.5

The table presents cross-sectional results for the discontinuity in the probability of selling around zero returns since purchase. The sample contains the daily holdings of retail investors who trade with a large discount broker in the period from January 1991 to December 1996. Observations are at the investor-stock-day level. The sample is limited to stocks with returns since purchase within ±0.5 standard deviations from zero (calculated separately for each prior holding period). The panels show analysis of the difference in the estimated residual probability of selling winners and losers (PSW residual – PSL residual) for subsamples classified by stock position amount (Panel A), trading frequency (Panel B), and investor gender (Panel B). The residuals are calculated from a regression of a sell indicator of investor-stock-day on a 3rd-degree polynomial function of returns since purchase. Variable definitions are provided in Appendix A. Standard errors are clustered at the investor level. t-statistics are in parentheses. *, ** denote two-tailed significance at the 5% and 1% levels, respectively.

1996, divided by the length of the investor's active trading period, where the active period is defined as the interval from the first day to the last day in the sample in which an investor held an open position. We also divide the sample by investor gender. For both tests, there are no significant differences in effects across investor groups.

Overall, the cross-sectional findings reinforce the conclusion that it is hard to find the tracks of sign realization preference in the data. In none of the investor or trading subsamples do we detect statistically significant or economically important sign realization preference.

3.3 How investors trade as a function of profits

We estimate schedules of the probability that additional shares will be bought or sold per unit time, as a function of an investor's unrealized profit in the stock, to document how investors trade in response to gains and losses. These probability schedules in turn provide insight about why investors trade and whether they exhibit magnitude realization preference.

We perform a probit regression of a sale indicator on raw returns (*Ret*$^-$ and *Ret*$^+$) and controls. *Ret*$^-$ is defined as the minimum between the return since purchase and zero. *Ret*$^+$ is defined as the maximum between the return since purchase and zero. These return variables capture a linear relation between the probability of selling in the positive and negative regions of returns, separately.

We also include the following controls: an indicator variable for whether returns are positive, the square root of the time since purchase (measured in holding days), the logged purchase price, and two stock return volatility variables (computed on the 250 trading days preceding the purchase)—one is equal to the volatility if the observation is a gain, and is equal to zero otherwise; the other is equal to the volatility if the observation is a loss, and is equal to zero otherwise. The stock return volatility variables address the possibility that investors trade more actively in more speculative stocks.[17]

Table 4
V-Shape in the probability of selling and buying additional shares

Panel A: V-Shape in the probability of selling

	Dependent variable: I(Sell stock) × 100					
Prior holding period (days):	1 to 20	21 to 250	> 250	1 to 20	21 to 250	>250
	(1)	(2)	(3)	(4)	(5)	(6)
Ret$^-$	−3.60**	−0.20**	−0.00	−10.18**	−0.58**	0.00
	(−17.65)	(−7.18)	(−0.62)	(−15.67)	(−6.18)	(−0.38)
Ret$^-$ × sqrt(Time owned)				1.95**	0.04**	0.00
				(11.06)	(4.78)	(0.44)
Ret$^+$	3.79**	0.17**	−0.01*	10.54**	0.76**	0.04**
	(23.49)	(11.88)	(−2.33)	(18.26)	(12.98)	(3.20)
Ret$^+$ × sqrt(Time owned)				−1.93**	−0.05**	−0.00**
				(−12.62)	(−10.68)	(−3.58)
I(ret = 0)	−0.05	0.10**	0.02	−0.20**	0.00	0.14
	(−0.94)	(4.33)	(1.23)	(−2.73)	(0.01)	(1.44)
I(ret = 0) × sqrt(Time owned)				0.15**	0.01*	0.00
				(3.30)	(2.04)	(−1.18)
I(ret > 0)	0.40**	0.08**	0.00	0.37**	0.14**	0.04**
	(7.60)	(7.85)	(0.18)	(3.31)	(5.67)	(2.76)
I(ret > 0) × sqrt(Time owned)				0.00	−0.01**	−0.00**
				(0.05)	(−2.96)	(−3.06)
sqrt(Time owned)	−0.16**	−0.03**	−0.01**	−0.03	−0.02**	−0.01**
	(−13.47)	(−30.00)	(−30.71)	(−1.45)	(−10.30)	(−10.15)
log(Buy price)	0.28**	0.04**	0.00	0.28**	0.05**	0.00
	(17.15)	(9.30)	(1.71)	(17.58)	(9.62)	(1.81)
Volatility$^-$	9.04**	1.47**	0.02	8.19**	1.55**	0.05
	(11.42)	(5.35)	(0.22)	(10.38)	(5.82)	(0.49)
Volatility$^+$	9.38**	5.23**	1.34**	8.30**	4.93**	1.30**
	(10.60)	(19.54)	(10.69)	(9.26)	(18.19)	(10.45)
Observations	1,242,021	8,795,180	11,421,064	1,242,021	8,795,180	11,421,064
Pseudo R^2	0.036	0.019	0.012	0.040	0.020	0.013

continued

17 In the absence of a volatility interaction term, a V-shape could arise as an artifact of changes in the composition of the sample as a function of the gain or loss. Highly volatile stocks will tend to be more heavily represented among extreme gains and losses. If the probability of selling a more volatile stock is unconditionally higher, a spurious V could result.

Table 4
Continued

Panel B: V-shape in the probability of buying additional shares

	Dependent variable: I(Buy additional shares) × 100					
Prior holding period (days):	1 to 20	21 to 250	>250	1 to 20	21 to 250	>250
	(1)	(2)	(3)	(4)	(5)	(6)
Ret$^-$	−2.77**	−0.10**	0.00	−5.39**	−0.40**	0.00
	(−19.59)	(−13.06)	(0.69)	(−11.83)	(−12.14)	(−0.35)
Ret$^-$ × sqrt(Time owned)				0.81**	0.03**	0.00*
				(6.69)	(8.37)	(0.41)
Ret$^+$	1.83**	0.10**	0.00	4.01**	0.27**	0.00
	(12.55)	(11.08)	(1.74)	(8.67)	(7.46)	(0.65)
Ret$^+$ × sqrt(Time owned)				−0.62**	0.00**	0.00
				(−5.07)	(−5.23)	(−0.39)
I(ret = 0)	0.38**	−0.03**	−0.01	1.83**	0.00	0.00
	(8.61)	(−2.73)	(−1.71)	(9.30)	(−0.04)	(−0.04)
I(ret = 0) × sqrt(Time owned)				−0.19**	−0.00	−0.00
				(−5.64)	(−0.62)	(−0.27)
I(ret > 0)	−0.25**	−0.09**	−0.02**	−0.14*	−0.10**	−0.04**
	(−8.03)	(−12.53)	(−6.19)	(−2.36)	(−7.13)	(−4.10)
I(ret > 0) × sqrt(Time owned)				−0.05*	0.00	0.00*
				(−2.52)	(0.84)	(2.51)
sqrt(Time owned)	−0.18**	−0.01**	−0.00**	−0.11**	−0.01**	−0.00**
	(−29.29)	(−27.08)	(−11.33)	(−8.06)	(−12.84)	(−7.47)
log(Buy price)	0.08**	0.01**	0.00*	0.08**	0.01**	0.00*
	(6.10)	(3.73)	(−2.11)	(6.13)	(3.78)	(−2.15)
Volatility$^-$	6.94**	1.66**	0.14	6.78**	1.62**	0.15
	(11.23)	(8.61)	(1.78)	(10.36)	(8.41)	(1.87)
Volatility$^+$	0.60	−0.11	−0.21**	0.45	−0.20	−0.22**
	(1.03)	(−0.71)	(−2.64)	(0.71)	(−1.29)	(−2.76)
Observations	1,242,021	8,795,180	11,421,064	1,242,021	8,795,180	11,421,064
Pseudo R^2	0.037	0.019	0.009	0.040	0.021	0.010

The table presents results from probit regressions. The data set contains the daily holdings of 10,000 retail investors who trade with a large discount broker in the period from January 1991 to December 1996. Observations are at the investor-stock-day level. Panel A presents regressions in which the dependent variable is an indicator of whether a stock was sold. The sample is split by the prior holding period. Panel B presents regressions in which the dependent variable is an indicator of whether additional shares of a stock currently owned were purchased. The coefficients presented reflect the marginal effect on the average stock holding, and are multiplied by 100. The dependent variable is an indicator of whether stock was sold on the particular investor-stock-day. Variable definitions are provided in Appendix A. Standard errors are clustered at the investor level. t-statistics are in parentheses. *, ** denote two-tailed significance at the 5% and 1% levels, respectively.

3.3.1 The selling probability schedule. Columns 1 to 3 in Table 4, Panel A, show that up to 250 days from purchase, the probability of selling has an asymmetric V-shape around the origin: in the loss region, the probability of selling increases with the magnitude of losses, while in the gain region, selling increases even more sharply with the magnitude of gains. To illustrate, consider Column 1. An increase of one standard deviation in profits (3.3%, from Table 4, Panel C) increases the probability of selling by about 0.12% (= 3.79 × 0.033). Since the unconditional probability of selling in this prior holding period is 0.72% (Table 1, Panel A), this is a 17% increase relative to the unconditional probability of selling. In the medium holding period, the effect is similar: a one-standard-deviation increase in profit implies an increase in the probability of selling of about 0.0180% (5.5% increase relative to the unconditional probability of selling). For prior holding periods of >250 days, the relation between the probability of trading and profits flattens and is slightly negative.[18]

To illustrate these effects, in the left column of Figure 1, we plot the selling schedules for a set of prior holding periods. We limit the sample to within three standard deviations around the mean return for each day. For each holding period (e.g., Day 1 since purchase), we divide the range of profits into one-percentage-point segments and plot the average frequency of selling within each segment, as well as a two-standard-deviation confidence interval for the probability of selling (see the diamonds and crosses in the chart). Then, to fit trading behaviors in the positive and negative regions, we estimate separate 4^{th}-degree polynomials in each region for selling probability as a function of profit (see solid lines in each region; there is also a dot on the *y*-axis for the frequency at zero returns).

The charts show very strong V-shapes for the early holding periods (up to 125 days), which flatten as the time since purchase increases. The greater steepness of the positive than the negative branch of the V could cause the average probability of selling winners to be higher than the average probability of selling losers.

Since the figures show that the shapes of the selling schedules vary with the time since purchase, we add specifications to Table 4, Panel A (Columns 4 to 6) that interact the raw return variables with the square root of the number of days since purchase. Consistent with the plots, the regressions show that the arms of the V flatten as the time since purchase increases.

3.3.2 The probability of buying schedule. Before discussing what causes the V-shape in selling, we examine the probability schedule for buying additional shares of stocks that investors already hold. This can offer insight by providing a complementary stylized fact to be explained. Table 4, Panel B, performs a test similar to the one in Panel A. We regress (probit) an indicator as to whether the investor bought shares of the same stock on a particular day on Ret^{+}, Ret^{-} in addition to controls: square root of the time since purchase, the logged purchase price, and stock volatility variables (one for gains and one for losses). As in Panel A, we run the regression for several prior holding periods. The results in Columns 1 through 3 indicate that there is a V-shape for buying additional shares in relation to returns since purchase that is analogous to that for selling.[19] The economic magnitude can be interpreted as follows. A decrease of one standard deviation in profits (3.4%) increases the probability of buying

18 The weak negative relation in the long prior holding period may derive from the mechanical effect of aggregating observations with diverse prior holding periods. We discuss this bias in detail in Section 5.

19 Strahilevitz, Odean, and Barber (2011) report a V-shape in the hazard rate for additional purchases of stocks that were formerly owned by retail investors. This neither implies nor is implied by our finding of a V-shape in buying more shares of stocks that the investor currently holds.

additional shares by about 0.09% (= 2.77 × 0.034). Since the unconditional probability of selling in this prior holding period is 0.41%, this is a 23% increase relative to the unconditional probability of buying additional shares. In the medium prior holding period, a one-standard-deviation decline in profit translates to a higher probability of buying additional shares of 0.0095% (8.6% increase relative to the unconditional probability of buying additional shares).

As before, we also add the interactions of Ret^{+} and of Ret^{-} with the square root of the time since purchase. The findings are presented in Table 4, Panel B, Columns 4 through 6. The results indicate that, as with the probability of selling stocks, the V for buying additional shares also flattens over time.

Figure 1 (right column) plots the relation between the probability of buying additional shares against returns since purchase. The charts show a V-shape in buying whose asymmetry between gains and losses is almost a mirror image of the V for probability of selling. In addition, the plots show that the magnitude of the discontinuity around zero is small.

In sum, the reverse disposition effect for buying additional shares, where realization preference is not an issue, further suggests that realization preference is not the key to the disposition effect. Furthermore, the finding of a V-shape in probability of buying additional shares similar to that which exists in the probability of selling offers a challenge for future research: to develop a unified explanation for buying and selling disposition or reverse-disposition effects, and for buying and selling V-shapes.

3.4 Speculation, attention, and the V-shape

In the next subsection, we discuss why trading based upon belief revisions, perhaps combined with limited investor attention, can cause V-shapes for selling and buying. In the subsection that follows it, we perform cross-sectional tests to provide insight as to whether speculative trading based upon beliefs does indeed contribute to the V-shapes.

3.4.1 Discussion. A growing literature has documented the effects of limited attention in capital markets, and how extreme news grabs investor attention, increases trading, and affects market prices (Gervais, Kaniel, and Mingelgrin 2001; Seasholes and Wu 2007; Barber and Odean 2008). A possible explanation for the V-shaped buying and selling schedules is that speculative traders with limited attention are more likely to reexamine their portfolios after substantial gains and losses.

In this account, investors do not trade until their attention is directed to their position. When there is little change in price subsequent to the purchase date, investors have no special reason to reexamine their stock positions, revise their beliefs, and trade. A substantial gain or loss, on the other hand, grabs an investor's attention, causing him to reexamine his positions and, often, to trade. Upon examination, an investor may decide either to sell or to buy more. This would result in the V for both selling and additional buying.

This attention scenario is one version of the hypothesis that the V derives from the speculative motive for trading. We discussed earlier that speculative investors have at least two reasons to trade after large gains or losses: changes in (1) the perception of how much a trading opportunity has successfully run its course, which can encourage further buying after losses to exploit a perceived improvement in the buying opportunity, and selling off of purchased shares after gains, and (2) changes in the degree of faith the investor has in his original analysis, which can take the form of discouragement and selling after losses and further buying after gains. These effects suggest that investors will tend to react with greater trading (either buying or selling) after large price moves (high absolute profits).

So, the speculative motive for trading is consistent with a V-shape. More specifically, this argument explains why trading will be at a minimum at zero gain or loss, with possible increases in buying and/or selling as profits either decrease or increase. However, it does not quantify the opposing forces sufficiently to guarantee that the selling schedule will be monotonic throughout the positive and negative branches.

An interaction of the effects we have discussed can reinforce the argument for a V-shape. An investor who is trading for profit has better reason to reexamine the stock if the price has moved substantially than if his profit were zero. News arrival subsequent to the purchase date can help the investor decide whether his initial analysis was correct and whether the market has now impounded his information. So, it is after substantial gains and losses that the investor takes a fresh look, reevaluates, and trades.[20]

Trading based upon belief revisions need not be rational; for example, investors may be overconfident. So, evidence as to whether the disposition effect is associated with investors losing money (as found in a sample of individual stock investors [Odean 1998], but not in a sample of professional commodity investors [Locke and Mann 2005]) does not distinguish between preference versus belief-revision-based explanations for the disposition effect.

3.4.2 Cross-sectional analysis of the shape of the trading schedule. We estimate trading schedules conditional upon several investor or trade characteristics, in order to gain insight into the sources of the V-shape for both selling and buying additional shares. Our main informal hypothesis is that the V-shape is a consequence of speculative trading. A speculative investor enters into stock positions in the expectation of a gain. If little news arrives, the price moves little from the original purchase price, and the investor is relatively likely to hold his position without further trading. If the stock price increases, he may believe that the undervaluation has been removed and closes his position, or

[20] Supporting this conjecture, Kumar (2009) finds that stocks with high idiosyncratic volatility have a stronger disposition effect. Idiosyncratic volatility is a possible proxy for investors perceiving that they have private information about a stock.

he may become more confident about his information, and buy more. If the stock price declines substantially, he may interpret this as disconfirming his initial assessment, and therefore close the position, or may view the price as being even more attractive, and buy additional shares. Such behavior generates a V-shape in the probability of both selling and buying.

A similar mechanism can generate a V-shape in buying additional shares. If the price of a stock held by an investor increases, he may become more confident in his information (or intuition), and buy more. If the price decreases, and the investor remains confident about his private information, he may perceive an opportunity to increase the bet at a low entry price. Finally, in case the stock price remains around the original price, there is little need to react and purchase additional shares, as there is no new information. Hence, speculation activity generates also a V-like schedule in buying additional shares.

We therefore expect to observe a stronger V for speculative trades, and within subsamples of investors who are more likely to be engaging in speculation activity. We focus on the subsample of Days 1 to 20, the subsample in which the V is strongest, and measure the strength of the V by the difference between the slopes (i.e., coefficients) on the positive and negative branches of the V: $\beta^+ - \beta^-$. Since the coefficient in the loss branch is negative, this difference will be larger when the V is steeper.

In Table 5, Panel A shows how the steepness of the V varies with the size of the position, investors' trading frequency, and investors' gender. For dollar position size, the shape is basically flat instead of V-shaped, except for the bottom quartile of dollar amount. The V for buying additional shares becomes steeper as the dollar position increases. These findings have alternative possible interpretations. On the one hand, small traders are likely to be less financially sophisticated, and therefore more subject to overconfidence. On the other hand, greater overconfidence, ceteris paribus, should increase the size of the trade. Overall, there is no strong prediction.

The V-shapes for both selling and buying additional shares intensify as trading frequency increases. To illustrate the difference in the pattern of trading with respect to past profits, we plotted in Figure 3 the Vs for selling for frequent (investors in Q1 of trading frequency), and for infrequent traders (investors in Q2–Q4 of trading frequency) for a prior holding period of five days. The probability of selling tends to be higher for frequent traders than for infrequent ones, and the gap between the two increases with absolute returns. Panel A also shows how the steepness of the V varies with gender. We find that male investors have steeper Vs for both buying and selling.

The findings for trading frequency and gender are consistent with the hypothesis that speculation drives the V-shape. Previous studies have found underperformance of frequent traders, and that males trade more and thereby underperform (Odean 1998; Barber and Odean 2000, 2001). These authors attribute these findings to investor overconfidence resulting in frequent trading,

Table 5
Cross-sectional determinants of the V-shape

Panel A: Position amount, trading frequency, and gender subsamples

	Position Amount ($)				Trading Frequency				Gender	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Male	Female
Breakpoint	n/a	2650	4925	9750	n/a	0.006	0.015	0.036	n/a	n/a
N	309,119	311,428	310,365	311,109	310,011	310,629	310,853	310,528	628,776	77,063
Selling:										
Ret^-	−7.86**	−0.23**	−0.12	−0.23	−0.88**	−2.01**	−4.24**	−7.01**	−3.84**	−3.75**
	(−13.20)	(−3.85)	(−1.37)	(−1.08)	(−8.18)	(−8.93)	(−12.55)	(−9.35)	(−12.73)	(−5.97)
Ret^+	12.93**	0.21**	0.31**	0.33	0.98**	2.41**	4.48**	6.58**	3.95**	2.69**
	(23.89)	(4.16)	(5.88)	(1.65)	(12.97)	(16.25)	(16.06)	(10.61)	(17.12)	(4.37)
$\beta^+ - \beta^-$	20.79	0.44	0.44	0.56	1.86	4.41	8.72	13.59	7.79	6.45
Buying additional shares:										
Ret^-	−0.43**	−1.18**	−2.57**	−7.08**	−0.83**	−1.71**	−3.01**	−5.42**	−3.02**	−2.62**
	(−6.42)	(−12.23)	(−14.58)	(−13.97)	(−6.60)	(−11.50)	(−13.01)	(−10.07)	(−13.23)	(−5.48)
Ret^+	0.33**	0.53**	1.26**	4.01**	0.58**	1.40**	1.96**	3.17**	1.86**	1.96**
	(4.84)	(4.85)	(6.92)	(8.17)	(4.47)	(8.38)	(8.62)	(6.25)	(8.58)	(4.44)
$\beta^+ - \beta^-$	0.76	1.71	3.83	11.09	1.42	3.11	4.97	8.59	4.89	4.58

(*continued*)

Table 5
Continued

Panel B: Tax-loss selling

	Quarter of the Year				Month
	Q1	Q2	Q3	Q4	December
Breakpoint	n/a	n/a	n/a	n/a	n/a
N	350,886	321,646	282,376	287,113	96,345
Selling:					
Ret^-	−4.11**	−3.12**	−3.48**	−3.76**	−2.78**
	(−11.40)	(−10.92)	(−8.35)	(−10.47)	(−4.91)
Ret^+	4.05**	3.52**	4.15**	3.34**	2.56**
	(16.54)	(15.53)	(14.56)	(11.70)	(6.10)
I(ret > 0)	0.39**	0.41**	0.34**	0.45**	0.38**
	(5.42)	(6.41)	(4.36)	(5.93)	(3.71)
$\beta^+ - \beta^-$	8.16	6.64	7.63	7.10	5.34

Panel C: Margin calls

	Position ($) / Portfolio ($)			
	Q1	Q2	Q3	Q4
Breakpoint	n/a	0.125	0.295	0.733
N	310,263	296,123	309,915	309,465
Selling:				
Ret^-	−8.49**	−0.15	−0.08	−0.30
	(−13.07)	(−1.48)	(−0.77)	(−1.77)
Ret^+	10.94**	0.27**	0.19*	0.42**
	(17.49)	(3.72)	(2.11)	(3.32)
$\beta^+ - \beta^-$	19.43	0.42	0.27	0.72

The table presents results from probit regressions for selling or buying on gains and losses for different trade or investor categories. The coefficients presented reflect the marginal effect on the average stock holding, and are multiplied by 100. The sample contains the daily holdings of 10,000 retail customers of a large discount broker during the period from January 1991 to December 1996. Observations are at the investor-stock-day level. The dependent variable is an indicator of whether an investor-stock-day was a sell (or a buy, in the lower part of the panel). The independent variables (not all are presented in the table) include an indicator for zero return since purchase, an indicator for positive return since purchase, return since purchase interacted with a positive return sign indicator, return since purchase interacted with a negative return sign indicator, the square root of time owned, logged buy price, 250-day volatility interacted with a positive return sign indicator, and 250-day volatility interacted with a negative return sign indicator. Panel A presents analysis of the V-shapes in probability of selling stocks and of buying additional shares of stocks currently owned, for subsamples categorized by stock position amount, trading frequency, and investor gender. Panel B presents analysis of the V-shapes in the probability of selling a stock within subsamples categorized by calendar quarter, and for the month of December. Panel C presents analysis of the V-shapes in the probability of selling a stock within subsamples categorized by value weight of the position in the investor's portfolio (proxy for the likelihood of a margin call). Variable definitions are provided in Appendix A. Standard errors are clustered at the investor level. t-statistics are in parentheses. *, ** denote two-tailed significance at the 5% and 1% levels, respectively.

and in males being more overconfident than females. We find that the V is stronger for exactly these categories of investors.

As a further test, we split the sample by position size, calculated, as before, as the dollar amount of the stock held. This test is confounded by several possible correlates of position size. On the one hand, small investors are more likely to be naïve, and hence subject to overconfidence or magnitude realization preference. On the other hand, other things equal, we expect investors who possess private information and overconfident investors to take larger positions. So, we do not draw strong conclusions from this test, but the evidence is of descriptive interest. As summarized in Table 5, Panel A, only investors with small positions (bottom

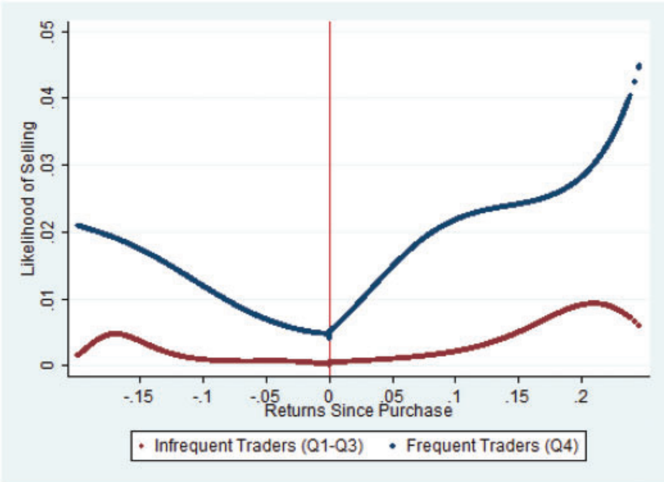

Figure 3
Frequent vs. infrequent traders
The figure presents the probability schedule of selling with respect to returns since purchase for two groups: infrequent traders (Q1–Q3) and frequent traders (Q4) and for Day 5. Trading frequency is the number of new stock positions opened by the investor between 1991 and 1996, divided by the length of the investor's active trading period, where the active period is defined as the interval from the first day to the last day in the sample in which an investor held an open position.

quartile) have an economically strong and statistically clear V for selling. For buying additional shares, it is investors with large positions that exhibit the stronger V.

3.5 Alternative explanations for the V-shapes for selling and buying

We next examine several other possible sources of the V-shapes.

3.5.1 Tax loss selling. Tax-driven sales of losers could induce a downward slope in the left side of the selling V-shape. Odean (1998) reports that the disposition effect reverses in December; he attributes this fact to tax-loss selling. Lakonishok and Smidt (1986) find stronger trading activity of losing stocks in December; however, they argue that other factors are more important than tax loss selling in determining trading. Lim (2006) finds that retail investors prefer to aggregate losses (i.e., on a given day, they prefer to realize losses together rather than realizing several small losses on different days). If investors wish to meet a tax-loss selling goal, then this behavior generates a steeper slope on the left side of the V for tax-loss selling.

Following Bailey, Kumar, and Ng (2011), we condition time of the year to identify tax-loss selling; in Table 5, Panel B, Columns 1 to 4, we explore this possibility by splitting the sample into calendar quarters. In addition, in Column 5, we examine a sample of December observations. The prediction is that tax loss selling is more intense toward the end of the calendar year, implying a steeper left branch of the V-shape late in the year.

For short prior holding periods (1–20 days), the V-shape does not shift as predicted by tax loss selling considerations; in fact, the slope on the negative branch is flatter in the last quarter of the year and in December, relative to previous quarters or months. Odean (1998) suggests that the weaker disposition effect toward the end of the year may be a consequence of tax-loss selling. The results in Table 5, Panel B, suggest that this could instead be a result of a flatter positive branch of the selling schedule rather than a steeper negative branch (the branch influenced by tax-loss selling). For medium prior holding periods, the slope of the negative branch increases slightly during the year, but there is no meaningful difference between the third and fourth quarters. Also, being in the last quarter has no effect on the V for the long-period holdings. Finally, the positive return indicator does not provide evidence that investors are more likely to sell losing stocks toward the end of the year.

Overall, this evidence does not support the proposition that tax-loss selling is a major force shaping the left branch of the probability schedule; we do not see greater selling of big losers near year-end. This evidence also does not support magnitude realization preference, as investors are more likely to sell their big losers than their small ones. An alternative possible explanation for the downward slope of the left side of the V is that investors who take a speculative position in a stock in the hope that it will appreciate tend to close out such positions after uncertainty is resolved (where the resolution results in larger gains or losses).

3.5.2 Portfolio rebalancing. Suppose that investors trade following large price stock movements in order to restore the value shares of different stocks. Then, the larger the loss in a stock, the more they would tend to buy, consistent with the left branch of the buying V-shape, and the larger the gain, the more they would tend to sell, consistent with the right branch of the selling V.

However, these predictions are mirrored by predictions that are inconsistent with the V-shapes. The larger the loss, the less investors would tend to sell, inconsistent with the left branch of the selling V, and the larger the gain the less they would tend to buy, inconsistent with the right branch of the buying V. Furthermore, it is not immediately obvious that investors should rebalance in order to restore value shares in an equilibrium setting.

This story also does not actually succeed in explaining the right branch of the selling V, as it predicts that investors will reduce but not eliminate their positions following large increases in prices. Empirically, as gains increase, investors are more likely to close their positions entirely (untabulated result). The story is also disconfirmed for the right branch of the buying V; as gains increase, investors are more likely to buy additional shares. So, although portfolio rebalancing may potentially contribute to some aspects of the V, overall it is not an adequate explanation.

3.5.3 Belief in mean reversion. Another proposed explanation for the disposition effect is that investors believe that stock price movements tend to reverse (Andreassen 1988; Odean 1998; Choe, Kho, and Stulz 1999; Grinblatt and Keloharju 2001; Vlcek and Wang 2008; Balkanska 2009). However, such beliefs imply a *general* tendency on the part of investors to trade in opposition to stock price movements, rather than a tendency to trade specifically in a stock that the investor already owns. Furthermore, a belief in mean reversion is inconsistent with the evidence of additional buying following price increases. Finally, experimental evidence opposes this explanation (Kadous et al. 2011).

3.5.4 Margin calls. The negative branch of the V-shape could be explained by investors with losing positions selling their stocks in order to comply with the margin requirements on their accounts. To explore this possibility, we conjecture that a margin call is less likely to take place for stock positions that comprise a smaller fraction of an investor's portfolios, since the other assets in the portfolio serve as collateral. Therefore, for each stock position, we calculate its value weight in the total portfolio value for each investor-day, and divide the sample into quartiles based on this measure.

We repeat the selling probability regression for the four subsamples and report the results in Table 5, Panel C. Contrary to the hypothesis, the V is steepest for stock positions that constitute a small fraction of an investor's portfolio. This evidence does not support the notion that margin calls drive the V. It is suggestive of an alternative possibility: that the V derives from speculative motives, and that investors are especially speculative with their "mad money," which they use to buy stocks that are only a small part of their overall portfolios.

4. The Meaning of the Disposition Effect

4.1 Preference versus belief-based sources of the disposition effect

We have documented how investors trade in response to gains and losses, and have tested a key hypothesis suggested by past research, that investors have a direct preference for realizing gains over losses. We now consider whether the disposition effect should be viewed as evidence in support of either realization preference, or of other preference-based explanations that have been offered for it, such as loss aversion or the dual risk-preference feature of prospect theory.

Realization preference implies that, *other things equal*, having a loss rather than a gain reduces the probability that the stock will be sold. However, tests of the disposition effect do *not* hold constant other factors influencing selling decisions that may be correlated with profit. In consequence, the disposition effect does not establish whether investors have realization preference, nor the nature of investor preferences.

To see this, we start by laying out some conditional selling probabilities that can potentially generate the disposition effect. We start with a scenario that is implicit in the binary design of disposition effect tests wherein pure sign realization preference induces the disposition effect. Figure 2A graphs the probability of an investor selling a stock as a function of the unrealized profit. The probability schedule is a step function, being constant except for an upward jump at zero. The jump reflects a preference for realizing gains more than losses. The trading behavior depicted in Figure 2A implies the disposition effect, because the conditional probability of selling given a gain is the high probability on the upper branch, and the probability of selling given a loss is the low probability on the lower branch. Figure 2A provides a possible motivation for interpreting the disposition effect as reflecting pure sign realization preference.

However, Figure 2B illustrates that asymmetry of the selling schedule induces the disposition effect even if there is neither sign nor magnitude realization preference. The figure shows an asymmetric V, which is steeper in the gain region than in the loss region. The steeper slope on the gain side results in greater selling after gains than after losses, so a disposition effect results. We will discuss possible reasons unrelated to realization preference, such as bias in self-attribution, why the slope of the V for sales can be greater on the upside than the downside.

This V-shape differs from what would be expected under simple forms of either pure sign realization preference (a step function selling probability schedule) or pure magnitude realization preference (a monotonically increasing selling probability schedule); it also does not follow in an obvious way from combining the two.[21,22] It is possible that some combination of magnitude realization preference together with some other force could generate an asymmetric, tilted V. What we can be sure of is that the disposition effect fails to distinguish either kind of realization preference from alternative hypotheses that might also generate a V.

In summary, the existence of the disposition effect says little about whether investors have a preference for realizing gains over losses per se. Even if

21 Our discussion is based on what we view as the simplest interpretation of realization preference: that the bigger the gain, the more likely the investor is to realize it (or the bigger the loss, the less likely he is to do so). This kind of argument is implicit in realization preference explanations for the disposition effect such as that of Shefrin and Statman (1985) in which investors are reluctant to realize their losses because they wish to avoid the immediate regret that would result. More generally, dynamic considerations can imply subtler effects, because an investor trades off the immediate psychic cost or benefit to immediate realization against the effects of holding longer and how that affects the probability distribution of future realization utility (Barberis and Xiong 2011). In this sense, our realization preference arguments and those in the previous literature can be viewed as based on investors who are myopic or weigh current realization utility heavily relative to future realization utility.

22 A dynamic multisecurity argument can be made based on realization preference and prospect theory that might potentially result in a downward slope. Owing to convexity in the loss region, individuals would like to "store up" their small losses, but if they badly need cash, would rather realize one big loss than two small losses of half the size. We are grateful to Nick Barberis for this point. This argument suggests that the downward slope of the V-shape should be weaker for investors who have only one stock in their portfolios. However, in an unreported test of this, we do not find a difference in the V-shape for investors with single-stock portfolios.

investors are indifferent about realizing gains versus losses, the disposition effect could easily result from asymmetry in selling schedules (Figure 2B).[23]

To understand why, even in the absence of unconventional preferences such as prospect theory or realization preference, investors may react to the sizes of their gains or losses, consider an investor who takes a speculative position in a stock owing to a belief that expected returns are high. In general, the speculator's decision to sell will be influenced by updates in his belief about whether the stock will rise or fall in the future. There are both rational and psychological reasons to expect this belief to be correlated with the size of the gain or loss that the investor has experienced. After a gain, a speculator may judge that the market has now impounded the analysis or information he was trading on, especially if he had formed a target price.[24] After a loss, a speculator may determine that his analysis or information was less compelling than he had once thought.[25]

As a result, possible updates can go in either direction, depending on the investor's faith in, and willingness to update, his beliefs. After a gain, an investor who believes that the market has now impounded his analysis or information may sell; on the other hand, if his faith in his original analysis increases, he may buy additional shares. Similarly, after a loss, a speculator may think that the upside potential is even greater, and "double down" by buying additional shares; alternatively, he may lose faith in his original analysis and sell. These possibilities suffice to establish that, interpreted as tests of preference-based theories such as prospect theory or realization preference, disposition effect tests do not adequately control for beliefs.

4.2 How speculative trading could induce asymmetry of the V-shape and the disposition effect

In Subsection 3.4.1, we discussed how trading based upon belief revisions, with or without limited investor attention, could induce V-shapes in selling and buying. Limited attention also suggests a simple possible explanation for the asymmetry of the V (i.e., a higher slope for selling on the gain side than the loss side). The key premise is that the higher an investor's profit, the more he enjoys

[23] If there is a symmetric V-shape in selling, then another way in which the disposition effect could be generated is if the distribution of returns has a large positive mean, so that investors are usually on the positive branch of the V. However, actual mean returns are not large enough for this effect to be strong in the data that we explore.

[24] Consistent with investors trading with target prices in mind, Linnainmaa (2010) provides evidence that limit order trading partially accounts for the disposition effect.

[25] In several models, investors form updates about the quality of their information signals based on price moves; this updating affects their trades. In Cao, Coval, and Hirshleifer (2002), rational investors with fixed trading costs wait for a price move before using their private signals. In Dorn and Strobl (2010), both informed and uninformed investors trade following the arrival of new information as long as there is information asymmetry between the groups. In Daniel, Hirshleifer, and Subrahmanyam (1998) and Gervais and Odean (2001), investors with self-attribution bias become more willing to trade after gains than losses. Lee et al. (2008) present a model and experimental evidence suggesting that pessimistic expectations about an investment's future performance lead subjects to sell losing positions.

reexamining his portfolio (see Karlsson, Loewenstein, and Seppi 2009). This reduces the probability of examining and selling losing stocks; the reduction is greater when the loss is greater. So, this effect tilts the loss branch of the V downward.

Similarly, performance-biased reexamination by investors of their portfolios increases the positive slope on the gain side. So, overall, the effect is to tilt the loss side of the V downward and the gain side of the V upward. Since empirically the asymmetry of the V explains the disposition effect, limited attention offers a possible explanation for the disposition effect.

The basic belief-revision-based trading argument (without attention effects) can also potentially explain why the selling V is asymmetric, thereby creating the disposition effect (though our informal discussion is no substitute for careful modeling of this issue). Recall that for a given signal quality, a lower profit (greater loss or smaller gain) implies that the market on average impounded the signal less, thereby increasing the incentive to hold on to the stock. This *information-impounding* effect alone creates an incentive for selling that increases as a function of profit.

The other effect, which can be called the *confidence updating* effect, acts in the opposite direction on both the upside (after a big gain, the investor esteems his original analysis even more, making him less willing to sell) and the downside (after a big loss, he loses faith in his original analysis, making him more willing to sell).

Suppose now that, owing to bias in self-attribution,[26] individuals are reluctant to admit to themselves that they had formed inaccurate beliefs, and therefore are slow to abandon their initial assessments. After losses, this weakens the precision updating effect relative to the impounding effect, so that individuals stubbornly refuse to sell. Consequently, the V-shape has a shallower slope on the downside than on the upside.

Our discussion of attentional and speculative sources of the V-shape has focused on the individual decision level. From an equilibrium perspective, trading is triggered by shifts in disagreement among investors. The changes in individual beliefs we describe in the basic speculative story and the attention story are consistent with shifts in investor disagreement, since big news tends to cause both gains and losses and shifts in investor disagreement. This could occur in a rational setting if big news is associated with shifts in uncertainty and in the diversity of private information signals. It could also occur for psychological reasons.

26 This is the psychological effect wherein the inferences that people draw from the information that they receive tend to be biased toward promoting their own self-esteem. Daniel, Hirshleifer, and Subrahmanyam (1998) and Gervais and Odean (2001) provide models of how self-attribution bias affects investor beliefs, investor trading, and market prices.

4.3 Disposition effect without realization preference: The case of buying additional shares

As discussed earlier, even if there were no realization preference, generically we would expect to see a non-negligible disposition effect (or its reverse), depending on other factors that plausibly would affect the shape of the selling schedule. To illustrate this point empirically, we perform a test in the domain of the purchase of additional shares. In this setting, realization preference is not involved, as investors are not realizing their gains or losses. Nevertheless, we find a kind of (reverse) disposition effect: the probability of buying additional shares of a stock is lower for past winners than it is for past losers. This is a further indication that the existence of the disposition effect or its reverse tells us little about whether investors have non-zero realization preference.

The test follows the disposition effect test (Table 1, Panel A), but instead of a selling indicator, it has an indicator for buying additional shares. We present the results in Table 1, Panel B. For all prior holding periods, the propensity to buy additional shares of winners (PBW) is lower than the propensity to buy additional shares of losers (PBL), a kind of reverse disposition effect. The difference, $PBW-PBL$, is statistically significant and economically substantial, as it accounts for about 31%, 42%, and 25% of the unconditional frequency of buying additional shares for the short, mid-range, and long prior holding periods, respectively.

5. Other Tests of Trading in Relation to Profits

A large literature documents the disposition effect, but very few studies test for a possible discontinuity around zero profit, or even focus directly on how selling probabilities vary as a function of profits. Calvet, Campbell, and Sodini (2009) find that for Swedish investors, the probability that a household will sell a stock increases with the absolute value of the stock's return since purchase, and that selling probability increases more strongly for winners than for losers. We confirm that similar effects obtain for U.S. investors. More importantly, we explore the sources of the disposition effect and whether it reflects realization preference.

Another exception is Kaustia (2010b), who examines the probability of Finnish investors selling losing and winning positions conditional on at least one stock from the portfolio being sold that day. Kaustia concludes that the probability of selling is fairly flat in the realm of losses and increasing or flat in the realm of gains. He further finds a substantial jump discontinuity at zero capital gains for a range of prior holding periods ranging from 1 day to 3 years. For example, Figure 3 displays a large (more than 20%) discontinuous increase in selling probability for stock holdings that are within a range of negative profits versus holdings that are within a range of zero or positive profits (the test also aggregates across a range of prior holding periods). These findings might seem to differ sharply from our finding that the jump discontinuity for U.S. investors is generally small and insignificant.

However, Kaustia (2010b) correctly refrains from interpreting his findings in terms of realization preference. Even in the absence of any sign realization preference, such jumps can easily occur when aggregating over wide ranges of negative or positive profits. The problem is identical to the one we have identified with using evidence of the disposition effect as evidence for sign realization preference: aggregating over different magnitudes of profits mixes any possible sign realization preference with other interfering effects. Of course, in disposition effect tests, the problem becomes more severe as the aggregation is over all loss firms, or all gain firms.

The tests of Kaustia (2010b) include profit bins with width of 2%. We have performed tests in our sample with similar-sized bins surrounding zero profit, and similarly find a jump in the probability of selling. However, when we refine the test by narrowing the size of the bins and/or by using regression analysis to control for variation in the magnitude of the profit, the jump becomes small and statistically insignificant. Similarly, in order to answer the question of whether there is sign realization preference in Kaustia's Finnish sample, it would be necessary to perform tests using the discontinuity methodologies employed here, to focus on whether the probability of selling jumps in a tight neighborhood is around zero.

Grinblatt and Keloharju (2001) provide a histogram for the returns from purchase to sale experienced by Finnish investors; this histogram shows that, conditional on a stock sale, the frequency distribution has a substantial jump near zero. They do not provide formal tests of the jump, which is not the main focus of their article. However, a seemingly obvious interpretation of their graph is that the jump in frequency is driven by a higher propensity to sell stocks with slightly positive returns than to sell stocks with slightly negative returns (realization preference).

However, examining the conditional distribution of returns is only an indirect means of testing for a discontinuity in the selling probability at zero return; it turns out that this conditioning makes the finding hard to interpret. Using our U.S. investor data, we confirm that when coarse bins are used, there appears to be a substantial upward jump in the frequency distribution of returns conditional upon a stock sale as returns climb from a negative to a positive value. However, we also show that this does not provide any clear evidence in support of sign realization preference.

We show that the jump in the conditional distribution is a subtle consequence of three factors. The first is that there are stand-alone peaks in both the *unconditional* and conditional distributions of returns at exactly zero—this occurs for purely mechanical reasons. Second, there is a smoothly increasing slope in the conditional distribution in the neighborhood of and above zero (which in part reflects the V-shape in selling probabilities). The third factor is the use of coarse bins.

In combination, these factors imply a jump in the histogram of returns at zero when using coarse return bins. When using a finer partition, this jump vanishes. There is instead a smooth upward slope that continues within the range of *positive* returns. In other words, the upward slope does not seem to be driven by whether the returns change sign. We discuss these findings in more detail in Appendix C.

In independent work, the review article of Barber and Odean (2011) reports a V-shape in the hazard rate of selling as a function of the profit using both U.S. and Finnish data. Plots of selling probabilities in relation to profits also appear in the contemporaneous study of Seru, Shumway, and Stoffman (2010), although these articles do not explore the source of these patterns or their relation to realization preference or the disposition effect.

Similarly, using Finnish data, Kaustia (2010b) and a prepublication version of Grinblatt, Keloharju, and Linnainmaa (2011) report patterns that are akin to a V for selling. None of these studies, however, consider the implication of it for understanding the source of the disposition effect or test for a discontinuity in the probability of selling at zero.

In contrast with our findings, Odean (1998) and Meng (2010) report an apparent *inverted* V-shape for selling, and Odean (1998) finds an inverted V-shape for buying as well. Both results are close to the opposite of our findings. Using retail data from 1987 through 1993 that are similar to the data used here, Odean (1998) finds that the probability of selling decreases with returns since purchase (Table VII in his article). Similarly, using the same data set that we use, Meng (2010) reports what is essentially a V-shape in the probability of *holding* (rather than selling) as a function of the absolute returns since purchase, which is again close to the opposite of our finding. Also, Odean (1998, p. 1794) finds that the probability of buying additional shares decreases with the absolute magnitude of returns since purchase, which basically inverts the buying V-shape that we obtain.

In an unreported test, we find a trough in the probability of holding similar to those found by Odean (1998) and Meng (2010) when, as in their tests, we aggregate trades across all prior holding periods. This illustrates that aggregating across all prior holding periods can introduce counterintuitive effects that do not reflect the relationship between gains or losses and trading per se. This occurs because, as we document, the selling (or holding) schedule as a function of profit differs greatly across different periods, and because larger absolute returns tend to be associated with longer holding periods.[27]

[27] To see this, consider the combination of three empirical facts that we document: (1) the V-shape in selling, which implies that at a given prior holding period, the probability of selling is low when the absolute return is low; (2) the higher probability of selling at short periods; and (3) the higher frequency of low absolute returns at short periods. Together, these suggest that when pooling across prior holding periods, low absolute returns will be associated with high selling by virtue of their association with short periods, not because they have any effect on selling. More complex effects of pooling will arise because, as we document, the steepness and degree of asymmetry of the selling schedule varies with prior holding period.

Our reported tests of the selling schedule as a function of returns have substantial disaggregation of trades by prior holding period and/or include regression interaction terms to control for the effects of the prior holding period. So long as the prior holding period is adequately controlled for, we find a V-shape (or a left-flattened V) for the probability of selling. Thus, our finding that the lowest probability of selling is around zero returns is evidence against the prospect theory (at least, in simple static formulations) as an explanation for trading in relation to past gains and losses.

6. Conclusion

We study how individual investors at a major U.S. brokerage trade in response to profits (signed gains or losses), both to gain insight about how preferences and beliefs motivate investors to trade, and to evaluate possible explanations for the disposition effect. We find that the probability of selling as a function of profit is V-shaped. For short prior holding periods, investors are much more likely to sell big losers than small ones, in contrast with the idea that investors myopically avoid realizing large losses. We also find that there is little evidence for an upward jump in the probability of selling at zero profits, which opposes the idea that the disposition effect is primarily driven by a simple direct preference for realizing a stock by virtue of its being a winner rather than a loser.

Furthermore, we document an asymmetric V-shape in the probability of buying additional shares as a function of profit, which induces what looks like a "reverse disposition effect" even though the test does not condition on any realization. These patterns weaken as holding period increases.

These findings provide no clear indication that realization preference helps explain investor trading behavior. We also perform cross-sectional tests that suggest that the V-shape may be driven by speculative trading in the expectation of profits.

These findings do not rule out the possibility that some dynamic form of realization preference, or realization preference combined with prospect theory, or realization preference relative to different reference points, may help explain investor trading. What we do establish is that strong conclusions in favor of the simple (static) realization preference hypothesis with purchase price as a reference point cannot be drawn from either the disposition effect or our findings. There is, at present, no general evidence that individual investors in U.S. stocks have an inherent preference or "disposition" to realize winner stocks or a direct reluctance to realize loser stocks.

Although sign realization preference is minimal in our U.S. individual investor stock sample, it could potentially matter more in other circumstances or for other assets and investor types. For example, the interfering effects of variation in beliefs may be less important for assets that have an important consumption component such as housing. Indeed, Genesove and Mayer (2001) document apparent loss realization avoidance in the real-estate market.

Weber and Camerer (1998) document that the disposition effect holds in an experimental setting used specifically for the purpose of eliminating the confounding with investor beliefs. One of our goals has been to test whether realization preference leaves visible tracks for the public trading of stocks outside the laboratory.

Realization preference as studied in the investments literature is based upon benchmarking relative to an arbitrary reference point, almost always the original purchase price. Other research has documented circumstances in which individuals benchmark their decisions relative to arbitrary reference points. Heath, Huddart, and Lang (1999) study stock option exercising patterns for employee option compensation and find that exercising decisions depend on past trends in the stock price, and are higher when the price is higher than the 52-week high. Baker, Wurgler, and Pan (forthcoming) find that merger bidders often anchor on past prices (e.g., 52-week high price), and that target shareholders are more likely to accept bids that exceed the 52-week high.

Our findings indicate more generally that the presence or absence of the disposition effect in different contexts or among different investor groups does not justify conclusions about whether there is realization preference. For example, the absence of a disposition effect among institutional investors says little about whether they lack realization preference.[28]

Our findings also raise the question of whether feelings are the key driver of investor trading in relation to gains and losses. Shefrin and Statman (1985) describe realization preference in emotion-laden terms (pride in realizing gains, and regret in realizing losses). People clearly do have strong feelings when they experience gains and losses, and also when they realize them. However, such events also trigger cognitive responses, such as reassessment of the original reason for taking the position, and of the stock's future prospects. Our findings suggest that the cognitive direction deserves further exploration.

More importantly, our findings support a reassessment of non-von-Neumann-Morgenstern preference theories, such as prospect theory or realization preference, as explanations for investor trading in the field. Contrary to most discussions in the literature, we show that the disposition effect in itself provides no evidence in favor of such preference as opposed to belief-revision explanations for investor trading in relation to gains and losses (see also the model of Barberis and Xiong 2009). The disposition effect was viewed as one of the most well-known and extensively documented victories for prospect theory outside the experimental laboratory. Since there have been recommendations that economics be rebuilt based upon prospect theory,[29] it

[28] Feng and Seasholes (2005) document that the disposition effect weakens with individual investor sophistication and experience. Dhar and Zhu (2006) find that the strength of the disposition effect varies with socioeconomic variables. Cici (2010) finds that U.S. equity mutual funds do not exhibit a disposition effect.

[29] Camerer (1998) urges that expected utility be replaced by cumulative prospect theory as the fundamental paradigm for economics.

is important to understand that the disposition effect does not provide grounds for doing so.

On a practical level, popular authors often admonish individual investors and professional traders to "be disciplined" in trading (by closing losing positions) and to "make peace with losses." By far the most commonly offered proof that investors lack discipline is the disposition effect. The limited importance of simple realization preference effects in our sample, and its minor relevance for the disposition effect, cast doubt upon this advice.

Appendix

A. Variable Definitions

Variable	Definition
Ret^- (Ret^+)	The return since purchase if the return since purchase is negative (positive), zero otherwise.
I(ret<0)	An indicator for whether the return since purchase is negative.
I(ret=0)	An indicator for whether the return since purchase is zero.
I(ret>0)	An indicator for whether the return since purchase is positive.
log(Buy price)	The logged purchase price (in dollars).
sqrt(Time owned)	The square root of the number of days since purchase.
$Volatility^-$ ($Volatility^+$)	The stock volatility calculated using daily returns using the 250 days prior to the purchase if the return since purchase is negative (positive), zero otherwise.
Position amount ($)	The size of the relevant stock position (in dollars).
Position amount ($) / Portfolio size ($)	The value weight of the position in the total investor's portfolio.
Trading frequency	The number of new stock positions opened by the investor between 1991 and 1996, divided by the length of the investor's active trading period, where the active period is defined as the interval from the first day to the last day in the sample in which an investor held an open position.

B. Robustness: Testing for a Discontinuity with 1/8s

We test for a discontinuity around zero profits, where profits are measured in 1/8s, rather than by return. It is crucial in performing such tests to control for stock price, as an increase by 1/8 has a very different economic and psychological importance for a high-priced firm versus a low-priced one. We therefore perform tests on three firm categories: low price (purchase price $\leq$ \$20), medium price (\$20 $\leq$ purchase price $\leq$ \$50), and high price (purchase price $>$ \$50). In addition, we restrict observations to have returns within 0.5 standard deviations of zero calculated for each day-price range.

There is a trade-off in estimating the discontinuity around zero when prices are measured with 1/8. On one hand, to avoid spurious jumps, the polynomial should have a sufficiently high degree to fit the curvature of the data. On the other, the price changes tend to be just a few 1/8s for the short prior holding periods. This leads to multicollinearity and imprecise estimates.[30] In Table B1, we present polynomial estimations for 3^{rd}-, 4^{th}-, and 5^{th}-degree polynomials. With each prior holding period range, standard errors increase with the degree of the polynomial.

30 To see the problem, consider, for example, a sample in which the price movement is either 0 or +1/8. A linear equation could then fit the relation between the average selling frequency and price change, but adding a quadratic term would create perfect multicollinearity and infinite standard errors.

The goodness-of-fit versus power trade-off is seen in comparing Columns 1 and 2 in Table B1, Panel C. For the 1–20-day prior holding period and a 3rd-degree polynomial (Column 1), point estimates are negative and standard errors are relatively large (0.052%). With polynomials at higher degrees (Columns 2 and 3), point estimates are generally positive, and standard errors are even larger. The magnitude of point estimates ranges between −23.2% and 11.8% of the unconditional probability of selling. Therefore, for this prior holding period range, the discontinuity is not estimated with much precision, but point estimates suggest that the magnitude of the discontinuity, if it exists, is relatively modest.

For the mid-range prior holding horizon of 21–250 days (Columns 4–6), there is greater precision in the discontinuity estimates (standard errors are about 0.013%). Although coefficients on the 3rd-polynomial regressions (Column 4) for low and high stock prices are significantly positive, the statistical and economic significance fades as the degree of the polynomial increases. In Columns 5 and 6, none of the coefficients are statistically significant (and the precision does not deteriorate much).

For the long prior holding period of >250 days, the picture is similar. Stocks in the low and high price ranges exhibit significant discontinuities in the cubic specifications. However, for the quartic and quintic specifications, these become statistically indistinguishable from zero and point estimates indicate relatively small economic magnitudes (from about zero to 13.9% of the unconditional probability of selling).

C. Conditional Return Frequency Effects

A less direct way to test for a discontinuity in the selling probability at zero is to condition on sale. Grinblatt and Keloharju (2001) provide a graph of the trading returns of Finnish investors that shows, conditional upon a stock sale, that the frequency of different returns has a substantial jump near zero. This raises the possibility (although this is not the main issue examined in their study) that the jump in frequency is driven by a higher propensity to sell stocks with slightly positive returns than stocks with slightly negative returns (sign realization preference).

Our focus in the main text has been on using a more direct approach of measuring the selling probability as a function of return. However, since previous work has identified graphically a jump in the conditional frequency of returns at zero, we discuss here this alternative testing approach.

Grinblatt and Keloharju (2001) graph the frequency of holding period returns both unconditionally and conditional upon selling, aggregating across prior holding periods and using 1% bins in a data set of the universe of Finnish stock holdings from December 1994 until January 1997. Although the authors do not formally test for a jump, their graph suggests a possible effect, which we explore in more detail using U.S. data.

An initial observation about Grinblatt and Keloharju (2001) Figure 1 is that there is a stand-alone peak at zero even in the unconditional distribution of returns. This is partly a mechanical effect, which we verify in U.S. data as well. If we set aside the frequency at zero returns, there nevertheless still appears to be an upward jump (albeit a slightly smaller one) in their Figure 1, moving from the negative bin closest to zero to the first positive bin.

We show here that U.S. individual investor data, conditioning upon sale, also indicates an apparent jump in the conditional frequency of returns when we use coarse bins as in Figure 1 of Grinblatt and Keloharju (2001). However, when we examine finer partitions, a very different picture emerges. The source of the discrepancy requires some explanation, because the intuition for conditional frequency distributions is more intricate than the intuition for a direct test of how selling probability varies as a function of return.

Because of this intricacy, we start by emphasizing two take-away conclusions. First, examination of the distribution of returns conditional upon selling is a poor means of identifying sign realization preference, because this approach mixes in unrelated effects: the shape of the unconditional distribution of returns, and, when coarse partitions are used, the interaction of the V-shape with bin size. Second, careful examination of such tests in our U.S. data does not provide clear evidence of sign realization preference.

Table B1
Regression Discontinuity (3^{rd}-5^{th} polynomials) on 1/8s Scale

Prior holding period (days):	Dependent variable: I(Sell stock) × 100								
Degree of polynomial:	1 to 20			21 to 250			>250		
	3rd	4th	5th	3rd	4th	5th	3rd	4th	5th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Low prices (Price < $20)									
I(ret > 0) (%)	−0.150	0.076	0.055	0.044**	0.012	−0.010	0.020**	0.007	0.002
t-stat	(−1.85)	(0.42)	(0.10)	(3.60)	(0.71)	(−0.41)	(2.90)	(0.76)	(0.16)
#obs		1,382,947			9,427,085			10,706,682	
β(I(ret > 0)) / Uncond. probability (%)	−23.2	11.8	8.5	12.7	3.6	−2.9	15.0	5.0	1.3
β(I(ret > 0)) / Disposition effect (%)	−32.5	16.6	11.9	14.9	4.2	−3.3	29.2	9.7	2.6
Mid prices ($20 < Price < $50)									
I(ret > 0) (%)	−0.077*	0.033	−0.040	0.009	−0.011	−0.017	0.007	−0.006	−0.013
t-stat	(−2.08)	(0.61)	(−0.50)	(0.96)	(−0.89)	(−1.11)	(1.13)	(−0.86)	(−1.50)
#obs		1,955,206			13,494,298			17,319,118	
β(I(ret > 0)) / Uncond. probability (%)	−10.0	4.2	−5.2	2.8	−3.3	−5.0	6.1	−5.7	−11.9
β(I(ret > 0)) / Disposition effect (%)	−15.7	6.6	−8.2	5.4	−6.3	−9.8	66.0	−62.2	−129.9
High prices (Price > $50)									
I(ret > 0) (%)	−0.085	−0.075	0.026	0.057**	0.030	0.015	0.017*	0.011	0.014
t-stat	(−1.65)	(−1.13)	(0.32)	(4.51)	(1.90)	(0.78)	(2.17)	(1.09)	(1.20)
#obs		979,647			6,690,122			8,026,608	
β(I(ret > 0)) / Uncond. probability (%)	−10.7	−9.5	3.3	18.7	9.9	5.0	17.2	10.6	13.9
β(I(ret > 0)) / Disposition effect (%)	−16.7	−14.8	5.2	43.4	22.9	11.6	441.6	271.3	355.6

The table presents evidence for a discontinuity in the probability of selling stocks around zero returns since purchase, where profits are measured on 1/8 scale. The data set contains the daily holdings of retail investors who trade with a large discount broker in the period from January 1991 to December 1996. Observations are at the investor-stock-day level. The sample is limited to stocks with returns since purchase of ±0.5 standard deviations from zero (calculated separately for each holding period). The table presents a regression discontinuity analysis (OLS) where the dependent variable is a selling indicator multiplied by 100. *I(ret>0)* is an indicator for whether the profit since purchase is positive. In addition, the regression includes two 3^{rd}-degree (4^{th}-degree and 5^{th}-degree, as indicated in the columns' headers) polynomials: one polynomial is interacted with an indicator of whether the return since purchase is positive, and the other is interacted with an indicator of whether the return since purchase is negative. The regressions also include interactions of these polynomials with the square root of time since purchase. Standard errors are clustered at the investor level. *t*-statistics are presented in parentheses. *, **denote two-tailed significance at the 5% and 1% levels, respectively.

Since we have shown that selling probabilities depend on the prior holding period, instead of pooling across all holding periods we focus on the day 1–20 period in which one might expect realization preference to be strongest. (Similar conclusions apply when longer holding periods are pooled.) Figure 4A shows a substantial jump in returns when we use bins of size 1% (the same size used in Figure 1 of Grinblatt and Keloharju 2001); there is still a mechanical upward stand-alone peak at zero (about 8% of the spike at the bin of zero is due to returns that are exactly equal to zero; another 10% are within 1/8 of the purchase price, potentially reflecting a bid-ask bounce). But even if we set aside the mechanical effect in the bin that contains zero, there is an apparent (though more modest) jump in frequency from the bin just below zero to the first positive bin. So, the finding of Grinblatt and Keloharju (2001), that when a coarse partition is used there is an apparent jump in the neighborhood of zero, is replicated in the U.S. data.

However, owing to the coarseness of the partition, this does not establish whether the jump in frequency is directly associated with returns *crossing* zero. The bars in Figures 4B and 4C show that when we use bin size of 0.5% or 0.25%, respectively, there is an upward slope in the frequency returns throughout the return interval (−2%, 2%). In particular, this slope seems to continue unabated within the positive region (0, 2%). (In tests using days 1–10, the upward slope continues up to about +2.5% returns.) Nor does the upward slope seem to be concentrated particularly strongly in the immediate neighborhood of zero (e.g., within the (−1%, 1%) interval).

Since there is nothing special in the frequency distribution about crossing zero, there is no indication here of sign realization preference. However, one might wonder about the source of the upward slope of the conditional distribution in the interval (−2%, 2%). The explanation is subtle, since the conditional distribution derives from the combination of the unconditional distribution and selling propensities as a function of price.

For example, the fact that there is an upward slope moving from returns of −2% toward 0% does not demonstrate any greater propensity on the part of individuals within this range to sell small losers rather than big ones; even the *unconditional* frequency distribution of returns is increasing within this range. In contrast, the upward slope in the conditional frequency of returns in the positive range does seem to come from a greater propensity on the part of investors to sell larger winners rather than smaller ones; the slope on (0, 2%) is positive in the conditional frequency distribution but not in the unconditional distribution. Thus, the upward slope on (−2%, 2%) seems to reflect a combination of effects, and there is no obvious inconsistency between this pattern and the conclusions drawn in the main body text: a V-shape in selling probability as a function of returns, with little or no jump at zero.

We now return to the mechanical effect mentioned earlier, the peak in the return distributions (both unconditional and conditional) at zero. Since this effect is present even in the unconditional return distribution, it obviously does not derive from realization preference. The actual source of this effect is price discreteness. Especially within a few days of purchase there is a non-negligible probability of a zero price move, or a very small change (e.g., bid-ask bounces) for high-price stocks, which induces a peak at zero when returns are aggregated into percentage point bins.[31] The peak at zero creates a jump when returns move up from a negative bin to a bin containing zero. Such a jump should not be interpreted as realization preference.[32]

A possible objection to the first argument, that frequencies are actually rising smoothly when a reasonably fine partition on returns is used, is that price moves are discrete. During this period, the

[31] A peak at zero can potentially derive from stop-loss transactions. Our data do not permit verification of the form of the order.

[32] The mechanical peak at zero also creates a drop in frequency when moving from the bin containing zero to a larger positive bin, but this effect will tend to be diminished when the bin size is coarse. Since selling propensity tends to rise with returns in the positive region (the right branch of the V-shape), when using large bins the selling frequency, in moving up to the next bin, might have a relatively modest decline.

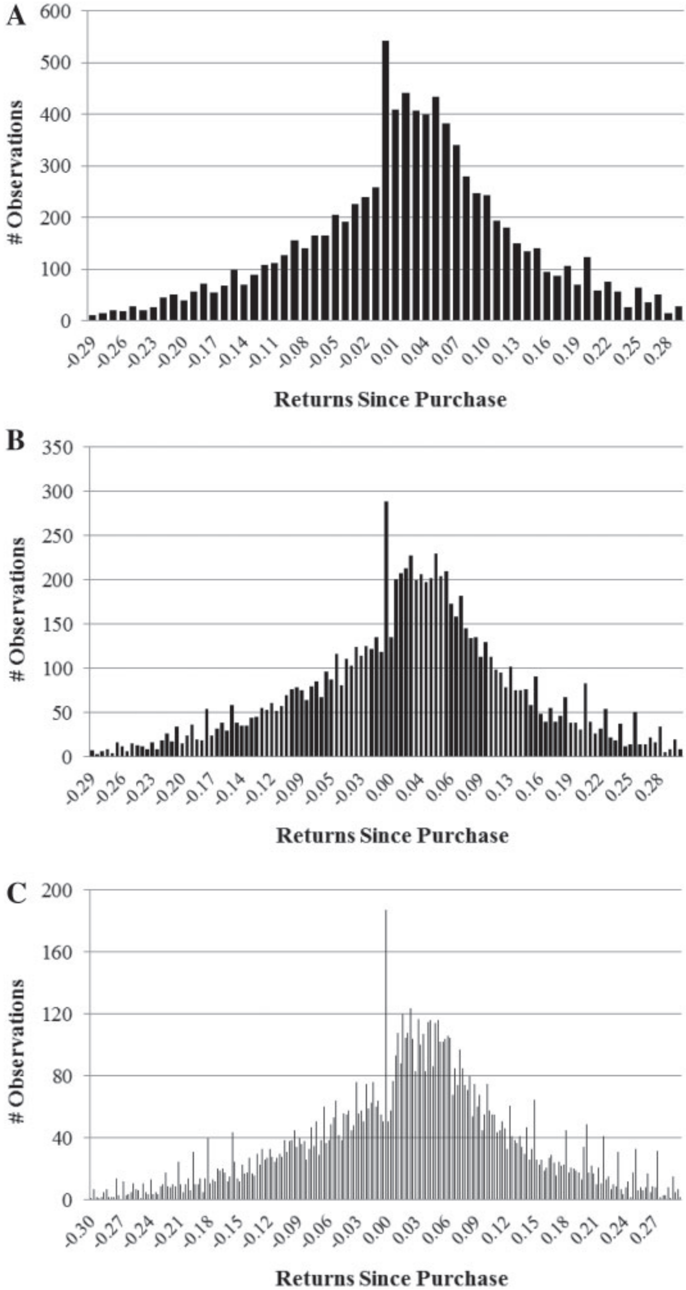

Figure 4
Return distribution by various bin sizes
Figure 4A. Return distribution of sold stocks clustered at 1% bins
The sample includes all investor-stock-days that were sold between prior holding days 1 and 20. Observations are clustered at 1% bins.
Figure 4B. Return distribution of sold stocks clustered at 0.5% bins
The sample includes all investor-stock-days that were sold between prior holding days 1 and 20. Observations are clustered at 0.5% bins.
Figure 4C. Return distribution of sold stocks clustered at 0.25% bins
The sample includes all investor-stock-days that were sold between prior holding days 1 and 20. Observations are clustered at 0.25% bins.

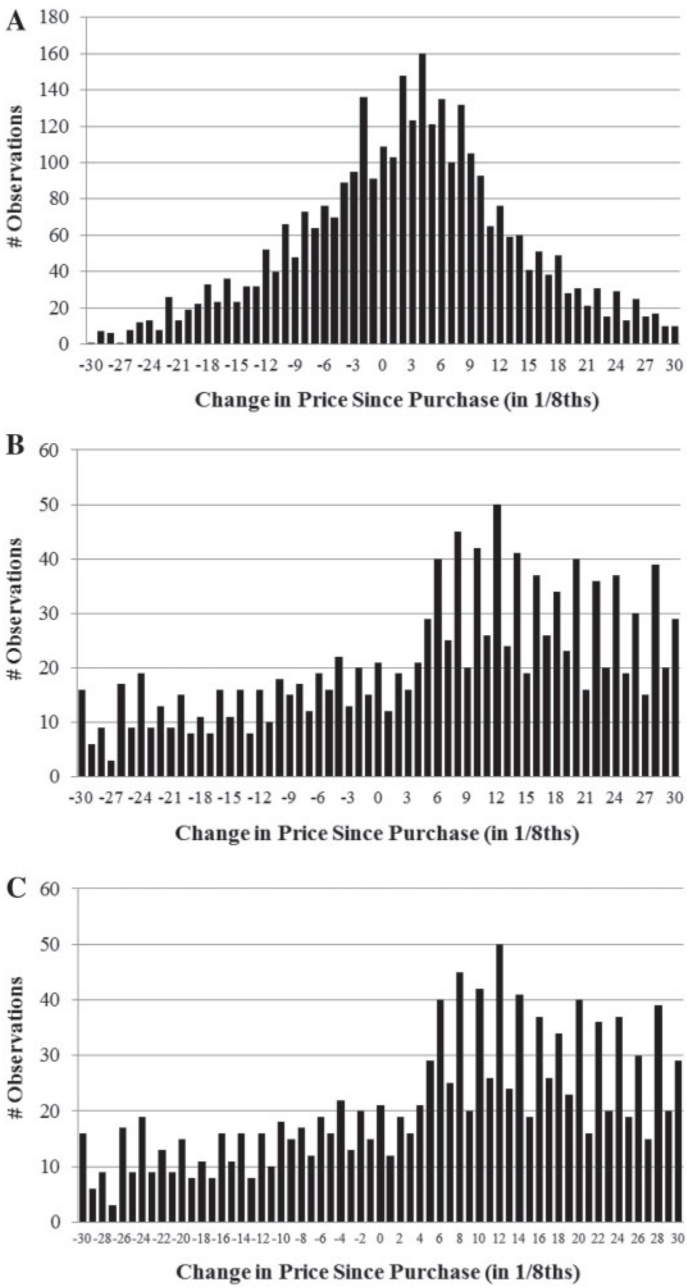

Figure 5
Return distribution measured by 1/8s
Figure 5A. Return distribution of sold stocks measured by 1/8s for price ≤ $20
The sample includes all investor-stock-days that were sold between holding days 1 and 20 with a purchase price lower than $20. Profit is measured in changes in 1/8s from the purchase price.
Figure 5B. Return distribution of sold stocks measured by 1/8s for $20 < price ≤ $50
The sample includes all investor-stock-days that were sold between holding days 1 and 20 with a purchase price between $20 and $50. Profit is measured in changes in 1/8s from the purchase price.
Figure 5C. Return distribution of sold stocks measured by 1/8s for price > $50
The sample includes all investor-stock-days that were sold between holding days 1 and 20 with a purchase price greater than $50. Profit is measured in changes in 1/8s from the purchase price.

minimum move of 1/8 implies a non-negligible percentage stock return, especially for low-priced stocks. So, the apparently smooth increase in frequency of returns from roughly −2% to +2% might come from a mixing of different stocks each of which has its own discontinuous jump.

For example, a move of 1/8 implies a 2% move if the stock price is rather low, 50/8 = $6.25, whereas for a firm with a price of $50, a move of 1/8 implies a percentage return of only 0.25%. So, in the close neighborhood of zero returns, we disproportionately observe firms with higher stock prices. In other words, price discreteness causes a sample selection bias toward firms with high stock prices when examining returns in the neighborhood of zero.

We address this issue here in two ways. First, we perform the conditional return frequency tests within for a subsample of stocks whose prices are at least $30. The results are similar to those discussed above: using a reasonably fine partition, the jump in conditional return frequency vanishes.

Second, instead of examining returns, we examine the conditional distribution of price changes measured in 1/8s (the minimum possible move). As discussed in the main text, the economic meaning of such moves as measured by return is very different for high- and low-priced stocks, so we examine subsamples defined by stock price. In Figures 5A–C, we see that for holdings periods of 1–20 days, for stock prices in the ranges of $P \leq \$20$, $\$20 < P \leq \$50$, and $\$50 < P$, respectively, there is no indication of a jump at zero. In each case, there is an upward slope to the price change distribution in a range that surrounds zero.

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