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Do markets reveal preferences or shape them?☆

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ABSTRACT

We contrast the proposition that markets reveal independently existing preferences with the alternative possibility that they may help to shape them. Using demand-revealing experimental market institutions, we separate the shaping effects of price cues from the effects of market discipline. We find that individual valuations and prevailing prices are systematically affected by both exogenous manipulations of price expectations and endogenous but divergent price feedback. These effects persist to varying degrees, in spite of further market experience. In some circumstances, market experience may actually consolidate them. We discuss possible explanations for these effects of uninformative price cues on revealed preferences.

1. Introduction

There is now abundant evidence that, contrary to the standard assumptions of economic models, the preferences of economic agents are often affected by salient but informationally irrelevant cues, specific to the particular contexts in which those preferences are revealed (Slovic and Lichtenstein, 1968; Bohm et al., 1997; Ariely et al., 2003; Mazar et al., 2013; Sugden et al., 2013; Maniadis et al., 2014).

In this paper, we focus on a specific form of context-dependence: the systematic effect that observations of, or expectations about, actual market prices exert on the valuations of economic agents, even when those prices have no useful informational content for the formation of private values (see Knetsch et al., 2001; Loomes et al., 2003; Tufano, 2009). This effect poses a challenge to the long-standing view in economics that markets are institutions that simply allow economic agents to reveal their pre-existing and market-independent preferences: it suggests by contrast that markets may, to a considerable extent, *shape* preferences. In the traditional view, the market is liable to penalise traders who misreport their preferences

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and thereby encourages them to correct their behaviour (e.g. Binmore, 1999; List, 2003, 2004). Such *market discipline*, it is argued, helps to refine the revelation of one's underlying preferences when these are not immediately accessible but emerge as the result of a process of 'discovery' (Plott, 1996).

Shaping and market discipline are both mechanisms by which prices generated in one trading period can affect behaviour in subsequent periods, and the effects of both can be cumulative. However, while market discipline is supposed to pull revealed preferences towards their underlying market-independent value, shaping may arbitrarily pull them towards irrelevant cues. In the normal operation of markets, discriminating between these opposing forces may prove extremely challenging, as they can result in observationally equivalent behaviour. Taking up this challenge is the main contribution of our paper. We present an experiment which uses two manipulations aimed at identifying the extent of shaping effects in the absence of market discipline, and the power of market discipline to erode the effects of shaping.

In our experimental setup, price cues are devoid of any relevant informational content: people trade privately owned and individually consumed goods, for which valuations cannot be objectively affiliated (e.g. List and Shogren, 1999). Since these goods only exist in our experiment and are consumed inside the lab, price cues cannot convey any information about alternative trading opportunities (Harrison et al., 2004).

We use an exogenous and non-informative manipulation to influence stated price expectations, which act as cues for valuations. Notice that these are expectations about actual market prices, but have not been influenced by any previous market behaviour. So a pure shaping effect – that is, an effect that cannot be attributed to market discipline – can be observed, if it occurs, in the first round of trading. Then, subsequent rounds allow us to observe the effects of market discipline.

We also use a more innovative manipulation that allows us to 'switch off' market discipline for identifiable subsets of traders: traders who repeatedly trade at prices that are clearly very advantageous, and traders who repeatedly do not trade because they face very disadvantageous prices. By repeating the market in the absence of market discipline, we can observe the cumulative shaping effects of endogenous price feedback. By switching market discipline back on for the same traders, we can observe its power to erode these shaping effects which, given their cumulative nature, could be quite large.

To preview our results we find that, in the absence of market discipline, both manipulations induce extensive shaping effects. When these shaping effects are exposed to the full forces of market discipline, they are sometimes weakened, but are not eliminated.

Ultimately, shaping may arise for a number of reasons. One extreme possibility is that agents do not have preferences when they get to the market, and *construct* them using arbitrary cues as anchors (e.g. Slovic, 1995; Lichtenstein and Slovic, 2006; Ariely et al., 2006; Stewart et al., 2006). Or they may react to price information because they use prices as reference points (e.g. Thaler, 1985; Putler, 1992; Isoni, 2011; Weaver and Frederick, 2012; Bordalo et al., 2012). Our results suggest that the proposition that preferences are completely malleable is too extreme. Rather, they are compatible with the existence of underlying preferences of some form, but suggest that these are susceptible to extraneous influences that may have some long term residual effect, in spite of the disciplining forces operating in markets.

The paper is organised as follows. In Section 2, we describe our market institution – a median price selling auction – and derive the institution-specific hypotheses about shaping and market discipline which our experiments will examine. In Section 3, we describe our broad experimental design. In Section 4, we present our first manipulation, designed to test for shaping effects obtained through exogenously influenced price expectations. Section 5 focuses on our second manipulation, in which we study the role of endogenous price feedback. Some issues raised by our results are discussed in Section 6. In Section 7 we offer some concluding remarks.

2. Shaping and market discipline in repeated selling auctions

All of our treatments employ repeated median-price selling auctions for monetary lotteries. In each auction round, each trader is endowed with a lottery and is asked to consider a set of discrete amounts of money spanning a given range and to say, for each amount, whether or not they would accept it in exchange for the lottery. The elicitation procedure (described in detail in Section 3) is constrained to impose consistency: anyone who reports willingness (unwillingness) to accept some amount x must also report willingness (unwillingness) to accept any higher (lower) amount. The smallest amount of money the trader would accept is their *willingness-to-accept valuation* (WTA); the largest amount of money they would *not* accept is their *not-willing-to-accept valuation* (NWTA). (Implicitly, the trader is reporting that they value the lottery at least as much as NWTA but no less than WTA.) The median NWTA is identified and announced as the market price for that round. Traders whose NWTAs are strictly less than the announced price (i.e. who have reported willingness to accept that price) sell their lotteries back to the experimenter at that price; and if this round of trading is randomly selected at the end of the experiment to be the basis of payment, they are then paid that amount. The other traders keep their lotteries: if this round is selected, they play out the lottery and are paid accordingly. Since we are interested in the shaping effect of price cues, there is no resolution of lotteries until after the last round and there is no information about other traders' responses except in the form of the median NWTA which constitutes the market price.

At the end of each auction round, traders are told the market price for that round and hence whether they have sold or not. According to the *shaping hypothesis*, traders are liable to revise their NWTAs for the next round in the direction of the observed prices. This creates a tendency for NWTAs to be pulled in the direction of price cues, other things being equal.

This tendency is conceptually different from value *affiliation*. Affiliated values reflect a positive correlation between non-observed *objective* properties of a good (e.g. the worth of a common-value resource), while shaping reflects a correlation between *subjective* attitudes (e.g. each individual's valuation of a private good) originating from a public signal. For a controlled test of the shaping hypothesis, we need a design that is able to screen out objective affiliation, while allowing for subjective values to be correlated. Whether or not shaping can be reconciled with standard rationality assumptions is a legitimate question, but not the focus of our investigation, which centres on whether the phenomenon exists or not, and how strong it is.

Our controlled test makes use of several convenient properties of monetary lotteries. Because attitudes to risk can vary across individuals, a given lottery is likely to have different private values for different individuals. So the market price for a lottery should provide no *objective* information that is relevant for an individual's judgement of its private value *to them*, even though it reflects other people's judgements about its worth. In addition, since the lotteries we use have no immediate substitutes outside the lab and are 'consumed' inside the lab (in the sense that lottery outcomes are resolved at the end of the experiment), the value of a lottery to a participant cannot be rationally affected by inferences about external trading opportunities. A further feature of lotteries, which we shall exploit, is that their maximum and minimum private values are given by the highest and lowest outcomes.

Controlling for objectively affiliated values and outside trading opportunities is not the only challenge one faces when testing for shaping effects. As we explain below, if other factors such as market discipline are not controlled for, observing that valuations move towards previously observed prices is not necessarily evidence that preferences are market-dependent. The first goal of our experiment is to see if shaping effects occur when market discipline is switched off.

The *market discipline hypothesis* posits that agents possess preferences of some form, which are independent of the market. For expositional convenience, here we make the conventional assumption that each trader has a unique true private value for the traded object.[1]

Our market institution is a variant of the Vickrey auction (Vickrey, 1961). So if traders have true market-independent private values, it is a weakly dominant strategy for each trader to report an NWTA consistent with their private value (Milgrom and Weber, 1982). If these true values were readily accessible and the dominant strategy were easily comprehended, then traders would behave optimally each time they took part in the auction, and repetition would have no effect whatsoever. However, even if underlying preferences satisfy standard assumptions, true values may not be readily accessible, or the best strategy may not be immediately obvious, so that there may be circumstances in which traders deviate from this strategy in one way or another. Such deviations may prove costly, in which case market discipline can come into play.

To see this, consider a median-price auction with n traders (where n is an odd number), indexed by $i = 1, \ldots, n$. Assume each trader has a true value v_i. If the trader responds optimally to the elicitation procedure, their reported WTA will be greater than or equal to v_i, and their reported NWTA, which we denote a_i, will be less than or equal to v_i. However, their actual response may be different because of some 'error' (which may be random, or may reflect some systematic behavioural anomaly). Market discipline operates by exposing the cases in which deviating from the optimal strategy of reporting WTA $\geq v_i \geq a_i$ results in an undesired outcome. This happens whenever $a_i \geq p > v_i$ or $v_i > p > a_i$. In the first case, the trader *over-asks* and fails to sell at p, which is more than their true valuation, thus foregoing a potential gain. In the second case, they *under-ask* and sell at p, which is less than their true valuation, making them worse off. In both of these situations, given the realised price, they would have experienced a better outcome had they followed the optimal strategy. To avoid incurring the same loss again, they should revise their a_i in the direction of v_i in subsequent rounds.[2] Notice that, if they do so, they also revise a_i in the direction of the market price. That is, market discipline produces an empirical tendency analogous to a shaping effect, which is why, when market discipline is in operation, it is difficult to isolate shaping effects.

However, this disciplining effect does not necessarily come to bear on every trader who does not behave optimally. There are situations in which traders over-ask or under-ask but the auction still has the same implications for them as if they had followed the optimal strategy. This happens whenever $p > a_i > v_i$ or else $v_i > a_i \geq p$.

Since market discipline works only on traders for whom $a_i \geq p > v_i$ or $v_i > p > a_i$, the traders who are subject to discipline are likely to have true values that are relatively close to the market price. If the market is repeated, changes in behaviour will continue to be induced among such *marginal* traders until they are no longer vulnerable to market discipline. This is the case if and only if $p > v_i$ holds for all traders i who sell, and $v_j \geq p$ holds for all traders j who do not sell. On the simplifying assumption that the median NWTA is reported by only one trader, the $(n-1)/2$ traders with the lowest NWTAs sell, and the $(n+1)/2$ traders with the highest NWTAs do not sell. Thus, when no trader is subject to market discipline, the market price lies between the $[(n-1)/2]$th highest and the $[(n+1)/2]$th highest true values – just as conventional microeconomic theory would predict for a median-price market. In other words, if one defines the *true market price* as the price that would prevail if all traders followed the optimal strategy, market discipline produces a *tendency for the market price to converge to its true value*. This is the implication of the market discipline hypothesis that we will test.

[1] As we will explain in Section 6, market discipline does not require that preferences are characterised by such a degree of precision, but can operate in an analogous way on imprecise preferences, as long as these are independent of the market.

[2] Here, we make no further assumption about the speed with which true values (or the optimal strategy for reporting these) are discovered. On an extreme interpretation, one could think that a single costly error would be sufficient for a participant to discover their true value. Alternatively, convergence could be a gradual process, in which NWTAs are slowly updated in the direction suggested by the error the participant made (i.e. by decreasing one's NWTA in case of over-asking and increasing it in the opposite case).

However, as noted earlier, there may be traders whose true values are far enough away from the prices generated by repeated markets that their NWTAs never fall between their true values and the realised price. Such traders never experience the costs that give rise to market discipline. Nevertheless, they *are* exposed to the shaping effects of price feedback. If traders with these characteristics can be identified, it is possible to test for the existence and strength of shaping effects while screening out the effects of market discipline. One of our manipulations allows us to switch off market discipline and expose traders to endogenous price feedback cues which, if shaping occurs, will tend to pull their NWTAs away from their true values in a particular direction. Then, by setting up repeated markets in which all participants' NWTAs have previously been shaped in the same way, we can switch market discipline on and test whether prices in these markets converge towards a hypothesised true market price.

In our experiment, we will test the following general implications of shaping and market discipline:

Hypothesis 1 *(Pure shaping).* Absent market discipline, NWTAs are pulled in the direction of uninformative price cues.

Hypothesis 2 *(Market discipline).* With repetition, prices converge to values independent of uninformative price cues.

3. Experimental procedures

The experiment was conducted in 18 sessions at the University of East Anglia and was implemented using the Zurich Toolbox for Readymade Economic Experiments (Fischbacher, 2007). The 204 participants were recruited via email shots from the general student population.

In each session participants took part in three auctions, each repeated eight times, for a total of 24 auction periods. In each session, there were either ten or twelve participants, who were assigned to two trading groups of either five or seven participants (our second manipulation required us to have auction groups of two different sizes). Participants were re-matched to form different trading groups before the start of each auction, but the composition of trading groups was kept constant during the eight rounds of an auction.

One of the auctions implemented our EXP manipulation (shaping through price expectations; see Section 4 for details). Whether this auction came first or last was counterbalanced across sessions. The remaining two auctions implemented our FBK manipulation (shaping through price feedback), and were always run in sequence (see Section 5).[3]

In each round of each auction, each participant saw a lottery displayed on their screen. Lotteries always had exactly two possible outcomes; these were positive amounts of money or *prizes*. Participants were told they owned the lottery displayed on their screen and had the opportunity to sell it. They were presented with a list of prices and asked to state whether or not they would be willing to sell their lottery at each price. The prices (in £) always ranged from $z+0.01$ to y, where y and z, $y>z$, were the two prizes.[4] The 0.01 was added to the lower prize to ensure that NWTA was defined for participants who accepted every price, in which case their NWTA was set equal to z. For participants who rejected every price, NWTA was set equal to y. It was explained to participants why it would be inconsistent to value the lottery above y or below z.[5] Participants were told that if they agreed to sell for £x, they should also be willing to sell for any amount greater than £x (i.e. they were not allowed to switch back and forth in the multiple-price list). Once entered, responses could be changed by restarting the whole process, but this was only possible once. At the end of the process, the computer recorded each participant's NWTA.

After an NWTA was recorded for each trader in a group, the computer determined the market price by selecting the median of these amounts. The instructions explained how the market price was obtained, and the possible trading implications. Before the beginning of the first auction, there was a practice round for participants to familiarise themselves with the elicitation procedures. Their understanding of the basic rules was tested by means of a computerised questionnaire.

At the end of each session the computer randomly selected one of the auction rounds that had been completed by the participant.[6] If the participant had sold their lottery in that round, they received the market price. If they had kept the lottery, they played it out and received its outcome. Lotteries were resolved by drawing one of a hundred numbered discs from a bag. The outcome associated with each number was clearly indicated by the lottery display (see online Appendix for an example). If the selected auction round was from the first manipulation, participants were also rewarded for their accuracy in predicting the market price in the other group (see Section 4.1). Sessions lasted an hour and five minutes on average, and the average earning was £7.50.

[3] The full list of sessions, outlining our manipulations and counterbalancing, can be found in the Appendix, Table A.2.1.

[4] In order to avoid having to present participants with very long lists of prices, the elicitation procedure had a number of steps. In the first step, the prices on offer started from £($z+0.01$) and went to £y covering all multiples of £1 (for one of our lotteries, we had an extra step at the beginning, in which all prices except the lowest were multiples of £10). In the last step, the £1 range between the lowest price that the individual accepted and the highest price she rejected in the previous step was broken down in £0.10 intervals, to arrive at an NWTA expressed as a multiple of £0.10. For some participants prices went up from £($z+0.01$) to £y, for others they went down from £y to £($z+0.01$). Some screenshots of this elicitation procedure can be found in the Appendix.

[5] As we explain in Section 5.1, this aspect of the elicitation procedure was crucial for our second manipulation. Gneezy et al. (2006) report evidence that some participants value lotteries less than their worst possible outcome, a finding that they label the *uncertainty effect*. However, one of the conditions for this effect to occur is that the prizes of the lottery to be valued are not directly expressed in monetary terms (*ibid.* p. 1290), which is not true in our experiment.

[6] Since our second manipulation required that some participants did not take part in one of the auctions, some participants completed 24 rounds and others just 16.

Table 1
Ranges for price expectation cues in EXP manipulation.

High Cue	Low Cue
£20 or more	£1.00–£2.00
£19.90–£15.00	£2.10–£3.00
£14.90–£10.00	£3.10–£4.00
£9.90–£5.00	£4.10–£5.00
£4.90–£1.00	£5.10 or more

In R1 and R8, participants stated their price prediction for the other group in their session by selecting one of the relevant five ranges and then entering a value falling within that range.

4. EXP manipulation: shaping through price expectations

4.1. Design

Our first manipulation was designed to investigate whether NWTAs can be shaped by divergent price expectations (Hypothesis 1), and whether any resulting shaping effects are removed by market discipline (Hypothesis 2). These treatments involved a repeated auction, in which every trader was endowed with the same lottery. In order to allow room for sizeable shaping effects, we chose a lottery with a fairly high variance. Let $K = (£z, p; £y, 1 - p)$ denote a generic binary lottery offering £z with probability p, and £y with probability $1 - p$. The lottery used in this part of the experiment was:

$$E = (£1, 0.95; £50, 0.05).$$

We randomly divided participants into two groups, which we label the *High Cue* and *Low Cue* markets. Each market consisted of eight auction rounds conducted as explained in Section 3. We told participants that there were two trading groups in the room, and that everyone had the same lottery. Before the first auction round, we asked them to predict what the price would be in the *other* trading group, by selecting a range from a list and then reporting a point estimate within the chosen range. If one of these auction rounds was selected to be paid at the end of the experiment, they were rewarded for the accuracy of their predictions, using an absolute loss function with maximum reward of £2. (Because predictions were made about the other group, there was no incentive for participants to misreport valuations in an attempt to make their predictions come true.) The same procedure was repeated before the last auction round to see if participants' expectations adjusted to the price feedback they received.

The High and Low Cue groups differed in terms of the ranges of prices they were presented with. These are shown in Table 1.

Both lists in Table 1 cover the whole range of values between the two prizes of lottery E, but they differ in two important respects. First, the middle range contains much higher values for the High Cue market than for the Low Cue market. Second, the High Cue ranges are presented in decreasing order, while the Low Cue ranges are presented in increasing order. We expected both of these aspects to induce higher price estimates in the High Cue condition than in the Low Cue condition, on the grounds that the first and the middle ranges are more salient than the others (these effects are known in the psychology literature as 'range frequency effects'; see Parducci, 1965; Parducci and Weddell, 1986).[7]

If participants have well-formed true values, such manipulations should have no effect; but if they are prone to shaping effects, the first-round NWTAs in the High Cue markets could be substantially larger than the first-round NWTAs in the Low Cue market. Since no feedback is provided until the end of the first round, the initial NWTAs may be subject to shaping, but cannot have been affected by market discipline. In this setting, Hypothesis 1 implies that NWTAs will be higher in the High Cue group than in the Low Cue group.

As the auction is repeated with feedback, market discipline is switched on and we can investigate its effects. Because traders have been randomised between the two treatments, any underlying true values – including the true value of the market price – should have similar distributions in the two subsamples. Therefore, as the auction is repeated, Hypothesis 2 implies that market discipline should induce convergence of the prices prevailing in the two markets.

4.2. Results

Table 2 reports the data of the High Cue and Low Cue markets of our EXP manipulation. For both treatments, the table reports the number of observations, mean, median and standard deviation of the predicted market prices, the actual NWTAs and the actual market prices in rounds 1 (R1) through 8 (R8).

We will discuss the data with reference to Fig. 1, which uses the following conventions. Solid markers joined by solid lines refer to the High Cue group, while empty markers joined by dashed lines refer to the Low Cue group. Mean NWTAs are

[7] This manipulation bears some similarity to anchoring manipulations (e.g. Ariely et al., 2003), but the final price prediction is, effectively, a self-generated anchor.

Table 2
Results of EXP manipulation: shaping through price expectations. NWTA valuations and market prices for lottery E = (£1, 0.95; £50, 0.05).

	NWTA				Market prices			
	Obs.	Mean	Median	St. dev.	Obs.	Mean	Median	St. dev.
E Low Cue predictions R1					102	6.72	4.05	7.23
E Low Cue predictions R8					102	4.94	4.35	3.18
E Low Cue R1	102	10.21	5.40	10.46	18	6.90	6.30	3.26
E Low Cue R2	102	8.56	5.35	8.54	18	7.37	5.10	5.68
E Low Cue R3	102	7.61	4.90	7.21	18	6.43	4.65	3.95
E Low Cue R4	102	8.61	4.80	10.50	18	6.42	4.70	4.65
E Low Cue R5	102	7.64	4.40	9.62	18	5.03	4.45	2.08
E Low Cue R6	102	6.85	4.30	7.62	18	4.74	4.25	2.07
E Low Cue R7	102	7.20	4.20	9.47	18	4.61	4.30	1.92
E Low Cue R8	102	6.73	4.20	7.92	18	4.38	4.20	1.98
E High Cue predictions R1					102	12.11	12.25	7.99
E High Cue predictions R8					102	7.51	6.05	4.82
E High Cue R1	102	12.11	10.05	9.97	18	10.19	10.00	4.17
E High Cue R2	102	9.64	8.90	6.95	18	8.37	7.90	3.10
E High Cue R3	102	9.36	7.40	8.28	18	8.68	8.00	3.91
E High Cue R4	102	8.04	7.30	5.04	18	8.19	7.40	3.61
E High Cue R5	102	8.13	6.40	5.99	18	7.48	7.10	3.14
E High Cue R6	102	8.28	6.20	7.57	18	6.77	6.50	2.86
E High Cue R7	102	8.29	5.40	8.64	18	6.06	5.20	2.51
E High Cue R8	102	8.08	5.15	8.96	18	6.33	5.70	2.71

102 participants (18 groups of 5 or 7) were assigned to the Low Cue treatment, 102 (18 groups of 5 or 7) to the High Cue treatment. Each group traded for 8 rounds, with feedback about market price and trading outcome after each round. Price predictions were elicited before R1 and before R8 using either Low or High cues.

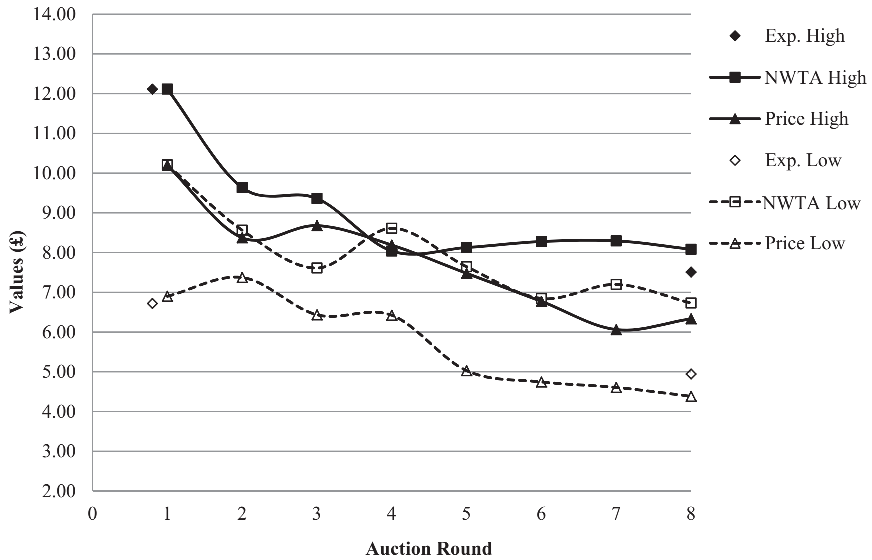

Fig. 1. Results of the EXP manipulation. Evolution of NWTAs and prices in the High Cue and Low Cue markets. *Note*: High Cue denoted by solid markers joined by solid lines. Low Cue denoted by empty markers joined by dashed lines; squares are mean NWTAs; triangles are mean actual market prices; solid (empty) diamonds are mean price predictions for High (Low) Cue.

presented by squares, while mean actual market prices are shown by triangles. The mean price predictions are represented by the diamonds.

The first issue is to establish whether our manipulation has affected price expectations. This is a prerequisite for testing the implications of Hypothesis 1. In R1, the mean (median) expectation is £12.11 (£12.25) in the High Cue market and £6.72 (£4.05) in the Low Cue market; this difference is strongly significant in a one-tail Mann–Whitney test ($Z = -6.44$, $p < 0.001$).

Given that we have been successful at manipulating participants' price expectations, we can test the implications of Hypothesis 1 by comparing NWTAs in R1 between the two groups, when market discipline cannot operate. The mean (median) NWTA in R1 is £12.11 (£10.05) in the High Cue market and £10.21 (£5.40) in the Low Cue market.[8] The two NWTA

[8] Some readers may find it surprising that our participants' NWTAs for a lottery whose expected value is just £3.45 were so high. However, lottery E has the characteristics of a '$-bet' (i.e. a lottery offering small chance of winning a large prize). The preference reversal literature provides robust evidence that such lotteries are often overvalued relative to their expected values (see Seidl, 2002).

Table 3
Evolution of NWTA valuations in Low Cue and High Cue markets for sellers and non-sellers.

Auction round	t	$\Delta NWTA_t$ if sold at $t-1$				$\Delta NWTA_t$ if not sold at $t-1$			
		<0	0	>0	Mean	<0	0	>0	Mean
Low Cue									
R1	1	–	–	–		–	–	–	
R2	2	3	7	31	2.85	48	7	6	−4.66
R3	3	7	11	24	1.03	38	13	9	−2.34
R4	4	6	12	21	2.42	43	9	11	0.12
R5	5	11	16	13	1.23	37	11	14	−2.38
R6	6	10	16	13	0.41	46	9	8	−1.55
R7	7	12	16	11	1.18	31	22	10	−0.16
R8	8	15	14	12	1.14	28	22	11	−1.55
High Cue									
R1	1	–	–	–		–	–	–	
R2	2	3	11	26	3.29	53	3	6	−6.20
R3	3	5	11	23	3.97	48	6	9	−2.91
R4	4	5	14	23	1.40	42	9	9	−3.22
R5	5	6	17	18	1.42	44	8	9	−0.80
R6	6	9	20	9	0.77	43	13	8	−0.22
R7	7	11	14	17	1.63	40	12	8	−1.11
R8	8	7	12	20	1.12	33	16	14	−1.03

Change in NWTA from round to round, $\Delta NWTA_t = NWTA_t - NWTA_{t-1}$, for participants who sold and participants who did not sell in the previous round. For each round of the auction, the numbers of sellers and non-sellers who decreased, kept constant and increased their NWTA valuation is reported together with the mean $\Delta NWTA_t$.

distributions differ significantly in a one-tail Mann–Whitney test ($Z = -2.17$, $p < 0.05$). These findings provide support for the implications of Hypothesis 1, and constitute our Result 1a.

Result 1a – Shaping through price expectations. In the absence of market discipline, NWTAs are pulled in the direction of uninformative price expectation cues.

We can now ask how far the shaping effects of price expectation cues persist in the face of market discipline. According to Hypothesis 2, market discipline should lead *market prices* to converge to values that are independent of uninformative price cues. Since participants were randomly allocated to the two treatments, this means that, with repetition, market prices should converge to the same value in the High and Low Cue groups. For this test to be meaningful, we need our EXP manipulation to have produced a difference in market prices. In R1, the mean (median) market price is £10.19 (£10) in the High Cue group and £6.90 (£6.30) in the Low Cue group, a difference that is statistically significant in a one-tail Mann–Whitney test ($Z = -2.36$, $p < 0.05$).

In order to test the implications of Hypothesis 2, we compare market prices in the last round of the auction, when market discipline has had the best opportunity to exert its effects. In R8, the mean (median) price is £6.33 (£5.70) in the High Cue group and £4.38 (£4.20) in the Low Cue group. Although the absolute difference between the mean (median) prices observed in the two groups is smaller in R8 than in R1, the distributions of market prices still differ significantly between the two groups in a one-tail Mann–Whitney test ($Z = -2.66$, $p < 0.01$).[9] Therefore, we do not find support for the implications of Hypothesis 2.[10] This constitutes our Result 2a.

Result 2a – Persistence of shaping through price expectations. After eight auction rounds, prices that have been shaped by uninformative price expectation cues are still significantly affected by those cues.

The evolution of NWTA valuations over the eight auction rounds is summarised in Table 3. For rounds 2 through 8 of the Low Cue and High Cue markets, the table reports the numbers of participants who decreased, kept unaltered or increased their NWTA, depending on whether they sold or kept their lottery in the previous round. For both sellers and non-sellers, the table also shows the mean change in NWTA, $\Delta NWTA_t = NWTA_t - NWTA_{t-1}$, from round to round.

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[9] Participants' price expectations, which we elicited again before R8, are consistent with this persistent difference. The mean (median) R8 prediction is £7.51 (£6.05) in the High Cue group and £4.94 (£4.35) in the Low Cue group. While the trends in the distributions of market prices are clearly visible in Fig. 1, it is possible that the elicitation of price expectations before R8 had an amplifying effect on NWTA (and price) differences. If we test the implications of Hypothesis 2 using the R7 prices instead, we still find significant differences ($Z = -2.06$, $p < 0.05$ in a one-tail Mann–Whitney test).

[10] The theoretical analysis of Section 2, which forms the basis for Hypothesis 2, presupposes that costly errors are entirely removed. This raises the question of whether eight auction rounds are sufficient for prices to have stabilised, a question that we have tried to answer by estimating a simple asymptotic function for the market price: $p_t = p^* + (1/t)b$ where p_t is the market price in round t, p^* is the asymptotic value of the market price, and b is a parameter related to the speed of convergence. Apart from its ease of interpretation, an advantage of this model is that it can be easily estimated with OLS. The key parameter is p^*. By comparing its value in the High Cue and the Low Cue treatments, we can check whether prices are tending towards different values. The estimated values of p^* are £6.35 in the High Cue group and £4.75 in the Low Cue group. These values are significantly different from each other ($p < 0.1$), indicating that prices appear to be tending towards different values in the two groups. See Table A.3.1 in the Appendix for details.

Table 3 reveals a striking regularity. In both the High and Low Cue groups, participants have a prevalent tendency to increase their NWTA if they sold in the previous round and an opposite tendency to decrease their NWTA if they did not sell.[11] The effect weakens over time, as more participants keep their NWTAs unaltered. This constitutes our first observation.

Observation 1 – NWTA updating in High and Low Cue markets. In High and Low Cue markets, sellers tend to increase their NWTA and non-sellers tend to decrease their NWTA.

Observation 1 shows that both sellers and non-sellers revise their NWTAs in the direction of the market price. But because we have no information about their true values, we cannot tell whether this is an effect of shaping, market discipline or both. This clearly illustrates why, if one is interested in the cumulative effect of shaping, it is useful to shut off market discipline. This is the objective of our FBK manipulation.

5. FBK manipulation: shaping through price feedback

5.1. Design

Our second manipulation is designed to study the effect of price feedback cues on NWTAs. Unlike the price expectation cues that we employed in our EXP manipulation, these cues are *endogenous*, as they are generated by the normal operation of the market.

We randomly divided participants between two treatments, the *control* treatment and the *shaping* treatment. The control treatment was run in sessions with ten participants. Each participant took part in two series of repeated auctions belonging to the FBK manipulation, one for each of two different lotteries, a low-value lottery *L* and a high-value lottery *H* (see below for the specifics of these lotteries). In each repeated auction, there were eight rounds. The order of the two lotteries was counterbalanced between sessions. In this treatment, all traders taking part in the same auction were endowed with the same lottery, so that the price feedback reflected the median NWTA for that lottery in the relevant round. Each of these markets had exactly five traders.

By contrast, the shaping treatment was run in sessions with twelve participants. As in the control treatment, there were two series of repeated auctions involving eight rounds per series. The first series in each session was designed to create conditions under which the cumulative effects of shaping could be observed in the absence of market discipline, hence allowing us to test the implications of Hypothesis 1. The second series of eight rounds was designed to examine the impact of market discipline on any such effects, as a test of Hypothesis 2.

In each session of the shaping treatment, the first series consisted of *mixed* markets, in which different traders were endowed with different lotteries. There was one market with seven traders – three endowed with *L*, three with *H*, and one with a medium-value lottery *M* – and another market with five traders – two endowed with *L*, two with *H*, and one with *M*. This arrangement allowed us to drop the two traders who had been endowed with *M* from the second series[12], and reassign the ten participants who had previously been endowed with *L* or *H* to two *homogenous* markets. That is, the five traders in a session who had been endowed with L in the first series continued to trade *L*, but now as part of one market where all five traders were endowed with *L*, while the other market consisted of the five traders who had been, and continued to be, endowed with *H*. Since both homogeneous and control markets consisted of traders endowed with the same lottery (*L* in some markets, *H* in others), we can judge the persistence of shaping effects by comparing the patterns of prices in our second-series homogeneous markets with those in the corresponding control markets.

The key innovation of the FBK manipulation is the ability to shape NWTAs through the first-series mixed markets. We now explain this manipulation in more detail. We used the following binary lotteries:

$$L = (£2, 0.8; £9, 0.2),$$

$$M = (£7, 0.5; £9, 0.5),$$

$$H = (£7, 0.2; £14, 0.8).$$

Since each trader's NWTA was constrained to be no greater than the higher lottery prize and no less than the lower (see Section 3), the distribution of endowments in the mixed markets ensured that the market price in these markets was bound to lie in the (£7, £9) interval.[13]

In these markets, traders were given no information about the lotteries owned by other traders. When we explained how participants should respond to questions about their willingness to accept stated prices, we stressed that these responses

[11] In both groups, being a seller in the previous round has a highly significant positive effect on $\Delta NWTA_t$ in a random-effects panel regression. See Table A.3.2 in the Appendix for details.

[12] These participants, whose presence was required for our manipulation of the price feedback (see below), were instead asked to complete an unrelated questionnaire.

[13] Because of the constraint on individual NWTAs, only *L* traders could report NWTAs below £7, and only *H* traders could report NWTAs above £9. The presence of one *M* trader in each group ensured that fewer than half of the traders in the market were endowed with *L*, and fewer than half with *H*, so the median ask was bound to be in the (£7, £9) interval, the range of admissible asks for *M* traders.

were strictly personal and should simply reflect their own evaluation of the lottery they were endowed with. Under these circumstances, from a conventional point of view, it should be irrelevant what other people do and what the actual market price turns out to be.[14]

A key feature of our mixed market design is that, since NWTAs in the (£7, £9) interval were admissible for all lotteries, the price feedback was credible for all traders. However, the expected value of *L* (£3.40) was much lower than the lowest possible price (£7), while the expected value of *H* (£12.60) was much larger than the highest possible price (£9). This makes the price feedback fairly high for *L* traders, and fairly low for *H* traders, creating the potential for sizeable shaping effects.

Because the expected values of *L* and *H* lie well outside the range of possible prices, most *L* and *H* traders were unlikely to be subject to market discipline, even if there were strong shaping effects. Consider *L* traders under the assumption that true values exist and are unique (the case of *H* traders is a mirror image). Since these traders were reporting NWTAs for lotteries that were far inferior to those held by the majority of traders in the market, it is natural to expect that in the first auction round the price would be much higher than the true values and NWTAs of almost all *L* traders. If this was the case, *L* traders would sell at such an advantageous price that market discipline would not bite. Nevertheless, the high price would still have the potential to exert an upward shaping effect on their NWTAs. Because of its cumulative nature, over successive auction rounds this shaping effect could be quite strong and yet still not raise NWTAs to a level at which any *L* traders would fail to sell (and hence become subject to market discipline). This feature of our design allows us, in effect, to switch off market discipline and test whether valuations can be shaped by endogenous price cues.[15] Therefore, Hypothesis 1 implies that, after repeated exposure to market price feedback cues, NWTAs for each of lottery *L* and *H* should differ between mixed markets and the corresponding control markets.

Market discipline was switched on when traders were reassigned to homogeneous markets. Suppose that five *L* traders whose NWTAs have all been shaped upwards in mixed markets now take part in the same homogeneous market, and that each of them initially reports the same NWTA as in the last round of the mixed market. Then, the traders reporting the highest of these NWTAs will no longer sell. For these traders, $a_i \geq p > v_i$: they over-ask and fail to sell at an advantageous price. According to the market discipline hypothesis, they should react by reducing their NWTAs in the next round. This tends to produce a fall in the price in the next round. Again, the traders who now state the highest NWTAs fail to sell; if these traders are still over-asking, market discipline leads them to lower their NWTAs in the following round, and the price falls again; and so on, until any over-asking is eliminated in the marginal traders. A mirror-image argument applies to homogeneous H markets.

As explained in Section 2, if agents had precise and market-independent true values, this process of adjustment would come to an end when the price reached its true value, which is fully determined by the distribution of traders' true values. Since participants were randomised between homogeneous and control markets, the distributions of traders' true values should not differ systematically between these markets. Thus, Hypothesis 2 implies that, with repetition, prices in homogeneous markets should converge to values that are not significantly different from those observed in the corresponding control markets.

5.2. Results

Table 4 reports the data we gathered in the mixed, homogeneous and control markets for the *L* lottery (in the top panel) and the *H* lottery (in the bottom panel). Each row reports the number of observations, mean, median and standard deviation of both the NWTAs and market prices for either the *H* or *L* lottery.

The key results will be presented with the aid of Fig. 2, which shows the evolution of NWTAs and prices in mixed and control markets (panels a and b) and in homogeneous and control markets (panels c and d). In each panel, squares denote mean NWTA and triangles denote mean market prices in the relevant market. Data for mixed and homogeneous markets are shown using solid lines (remember that the same participants took part in mixed markets followed by homogeneous markets), while dashed lines refer to control markets.

We start by looking at mixed markets. One of our objectives with these markets was to provide price feedback without the potential for this feedback to trigger market discipline. In order to have a sense of whether we achieved this, we can look at the frequencies with which *L* traders (who were expected to trade) and *H* traders (who were expected to keep their lotteries) did actually sell. Over the first seven rounds of the mixed markets (we do not consider the last round because feedback received in that round could have no effect on observed NWTAs or prices), 68% of the *L* traders sold in every round, and 93% sold at least six times. 88% of the *H* traders never sold, and 97% sold at most once.[16] Thus, although a small number of exceptionally high *L* NWTAs and an even smaller number of exceptionally low *H* NWTAs probably *were* subject to market

[14] We have no way to tell whether or not participants thought other traders in their group were trading the same lottery. Each individual's decision was framed as a decision as to whether or not they wanted to sell their lottery at any given price, and incentivised accordingly. This is all we need for our tests of the shaping hypothesis. Our assignment of lotteries to participants is analogous to the induced value technique adopted in experimental economics since Chamberlin (1948) and Smith (1962) to study market behaviour. We use lotteries instead of tokens to make large shaping effects possible, and employ a median-price instead of a double-oral auction, but participants only trade if the price is acceptable to them.

[15] The auxiliary hypothesis that *L* and *H* traders are rarely subject to market discipline can be verified by considering the frequencies with which *L* traders fail to sell and *H* traders sell (see Section 5.2 below).

[16] The raw numbers of sellers of each lottery in mixed markets can be found in the Appendix, Table A.3.3.

Table 4
Results of FBK manipulation: shaping through price expectations.

	NWTA				Market prices			
	Obs.	Mean	Median	St. dev.	Obs.	Mean	Median	St. dev.
NWTA valuations and market prices for lottery *L* = (£2, 0.8; £9, 0.2)[a]								
L control R1	60	4.25	4.00	1.10	12	4.15	3.95	0.72
L control R2	60	4.20	4.00	1.16	12	4.04	4.00	0.45
L control R3	60	4.21	3.90	1.38	12	3.85	3.80	0.44
L control R4	60	4.09	3.70	1.37	12	3.78	3.55	0.58
L control R5	60	3.94	3.80	1.15	12	3.78	3.80	0.53
L control R6	60	3.99	3.80	1.14	12	3.80	3.85	0.54
L control R7	60	3.96	3.70	1.20	12	3.73	3.65	0.56
L control R8	60	3.83	3.70	0.93	12	3.68	3.55	0.55
L mixed R1	60	4.64	4.40	1.62	24	7.93	7.90	0.55
L mixed R2	60	4.93	4.70	1.54	24	7.74	7.70	0.53
L mixed R3	60	5.04	4.95	1.51	24	7.60	7.50	0.59
L mixed R4	60	5.53	5.45	1.64	24	7.65	7.60	0.62
L mixed R5	60	5.46	5.45	1.52	24	7.61	7.80	0.55
L mixed R6	60	5.67	5.80	1.64	24	7.64	7.70	0.55
L mixed R7	60	5.72	5.90	1.71	24	7.67	7.65	0.58
L mixed R8	60	5.67	6.45	1.82	24	7.57	7.50	0.50
L homogeneous R1	60	5.35	5.40	1.49	12	5.53	5.40	0.88
L homogeneous R2	60	4.94	4.85	1.50	12	4.93	4.85	0.92
L homogeneous R3	60	4.52	4.40	1.48	12	4.38	4.20	0.87
L homogeneous R4	60	4.81	4.40	1.75	12	4.87	4.75	1.18
L homogeneous R5	60	4.65	4.40	1.59	12	4.62	4.35	1.19
L homogeneous R6	60	4.57	4.40	1.56	12	4.43	4.00	1.13
L homogeneous R7	60	4.40	4.10	1.47	12	4.23	4.00	0.98
L homogeneous R8	60	4.60	4.25	1.72	12	4.42	4.20	1.15

	NWTA				Market prices			
	Obs.	Mean	Median	St. dev.	Obs.	Mean	Median	St. dev.
NWTA valuations and market prices for lottery *H* = (£7, 0.2; £14, 0.8)[b]								
H control R1	60	11.17	11.45	1.66	12	11.46	11.45	0.71
H control R2	60	11.09	11.35	1.36	12	10.97	10.90	0.88
H control R3	60	11.10	10.95	1.34	12	10.93	11.05	1.00
H control R4	60	11.08	11.40	1.39	12	10.93	11.50	1.18
H control R5	60	11.21	11.50	1.45	12	11.02	11.45	1.26
H control R6	60	11.19	11.40	1.41	12	10.98	11.30	1.09
H control R7	60	11.14	11.30	1.34	12	10.98	11.10	1.13
H control R8	60	10.97	11.20	1.32	12	10.93	11.30	1.11
H mixed R1	60	10.91	11.10	1.66	24	7.93	7.90	0.55
H mixed R2	60	10.91	11.25	1.66	24	7.74	7.70	0.53
H mixed R3	60	10.26	10.45	1.97	24	7.60	7.50	0.59
H mixed R4	60	9.95	10.10	1.99	24	7.65	7.60	0.62
H mixed R5	60	9.93	10.15	2.07	24	7.61	7.80	0.55
H mixed R6	60	10.05	10.40	2.07	24	7.64	7.70	0.55
H mixed R7	60	9.86	9.95	2.00	24	7.67	7.65	0.58
H mixed R8	60	10.09	10.50	2.06	24	7.57	7.50	0.50
H homogeneous R1	60	10.26	10.40	1.81	12	10.55	10.35	1.05
H homogeneous R2	60	10.55	10.50	1.54	12	10.51	10.50	0.90
H homogeneous R3	60	10.51	10.50	1.42	12	10.41	10.50	0.98
H homogeneous R4	60	10.60	10.70	1.47	12	10.60	10.70	1.02
H homogeneous R5	60	10.61	10.55	1.37	12	10.55	10.60	0.97
H homogeneous R6	60	10.48	10.50	1.47	12	10.48	10.45	1.01
H homogeneous R7	60	10.47	10.50	1.51	12	10.40	10.40	0.95
H homogeneous R8	60	10.56	10.55	1.28	12	10.33	10.45	0.94

[a] 60 participants (12 groups of 5) were assigned to a control treatment in which each trader submitted an NWTA to sell the same lottery (*L*). Each group traded for 8 rounds, with feedback about market price and trading outcome after each round. 60 participants were given the *L* lottery and traded in mixed groups (of 5 or 7) in which some traders had different lotteries. Each group traded for 8 rounds, with feedback about market price (constrained between £7 and £9) and trading outcome after each round. The same participants were then re-assigned to trade in homogeneous groups of 5 with other participants endowed with the same lottery.

[b] 60 participants (12 groups of 5) were assigned to a control treatment in which each trader submitted an NWTA to sell the same lottery (*H*). Each group traded for 8 rounds, with feedback about market price and trading outcome after each round. 60 participants were given the *H* lottery and traded in mixed groups (of 5 or 7) in which some traders had different lotteries. Each group traded for 8 rounds, with feedback about market price (constrained between £7 and £9) and trading outcome after each round. The same participants were then re-assigned to trade in homogeneous groups of 5 with other participants endowed with the same lottery.

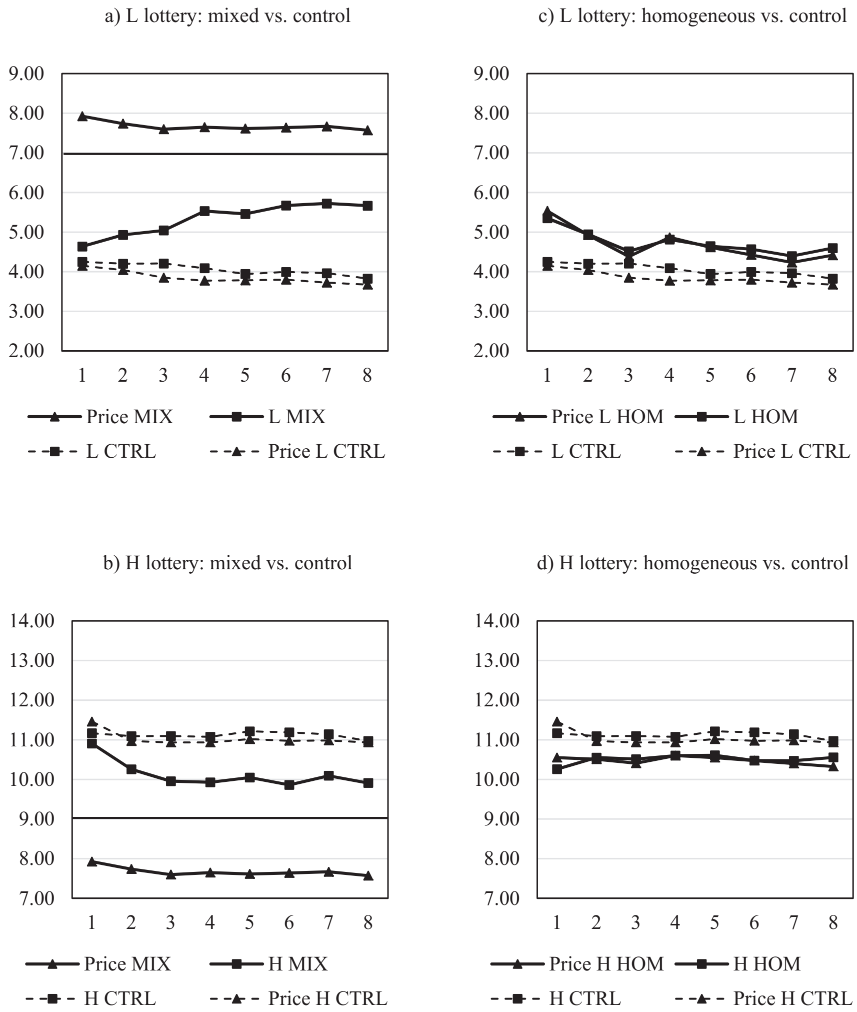

Fig. 2. Results of the FBK manipulation. Evolution of NWTAs and prices in the mixed, homogeneous and control markets. *Note*: In each panel, dashed lines depict the relevant control market, and solid lines either the corresponding mixed (panels a and b) or homogeneous market (panels c and d). Triangles are mean prices and squares are mean NWTAs.

discipline, it seems clear that market discipline could have had very little effect on any general trends in the NWTAs reported by *H* and *L* traders in mixed markets. Such trends can safely be treated as isolating the effects of shaping.

By construction, the average market price is constrained to be between £7 and £9, as indicated by the horizontal lines in panels a and b of Fig. 2. Throughout the eight rounds the mean (median) price fell slightly from £7.93 (£7.90) in R1 to £7.57 (£7.50) in R8. As prices for *L*, these figures are quite high; as prices for *H*, they are rather low. Did this price feedback have any effect on NWTAs? The answer is a clear yes.

In the top panel of Table 4 and panel a of Fig. 2, we can see that the mean (median) NWTA for the *L* lottery rose from £4.64 (£4.40) in R1 to £5.67 (£6.45) in R8.[17] The strength of these shaping effects is confirmed by the totally different pattern observed in control markets, in which NWTAs declined over repetitions. As expected, because participants were randomly assigned to the shaping and control treatments, in R1 NWTA values in mixed markets do not differ significantly from those in the control markets (two-tail Mann–Whitney test: $Z = -1.32$, $p = 0.1871$). However, the difference between the two groups is strongly significant in R8 (one-tail Mann–Whitney test: $Z = -5.39$, $p < 0.001$).

Marked shaping effects, although not as strong as for *L*, also show up for lottery *H*. The mean (median) NWTA was £10.91 (£11.10) in the initial round, dropping to £9.91 (£10.45) in R8.[18] In the corresponding control market, NWTAs varied very little over the course of the eight rounds, starting at £11.17 (£11.45) and ending at £10.97 (£11.20). The between-subject comparisons with the control market confirm that these shaping effects were sizeable. NWTAs were not significantly

[17] In fact, a significant increase in NWTAs is already detectable in R2 (Mann–Whitney test: $Z = -3.11$, $p < 0.001$).
[18] This decrease was already significant in R2 (Mann–Whitney test: $Z = 2.26$, $p < 0.05$).

Table 5
Evolution of NWTA valuations in mixed markets for sellers and non-sellers.

Auction round	t	$\Delta NWTA_t$ if sold at $t-1$				$\Delta NWTA_t$ if not sold at $t-1$			
		<0	0	>0	Mean	<0	0	>0	Mean
L = (£2, 0.8; £9, 0.2)									
R1	1	–	–	–	–	–	–	–	–
R2	2	8	13	35	0.49	3	1	0	−2.43
R3	3	10	18	28	0.22	4	0	0	−1.43
R4	4	10	18	30	0.51	2	0	0	−0.10
R5	5	11	17	24	0.11	5	1	2	−1.26
R6	6	11	22	24	0.23	3	0	0	−0.13
R7	7	14	22	18	0.15	4	0	2	−0.83
R8	8	11	22	20	0.11	7	0	0	−1.30
H = (£7, 0.2; £14, 0.8)									
R1	1	–	–	–		–	–	–	
R2	2	0	1	2	0.20	35	15	7	−0.69
R3	3	0	1	1	0.20	31	13	14	−0.32
R4	4	0	0	1	0.30	23	23	13	−0.03
R5	5	0	0	0	(n/a)	14	30	16	0.12
R6	6	1	0	0	−0.20	17	31	11	−0.18
R7	7	0	0	2	2.35	17	28	13	0.16
R8	8	0	2	1	0.27	19	27	11	−0.21

Change in NWTA from round to round, $\Delta NWTA_t = NWTA_t - NWTA_{t-1}$, for participants who sold and participants who did not sell in the previous round. For each round of the auction, the numbers of sellers and non-sellers who decreased, kept constant and increased their NWTA valuation is reported together with the mean $\Delta NWTA_t$.

different in R1 (two-tail Mann–Whitney test: $Z = 0.87$, $p = 0.3846$), but differed strongly after eight auction rounds (one-tail Mann–Whitney test: $Z = 2.78$, $p < 0.01$).[19]

Taken together, these findings provide strong support for the implications of Hypothesis 1. We can summarise them as Result 1b:

Result 1b – Shaping through price feedback. In the absence of market discipline, NWTAs are pulled in the direction of uninformative price feedback cues.

Our data seem to indicate that shaping effects are stronger when feedback is relatively high (for lottery L) than when it is low (for lottery H). This forms our second observation.

Observation 2 – Asymmetry in the strength of shaping. When shaping is generated through uninformative price feedback cues, its effects are stronger when the feedback is relatively high than when it is relatively low.

Before turning to the implications of *Hypothesis 2*, it is interesting to ask to what extent this aggregate picture reflects *general* tendencies rather than being driven by a small number of particularly malleable individual valuations. Table 5 reports information on the round-by-round evolution of NWTAs in mixed markets for L and H, separately for participants who sold in the previous round and participants who kept their lotteries. The structure of the table is entirely analogous to that of Table 3.[20]

As we discussed above, because of our manipulation of the price feedback, there are very few L traders who do not sell and very few H traders who do. Amongst the L sellers, the great majority responds by increasing their NWTAs, while H non-sellers have a preponderant propensity to decrease theirs.[21] As in Table 3, these effects slow down slightly over time. This forms our third observation.

Observation 3 – Shaping at the individual level. Uninformative price feedback cues affect the NWTAs of the majority of participants in the direction of observed prices.

We now turn to the homogeneous markets and our tests of the implications of Hypothesis 2. The evolution of NWTAs and prices in the homogeneous and control markets is displayed on the right-hand side of Fig. 2. In homogeneous markets, the shaping effects generated through price feedback cues are exposed to the effect of market discipline.

The first important aspect highlighted by the right-hand side of Fig. 2 is that for both lotteries there is a re-start effect that partly offsets the shaping effects generated in mixed markets. NWTAs for lottery L drop from their R8 level in mixed markets, while NWTAs for H increase. That is, L traders (who experienced consistently high prices in a mixed trading group and responded by gradually increasing their NWTAs) lowered their NWTAs on joining a new trading group, *prior to any price feedback*; there is a mirror-image effect for H traders. These effects are suggestive of some form of underlying true values.

[19] As explained in Section 3, in some sessions mixed markets came first, while in others they followed the market involving lottery E, in which all traders traded the same lottery. It is reasonable to ask whether shaping effects are stronger in the latter case. We found no order effects of this kind. For both lotteries and in both R1 and R8, the distributions of NWTAs when mixed markets preceded the market for lottery E are not statistically different from the distributions when they followed it.

[20] The corresponding information for control markets is reported in the Appendix, Table A.3.4.

[21] For both lotteries, being a seller in the previous round has a significant positive effect (at the 1% level for L and 10% level for H) on $\Delta NWTA_t$ in a random-effects panel regression. See Table A.3.2 in the Appendix for details.

Table 6
Evolution of NWTA valuations in homogeneous markets for sellers and non-sellers.

Auction round	t	$\Delta NWTA_t$ if sold at $t-1$				$\Delta NWTA_t$ if not sold at $t-1$			
		<0	0	>0	Mean	<0	0	>0	Mean
L = (£2, 0.8; £9, 0.2)									
R1	1	–	–	–	–	–	–	–	–
R2	2	3	8	13	0.40	29	3	4	−0.94
R3	3	8	5	11	0.15	25	5	6	−0.81
R4	4	7	7	7	0.60	20	7	12	0.13
R5	5	3	7	14	0.52	21	7	8	−0.63
R6	6	4	5	13	0.54	20	14	4	−0.43
R7	7	1	11	10	0.26	17	14	7	−0.43
R8	8	5	10	9	0.57	13	14	9	−0.04
H = (£7, 0.2; £14, 0.8)									
R1	1	–	–	–		–	–	–	
R2	2	0	4	17	0.99	17	10	12	−0.08
R3	3	1	5	17	0.51	16	15	6	−0.39
R4	4	3	9	11	0.18	12	14	11	0.04
R5	5	3	7	13	0.34	16	17	4	−0.20
R6	6	4	7	13	0.17	17	17	2	−0.34
R7	7	2	13	7	0.26	14	20	4	−0.16
R8	8	2	11	9	0.45	11	21	6	−0.13

Change in NWTA from round to round, $\Delta NWTA_t = NWTA_t - NWTA_{t-1}$, for participants who sold and participants who did not sell in the previous round. For each round of the auction, the numbers of sellers and non-sellers who decreased, kept constant and increased their NWTA valuation is reported together with the mean $\Delta NWTA_t$.

To test the implications of Hypothesis 2, we look at market prices. For both L and H, the R1 prices in homogeneous markets were significantly different from those of the corresponding control markets (one-tail Mann–Whitney tests: for L, $Z = -4.85$, $p < 0.001$; for H, $Z = 4.61$, $p < 0.001$), showing the continuing effects of the price feedback cues that traders received in the mixed markets, despite the re-start effect. Over the eight rounds of the homogeneous markets, the prices for L decreased, while those for H remained more or less stationary. But at the end of the last auction round, prices were still significantly higher than in the control group for L (one-tail Mann–Whitney test: $Z = -1.70$, $p < 0.05$), and still significantly lower for H (one-tail Mann–Whitney test: $Z = 1.68$, $p < 0.05$), indicating the persistence of shaping effects on prices. As for our EXP manipulation, we do not find support for the implications of Hypothesis 2.[22] Our findings are summarised in Result 2b.

Result 2b – Persistence of shaping through price feedback. After eight auction rounds, prices that have been shaped by uninformative price feedback cues are still significantly affected by those cues.

Table 6 summarises the evolution of NWTAs over the eight auction rounds of the homogeneous markets for the L and H lotteries. Its structure is analogous to that of Tables 3 and 5. So are the results. For both lotteries, there is a prevalent tendency for those who have sold in round t to increase their NWTA in round $t+1$, and an opposite tendency for those who have not sold to reduce their stated valuations, with the number of participants who kept their NWTA unaltered slowly increasing over the eight auction rounds.[23] This forms the basis for our fourth observation.

Observation 4 – NWTA updating in homogeneous markets. In the homogeneous markets, sellers tend to increase their NWTA and non-sellers tend to decrease their NWTA.

The behaviour of L sellers and H non-sellers is of particular interest because it is consistent with shaping but hard to reconcile with market discipline. Remember that all participants entered homogeneous markets after being exposed to the mixed markets shaping manipulation, which pulled their NWTAs away from their (unobservable) true values. Given the magnitude of these shaping effects, it is reasonable to infer that, in the final rounds of the mixed markets, most L traders were over-asking and selling at very advantageous prices, i.e. $v_i < a_i < p$. However, when these traders were subsequently assigned to homogeneous markets, the median price rule meant that (approximately) three-fifths of them would no longer sell. According to market discipline, these traders, for whom now $v_i < p < a_i$, should decrease their NWTAs, which is what we see in Table 6. But even those L traders who continued to sell were likely to be over-asking. For them, $v_i < a_i < p$, so market discipline would not bite and they should not have changed their behaviour in any systematic way. Yet, as we also see in Table 6, they actually increased their NWTAs more than twice as often as they reduced them – a pattern that suggests they were continuing to be influenced by market price feedback.

The behaviour of H non-sellers shows a mirror image of this pattern. In the final rounds of the mixed markets, most H traders were presumably facing disadvantageous prices, under-asking, but not selling and therefore not subject to market

[22] Since in both the homogeneous and control treatments valuations and prices vary little for the H lottery, we do not need to worry about price convergence in relation to that lottery. For L, we have estimated asymptotic functions of the same form as for E (see footnote 12). The resulting estimates of p^* in the homogeneous market (£4.23) and in the control market (£3.67) are significantly different from each other ($p < 0.1$). See the Appendix for details.

[23] For both lotteries, being a seller in the previous round has a significantly positive effect (at the 1% level) on $\Delta NWTA_t$ in a random-effects panel regression. See Table A.3.2 in the Appendix for details.

discipline (i.e. $p \leq a_i < v_i$). When they were assigned to homogeneous markets, (approximately) two-fifths of them would sell their lotteries; market discipline would then lead these traders to raise their NWTAs. But market discipline would not bite for those with $p < a_i < v_i$, who would continue not to sell. And yet, as we see in Table 6, these traders subsequently reduced their asks more than twice as often as they increased them, once again suggesting that the market price continued to have some shaping influence.

Observations 1, 3 and 4 highlight a pervasive tendency for NWTAs to move in the direction of the market price. This tendency is compatible with another regularity in our data: that the variance of NWTAs *within* auction groups decreases over repeated rounds, while NWTA differences *between* groups increases.[24]

6. Discussion

In this section, we discuss some issues raised by our results.

The first issue concerns the explanation of shaping effects. Our data show an interesting asymmetry which, were it to be replicated, might throw some light on the mechanism(s) that lie behind shaping: shaping effects seem to be stronger when NWTAs are being pulled up by high prices than when they are being pulled down by low prices (see observation 2).

This regularity is consistent with the theory of 'bad deal aversion' (Isoni, 2011; Weaver and Frederick, 2012; for related ideas, see Thaler, 1985; Putler, 1992). In this theory, preferences are reference-dependent in a way that makes individuals' valuations of goods depend directly on price expectations. Specifically, individuals derive utility from making 'good deals' (buying at prices that are lower than expected, selling at prices that are higher than expected) and disutility from making 'bad deals' (the opposite). In the context of a selling auction, a trader for whom the expected price is *higher* than their reference-independent valuation of the good will report an NWTA higher than that valuation in order to avoid particularly bad deals; conversely, a trader for whom the expected price is *lower* than their reference-independent valuation will state an NWTA lower than that valuation in order to enjoy particularly good deals. If, other things being equal, the pain of bad deals is stronger than the pleasure of good ones, the tendency for NWTAs to be pulled up by high price expectations will be stronger than the tendency for them to be pulled down by low expectations.

An alternative explanation of this apparent asymmetry is the following. When NWTAs are being pulled up by a high market price, the traders whose preferences are being shaped are *trading at*, and *benefiting from*, that price. These features of the price may contribute to its psychological salience and may encourage further over-asking, in the belief that this could prolong a particularly favourable state of affairs. Conversely, when NWTAs are being pulled down by a low price, the traders whose preferences are being shaped are *not* trading at that price, and the low level of the price is a source of *disbenefit* to them.[25]

A more fundamental issue raised by our results is that of explaining why shaping effects are *partially* but *not wholly* eroded by market discipline. Had we found that shaping effects were completely resistant to market discipline, that would have been consistent with the hypothesis, advocated by some psychologists, that preferences do not exist prior to elicitation, and are *constructed* by individuals as and when they are needed (e.g. Payne et al., 1993, 1999; Slovic, 1995; Stewart et al., 2006). But that is not what we found.

Alternatively, suppose we had found that, when market discipline was switched on, market prices converged towards values that were independent of our shaping manipulations. That would have been consistent with an interpretation of Plott's (1996) *discovered preference* hypothesis in which the discovery mechanism is market discipline (Loomes et al., 2003). According to this account, psychological factors may cause irrelevant cues to have significant impacts on market behaviour, so long as that behaviour does not lead individuals to make losses; but when behaviour is subject to market discipline, true preferences are gradually discovered. But again, that is not what we found.

In broad-brush terms, what we seem to have found is the following. When our shaping manipulations induce large changes in NWTAs (as in the mixed market for lottery *L*), the initial effect of introducing market discipline is that NWTAs move in the direction that offsets this shaping (NWTAs for *L* decrease in the early rounds of the homogeneous market). Indeed, a detectable move in this direction is induced merely by telling participants that they have joined a new trading group (NWTAs for *L* are already lower in R1 of the homogeneous market than they are in R8 of the mixed market). These effects might indicate that participants have some vague sense that their shaping-induced NWTAs do not altogether reflect their underlying preferences. However, the effects of shaping are not eliminated. After eight auction rounds in which market discipline has been switched on, market prices still do not converge to values independent of the shaping manipulation. The implication is that participants are not discovering *precise* underlying valuations.

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[24] Table A.3.5 in the Appendix reports the within- and between-group variances of NWTAs for all or our treatments in R1 and R8. In five out of six cases, the within-group variance falls between R1 and R8. NWTA distributions are not different across auction groups in matched treatments in R1, as one would expect given that participants have been assigned to treatments at random. But the null hypotheses that NWTAs are the same across groups can be rejected in five out of six cases in R8. A similar result is found by Tufano (2009).

[25] This idea was suggested to us by Ben McQuillin. Note that, while evidence suggests that participants in auctions may derive utility from the fact that they are 'winning' the auction (e.g. Dechenaux et al., 2014), joy of winning seems incompatible with the asymmetry that we find (as well as the general trends in valuation updating shown in Tables 3, 5 and 6) because, in a selling auction like ours, *L* traders should, if anything, decrease their NWTAs instead of increasing them as they clearly do.

One hypothesis that is consistent with this combination of observations is that each individual has broad preferences which exist prior to elicitation, but which are characterised by some degree of noise or imprecision (see, for example, Butler and Loomes, 2007). This idea can be applied to the case of a selling auction by generalising the model we presented in Section 2 in the following way. For each trader *i*, there is an *imprecision interval* of values $[v_i^{\min}, v_i^{\max}]$, with the interpretation that *i* 'knows' that their value lies in this interval, but cannot specify that value with any more precision. The rules of the auction mechanism require *i* to report a unique NWTA a_i in any given round. Because of random error and systematic behavioural anomalies, a_i need not lie within the imprecision interval. Market discipline comes into play when the market price *p* is such that *i* is *sure* that their chosen a_i has led to a loss. This is the case if $a_i \geq p > v_i^{\max}$ (unambiguous over-asking) or $v_i^{\min} > p > a_i$ (unambiguous under-asking). In each of these cases, *i* responds by adjusting their next-round NWTA in the direction of their imprecision interval. If the market is repeated, changes in behaviour will continue to be induced among marginal traders until $p \geq v_i^{\min}$ holds for each of the $(n-1)/2$ traders *i* who sell, and $v_j^{\max} \geq p$ holds for each of the $(n+1)/2$ traders *j* who fail to sell. This result defines an interval of *preference-consistent* values to which the market price converges. If a shaping manipulation pulls the price outside this interval, market discipline will tend to pull it back; but once the price is within the interval, market discipline ceases to operate. Thus, shaping manipulations may have a persistent effect on the location of the market price *within the preference-consistent interval*.

7. Conclusion

Our results raise doubts about a fundamental assumption of traditional economic analysis – that individuals have precise true preferences that are independent of the market institution in which they are revealed. We have found that experimental manipulations of exogenous and endogenous price cues can have a substantial and cumulative impact on the amount of money that people are willing to accept in exchange for items in their possession, even when values are entirely private and valuations are elicited using a demand-revealing market institution. There is a systematic tendency for individuals' stated valuations in such markets to be pulled towards the prices that have been observed in previous market rounds, and/or that individuals expect to observe in current and future rounds.

By using experimental designs which allow the disciplining effects of markets to be 'switched off', we have been able to observe shaping effects in isolation, and we have found these effects to be significant. The finding that these effects operate not only for exogenous price cues, but also for cues that are endogenous to the way markets normally operate suggests that the conventional belief in the ability of markets to reveal preferences in an unbiased manner may not be warranted. When individuals are exposed to market discipline, there is a tendency for the more extreme effects of previous shaping to be eroded. However, substantial elements of shaping persist. To the extent that these effects enter into market prices that exert continuing influences on stated valuations, the operation of markets may actually consolidate them.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jebo.2015.11.006.

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