Research Article

The Price of Pain and the Value of Suffering

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ABSTRACT—*Estimating the financial value of pain informs issues as diverse as the market price of analgesics, the cost-effectiveness of clinical treatments, compensation for injury, and the response to public hazards. Such valuations are assumed to reflect a stable trade-off between relief of discomfort and money. Here, using an auction-based health-market experiment, we show that the price people pay for relief of pain is strongly determined by the local context of the market, that is, by recent intensities of pain or immediately disposable income (but not overall wealth). The absence of a stable valuation metric suggests that the dynamic behavior of health markets is not predictable from the static behavior of individuals. We conclude that the results follow the dynamics of habit-formation models of economic theory, and thus, this study provides the first scientific basis for this type of preference modeling.*

Attaching economic value to aversive states and clinical symptoms is central to health economics. In most cases, the cost of relieving suffering must somehow be balanced against the amount of suffering relieved. Economic theories of valuation generally assume that the prices of such commodities are derived from genuine fundamental values. The assumption is that people have robust endogenous preferences that allow a trade-off between goods, including analgesics, and money (Shafir & LeBoeuf, 2002). However, the validity of this assumption, and its applicability to health products, is being questioned increasingly, and it has been placed in contrast with an emerging alternative possibility that preferences are labile, and predictably so. A lack of stable underlying values would raise the possibility that consumers in some markets may, as Oscar Wilde (1892/1967) remarked about cynics, know "the price of everything and the value of nothing" (p. 329).

Indeed, psychological experiments suggest that sensory judgments of magnitudes and probabilities are made relative to other recently experienced events, and are not bound to an absolute scale (Laming, 1997; Stewart, Brown, & Chater, 2005). Hypothetical prices that experimental participants say they are willing to pay to avoid a negative outcome are typically biased toward random price anchors (given in the question, but even sometimes explicitly derived from a person's Social Security number, as shown by Ariely, Loewenstein, & Prelec, 2003). These findings resonate with the idea that an option in a choice set may change the way another option is judged and, more broadly, evoke the idea that preferences are constructed afresh, rather than revealed, in light of the salient options in each new situation (Slovic, 1995).

However, this conclusion might be premature, because it is conceivable that people do not need to know the value of something if they already know its price. Existing studies have not tested preference formation at its very root, where prior price information is not available—for example, when people experience stimuli or events for the very first time and must pay to obtain or avoid this experience in the future.[1] Indeed, such a scenario is a close approximation to consumer behavior in many health contexts, where pain or symptoms of illness are likely to represent new events. Observing relativistic effects in this context would imply that the price consumers pay may be substantially determined by current or recent experiences, rather

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[1]For example, Boyce, Brown, McClelland, Peterson, and Schulze (1992) asked people to value a houseplant (Norfolk pine with a retail value of $6) by indicating what they were willing to pay to buy the tree or what they were willing to accept to sell it; if they did not buy the plant, or if they sold it back to the experimenter, the experimenter was going to kill it. In this design, the price anchor was the existing retail price. The participants were not told the price, but they could have guessed it or known it in advance. Also, such trees are a common commodity with many substitutes in the market.

than by stable underlying values, which would pose real challenges for health economics.

We designed an experimental market in which healthy participants could choose to pay money to avoid a painful electrical stimulus. Our use of electric shocks was based on the idea that they are not generally encountered in daily life (i.e., they cannot be related to any existing commodity or price), and hence prior price-related information cannot be brought to bear in evaluating them. Additionally, a painful shock is evaluated and "consumed" immediately, is consistently judged as aversive across participants, and is largely resistant to habituation over the course of an experiment. Finally, the underlying neurophysiology of shock-induced pain is well understood, and the affective properties (hedonic unpleasantness) of pain are known to be dissociable from its sensory properties (intensity, location, etc.; Singer et al., 2004). Note also that phasic pain (pain that varies over short time intervals) is used widely in laboratory pain research, in both animals and humans, with the ultimate goal of treating chronic pain (McMahon & Koltzenburg, 2005). The vast majority of research on chronic (e.g., cancer) pain involves tests of phasic noxious stimuli, with humans and animals. This is not because people do not recognize the difference between phasic and chronic pain (quite the opposite), but rather because there are numerous methodological and ethical reasons for not conducting laboratory studies of chronic misery.

In our experiment, participants received a single electric shock and were then asked to decide how much they were willing to pay, from an initial monetary endowment for that trial, to avoid 15 additional shocks. If the offer was more than a randomly determined market price, avoidance was "bought" at the market price. Otherwise, the endowment was kept, and all 15 shocks had to be endured (see Fig. 1a). This situation was analogous to buying pain relief in a computerized second-price auction (Becker, DeGroot, & Marschak, 1964), and the rational strategy was to reveal one's true preferences. This point was carefully explained to each participant. Participants completed 60 trials, in which both shock intensity and the monetary endowment were varied.

Participants did not know that only three pain levels (low, medium, and high) were actually used, and that the pain levels were grouped into blocks (of 10), such that two different levels were used in each block (low-medium, medium-high, low-high; see Fig. 1b). The endowment for each trial was 40 pence in one experimental group and 80 pence in a second experimental group.

METHOD

Participants

Thirty-four students from the University of London participated in the experiment. Approximately half were undergraduates; the rest were graduate students. Participants were randomly assigned to two experimental conditions. Each session lasted an average of 2 hr, and each participant was awarded between £20 and £40 at the end of the session, as determined by his or her decisions (see Procedure and Design). Each individual participated at a separate time, and thus only 1 participant was present at each session. Sessions were conducted at the Wellcome Trust Centre for Neuroimaging, University College London. All participants gave full informed consent before the experiment, and knew they would be receiving electric shocks and money on a probabilistic basis. The study was approved by the joint ethics committee of The National Hospital for Neurology and Neurosurgery and the Institute of Neurology.

Procedure and Design

The sequence within each training and experimental trial is illustrated in Figure 1a, which also provides an example of the displays during a typical trial. The experiment had the following design characteristics: trial-based payment, willingness-to-pay method, and auction-based valuation.

On each trial, the participant was given a fixed endowment that could be spent on analgesia and that was not transferable to the next trial. The participant kept whatever was left at the end of the trial, and the total payment for participation in the experiment was equal to the money accumulated over all experimental trials (i.e., the money not spent on pain relief).

After receiving the endowment, the participant experienced one pulse of the electric shock. Thus, we provided the participant with a sample of the experience before he or she made a decision. Consequently, the participant entered the pricing phase with full information about the experience he or she was evaluating. Next, the participant had to state the maximum amount that he or she was willing to pay in order to avoid 15 pulses of the same shock intensity. The participant marked an offer as a location on a visual scale, using a cursor operated by two keys on the keyboard (one that moved the cursor to the left, and another that moved it to the right). On each trial, the initial position of the cursor was located randomly on the scale.

After the participant stated his or her maximum value, a second-price auction (a standard incentive-compatible preference-elicitation procedure proposed by Becker et al., 1964) determined how much the participant had to pay. The computer randomly picked a price from a uniform distribution ranging from 0 pence to 40 or 80 pence, depending on the condition. The distribution was displayed on the screen in the form of a wheel with a pointer. If the computer's price was higher than the participant's price, the participant would experience the pain. If the computer's price was lower than the participant's price, the participant would pay this (computer-generated) price and avoid the pain.

At each session, we informed the participant that the spinning wheel ("wheel of fortune") would determine the market price completely randomly, and that, therefore, the market price
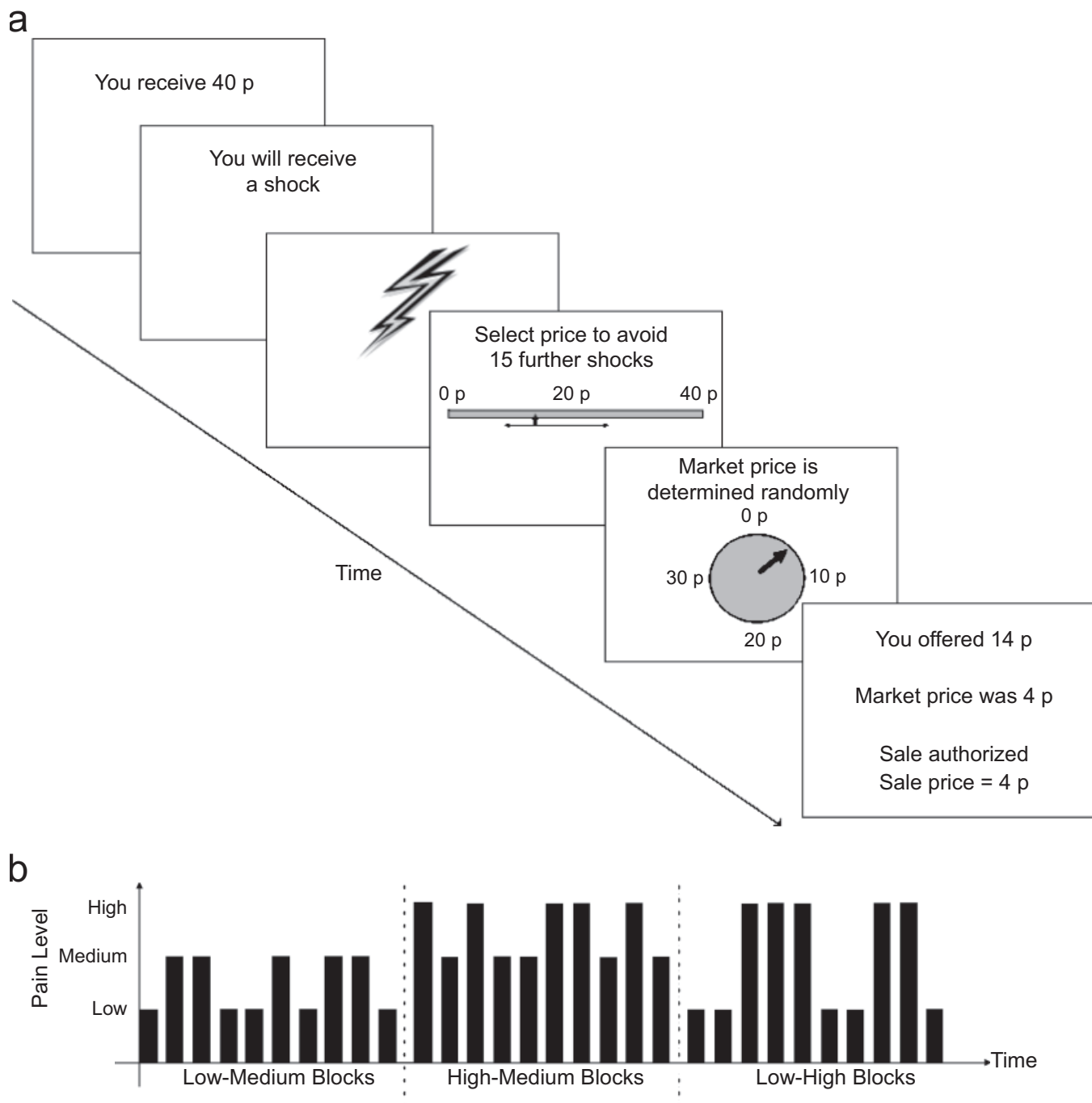
Fig. 1. The experimental task: (a) the trial sequence and (b) grouping of pain levels. In each trial (a), participants first saw the financial endowment for that trial and then received a single exemplar of painful electric shock, of low, medium, or high intensity. (Participants were not informed, nor did they report, that the pain was always at one of only three discrete levels.) They then selected the maximum price they were prepared to pay to avoid 15 additional shocks. The maximum price they could offer was their full endowment, which was given on a strictly trial-by-trial basis (such that there was no sense that endowments could be ''saved'' or carried over to pay for later pain relief). The market price was set randomly between zero and the full endowment amount, and if this price was lower than the participant's price offer, the 15 painful stimuli were omitted at the cost of the market price (and not the participant's offer). Trials were grouped into low-medium, high-medium, and low-high blocks (b). We repeated each block twice, so there were six blocks and 60 trials in total. The order of pain levels within each block was randomized, as was the overall order of the blocks.

would not depend on the intensity of the electric shock or on the offered price. The participant was told that this procedure ensured that the best strategy was to pick the maximum price he or she would be willing to pay in order to avoid the pain, not a few pennies more and not a few pennies less. We used the following argument to justify this claim:

Thus, it is in your best interest to offer a number that accurately reflects how you value the pain from the electric shock. If you write down a number that is higher than your personal valuation of the pain, then you may end up paying more than you feel it is worth to avoid the shocks. On the other hand, if you write down a number that is lower than your personal valuation of the pain, then you may end up suffering the pain, even though you would have been willing to pay a price to avoid it. Therefore, there is no "right" or "wrong" value to enter on the offer screen; rather it is a matter of offering a value which truly reflects your own valuation of the pain from the electric shock.

Each session consisted of three parts, a thresholding procedure, a training phase of five trials without payment, and an experimental phase consisting of a series of 60 trials for real money.

At each session, the participant underwent a standard thresholding procedure after providing consent. This procedure allowed us to control for heterogeneity of skin resistance between participants and to administer a range of potentially painful stimuli in an ethical manner during the task itself. As in previous experiments (Seymour et al., 2004, 2005), shocks with step increases in amplitude were administered, and participants provided a simple visual analog rating of each shock on a scale from 0 (not painful) through 10 (worst imaginable pain; participants effectively rated the stimuli along a continuous monotonic scale between these points). The shocks started off with very mild intensities while participants became familiar with the setup. Three series of shocks were administered, as repeated escalation allows subjects to adapt to initial anxiety about the shocks, and thereafter ratings are more consistent.

When the maximum tolerated current was reached, we performed a second procedure, designed to estimate the current-to-rating response curve. We statistically fitted a Weibull (sigmoid) function to a short series of randomized shocks (14 in total) below the maximum tolerance level. (Randomizing intensities removes participants' ability to predict the intensity of the next shock, and so removes placebo-nocebo effects, i.e., the influence of expectation on perception). From this function, we estimated the current intensities that related to three levels of pain (mild: 4, moderate: 6, strong: 8); these intensities were used for the three shock levels (low, medium, and high) in the experiment. Although the stimulation was necessarily within the painful range, electrical stimulation is safe and does not cause any significant side effects. It has been used extensively in the past in human experiments, and many times in our lab. Note that general variation in subjective ratings of electrical pain (and indeed other forms of pain) are easily sufficient to have masked the fact that the pain fell into three levels; postexperimental questioning confirmed that participants assumed an even distribution.

In each trial of the training and experimental phases, participants received one or more electric shocks. In the experimental phase, we used only three pain levels (low, medium, and high), which were grouped into 10-trial blocks such that two different levels were used in each block—low-medium, medium-high, and low-high (see Fig. 1b). Each of these three pairings (contexts) was repeated (so that we could collect more reliable data), which created a sequence of six blocks (60 trials in total). The endowment for each trial was 40 pence in one experimental group and 80 pence in a second experimental group; assignment to these groups was random.

Also, the order of shock intensity was randomized individually for each participant. Shocks were delivered using a Digitimer DS3 (Letchworth Garden City, England) electrical stimulator through silver chloride surface electrodes placed 2 to 4 cm apart on the dorsum of the left hand. Each shock consisted of a 1-s train of monophasic 10-Hz pulses of 10-ms duration. Throughout the session, the participant sat in front of a computer; the trials were presented on the screen of the computer, and decisions were indicated by using two keys on the keyboard. The software package COGENT 2000 (University College London) was used for stimulus presentation and response acquisition. At the end of the task, participants were fully debriefed and thanked for their participation, and given an opportunity to make any comments.

RESULTS

Figures 2a and 2b show the mean offers for all three pain levels as a function of the pain context in the two endowment conditions. Price offers for relief of medium pain were higher when the pain was experienced in a sequence including many low-pain trials (low-medium block), compared with when the same pain was experienced in a sequence including many high-pain trials (medium-high block). That is, participants were willing to pay more to avoid the same pain when that pain was more painful, rather than less painful, compared with the pain experienced on recent trials. This effect was evident for both the 40-pence condition, $t(17) = 5.68$, $p < .001$, and the 80-pence condition, $t(17) = 3.82$, $p = .001$. Thus, results were consistent with a relative valuation of medium-intensity pain that depended on whether it was in the context of high- or low-intensity pain stimuli.

To further explore this relativity in valuation, we tested for a rescaling of the value of pain relief as a function of the endowment (40 vs. 80 pence). We found that higher offers were given when the high endowment was received and relatively low offers were given when the low endowment was received (note the difference in the price scales on the y-axes in Figs. 2a and 2b). For example, in comparison with the 40-pence group, the 80-pence group offered significantly higher prices for medium shocks in both the low-medium context, $t(34) = 4.05$, $p < .001$, and the medium-high context, $t(34) = 2.79$, $p = .01$. If people had twice as much endowment in a trial, they were willing to pay approximately twice as much to avoid the same pain. Thus,
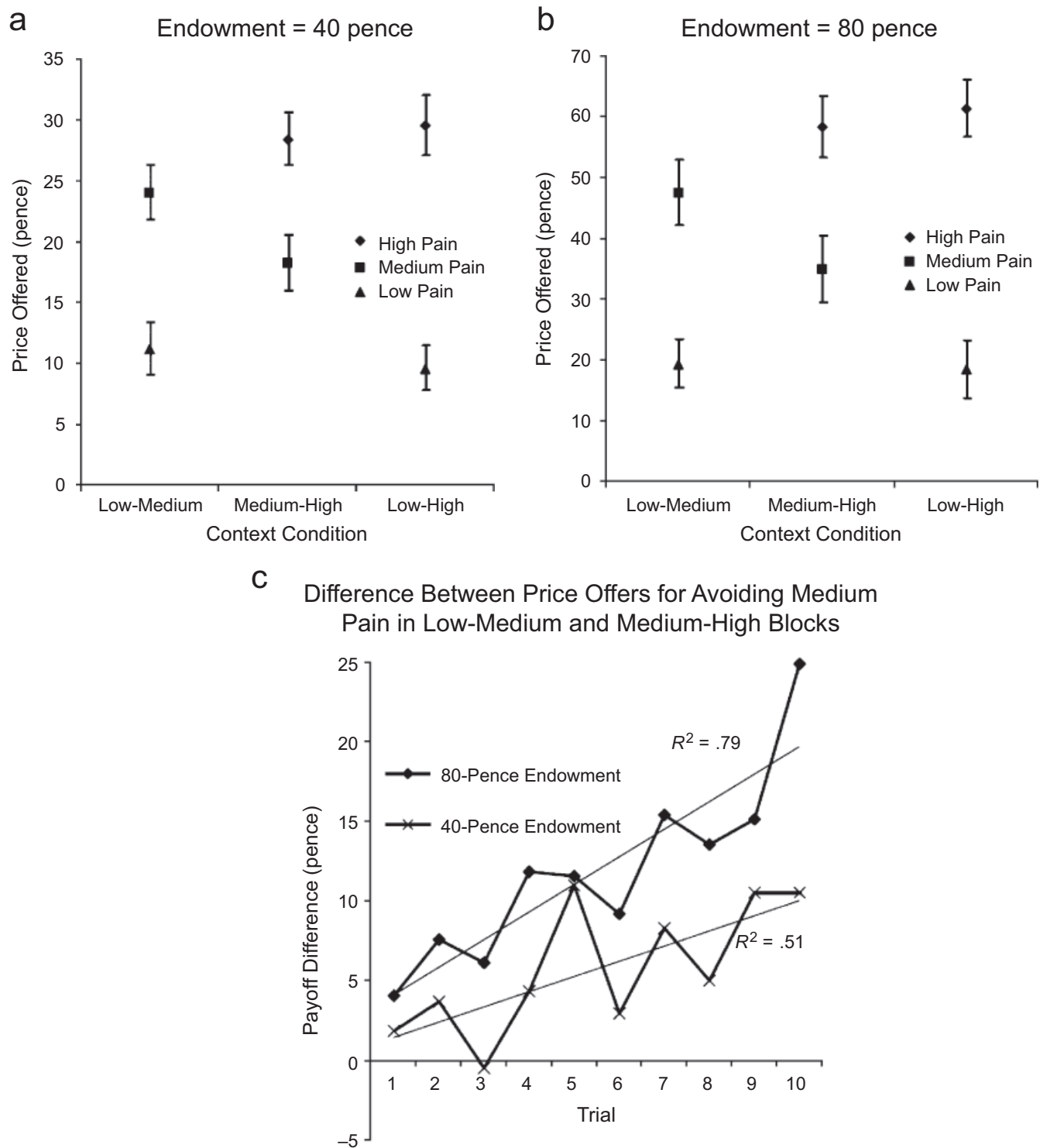
a

Endowment = 40 pence

b

Endowment = 80 pence

c

Difference Between Price Offers for Avoiding Medium
Pain in Low-Medium and Medium-High Blocks

Fig. 2. Mean offered prices (error bars represent ±1 *SEM*) for avoiding the different levels of pain as a function of the pain context (a, b) and difference between the price offered to avoid medium pain in low-medium blocks and medium-high blocks as a function of trial within each block (c). Mean prices are shown separately for (a) participants given a 40-pence endowment on each trial and (b) participants given an 80-pence endowment on each trial. The graph in (c) plots results separately for the two endowment groups and also shows regression lines.

the exchange rate between money and pain is extremely flexible with respect to the endowment.

We subtracted the average price offer for medium pain in the medium-high blocks from the average price offer for medium pain in

the low-medium blocks and plotted this difference across trials (see Fig. 2c). As expected, in each type of block, the difference between prices was initially small, but increased with greater experience within the block: The positive slope of the regression line was sig-

nificant for both the 40-pence condition, $b = 0.96$, $t(9) = 2.86$, $p = .02$, and the 80-pence condition, $b = 1.73$, $t(9) = 5.41$, $p = .001$.

To frame our results within economic theory (in terms of what is known as *comparative statics*), we plotted the estimated consumer demand curves for pain relief (see Fig. 3). To make the data relevant to chronically experienced pain, and also to economic theories of consumption, we included only trials that followed a long duration of pain (15 shocks, rather than a single shock, on the previous trial; i.e., we included only trials following consumed pain). These curves were constructed directly from our data and address two questions: First, how much pain

relief would our participants have bought at different prices, given their stated willingness to pay? Second, what are the consequences of increases in income? For *normal goods*, the standard assumption in health economics is that demand functions are downward sloping and shift rightward with greater income (in our case, with greater endowment; in contrast, demand for *inferior goods* decreases when consumer income rises). Our findings are in accordance with these assumptions, as Figure 3 shows. Although finding an effect of income in our setting might be puzzling, because the income received during the experiment was tiny relative to participants' total income (in
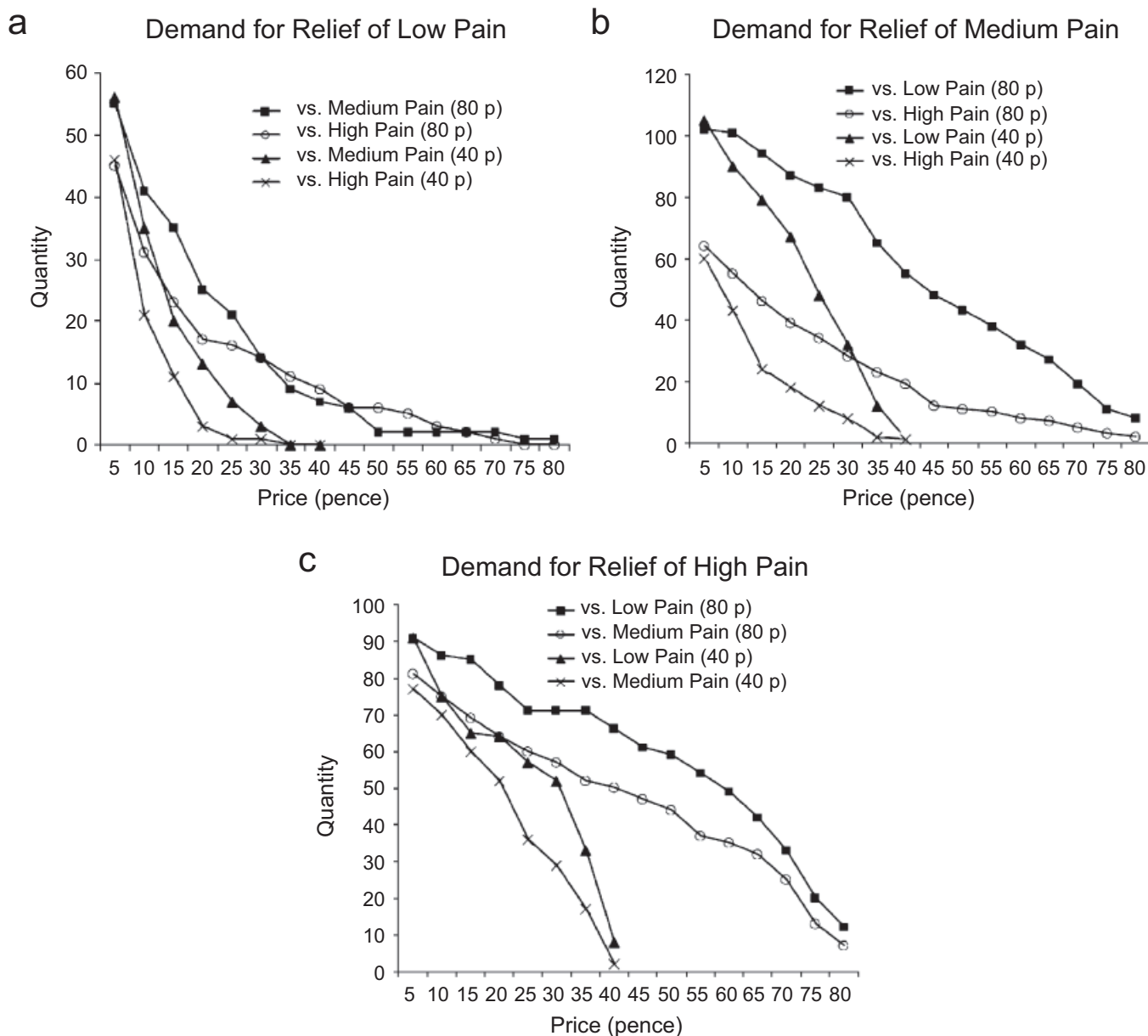

Fig. 3. Demand curves for pain relief derived from the trials following experienced (consumed) pain of a long duration (i.e., 15 shocks). These curves show the quantity of pain relief that can be expected to be sold at different prices; the demand was determined by the number of price offers within a given price range (below a given level), which showed how many sales would have occurred if the market price had been within this price range. The three panels show results for (a) low, (b) medium, and (c) high pain levels, and within each graph, results are shown separately for the two endowment amounts and two pain contexts.

the lab plus from outside sources), it is well known that economic choices in the lab are considered within a narrow context. Much research in experimental economics has studied the *adaptive encoding* phenomena (also known as *narrow framing*), for instance, in the context of risk aversion (e.g., Barberis, Huang, & Thaler, 2006). These studies have shown that economic problems are not put in their wider context, but are viewed only within the narrow situation at hand, because the brain's limited resources are allocated so as to discriminate better among relatively likely (i.e., recent) outcomes (Tobler, Fiorillo, & Schultz, 2005). Therefore, we conclude that the income effect we observed is yet more evidence for adaptive encoding.

There was also a significantly higher potential demand for relief of medium pain (Fig. 3b) when it was paired with low rather than high pain, and this was true for both the 40-pence endowment condition, $\chi^2(7, N = 360) = 24.7, p < .001$, and the 80-pence endowment condition, $\chi^2(15, N = 360) = 32.7, p = .01$. These results imply that the demand to avoid the medium pain was substantially affected by whether the previous pain was higher or lower (as in Fig. 2), which suggests that consumer demand estimated from real markets does not necessarily always reveal stable underlying preferences (as assumed by some normative decision theories). These effects can be explained by looking at how economics deals with problems involving *dynamics*: changes in prices and quantities over time. The conclusions depend crucially on how demand is modeled. Since the early 1970s, habit has become an important component of modeling preferences. Such models assume that the overall level of satisfaction derived from a given level of consumption depends not only on the current consumption level itself, but also on how it compares with some benchmark reference level, which is an internal criterion based on the individual's own past consumption levels (Osborn, 1988). A simple approach is to model habit by making the utility of time t consumption, $c(t)$, depend on past consumption, $c(t-1)$, as follows: utility $= u(c(t) - c(t-1))$, where u is some standard, monotonically increasing utility function that is strictly concave, which means that the slope of the curve decreases as its argument, $c(t) - c(t-1)$, increases. That is, utility depends on the *change* in consumption over the last period. Such a utility function based on habit can explain our results in the following way.

Let c denote consumption without pain (when one buys oneself out of pain), and let c_l, c_m, and c_h denote consumption under low, medium, and high pain, respectively. Obviously, consumption is highest under c and lowest under c_h; hence, these values are ordered as follows: $c_h < c_m < c_l < c$. First consider Figure 3b. Keeping income the same, we need to determine whether the value of (a) avoidance of medium pain subsequent to experiencing low pain (and hence, c_l) is higher than the value of (b) getting out of medium pain subsequent to experiencing high pain (and hence, c_h). Mathematically (following the habit model in the previous paragraph), the former value equals $u(c - c_l) -$ $u(c_m - c_l)$, and the latter equals $u(c - c_h) - u(c_m - c_h)$. Algebraically, $c_m - c_l < c_m - c_h$ and $(c - c_l) - (c_m - c_l) = (c - c_h) - (c_m - c_h)$, and given that the utility function (u) is strictly concave, it follows that (a) is more valuable than (b) and, hence, that the demand curve for avoiding medium pain after experiencing low pain is higher than the demand curve for avoiding medium pain after experiencing high pain. The demand curves in Figure 3b satisfy this prediction, as the curve for the medium-low blocks lies to the right of the curve for the medium-high blocks, for both endowments.

An analogous analysis predicts that the demand curves for relief of low pain and high pain should follow a similar pattern: For low pain, the curves for low-medium blocks should be to the right of the curves for low-high blocks, as indeed they are in Figure 3a, and for high pain, the curves for low-high blocks should be to the right of the curves for medium-high blocks, as is indeed the case in Figure 3c. Note also that the gradual increase over time in the difference between the offer prices for relief of medium pain in low-medium versus medium-high blocks (Fig. 2c) is consistent with habit formation (which also happens gradually), because, as the demand-curve analysis demonstrated, avoiding medium pain is more valuable in the context of low pain than in the context of high pain. In summary, the demand-curve analysis clearly supports the habit-based interpretation of our overall results.

DISCUSSION

The observed impact of the magnitude of the cash endowment on each trial is consistent with the idea that people will spend roughly a constant fraction of their experimental income on pain relief. However, this behavior implies that people cannot integrate their behavior in the experiment with their finances outside the experiment. After all, whatever the experimental conditions, the money received in the experiment would not change in value when spent later outside the experimental setting (i.e., money is money, and its value outside of the experiment does not depend on the conditions under which it was acquired). Nevertheless, to provide a tighter control for such budget issues, we conducted a second experiment using a within-participants design. In this experiment, the endowment (40 vs. 80 pence) varied randomly across trials for each participant (in all other aspects, the design was identical to that of the original experiment). This second experiment replicated all our original results and thus confirmed our paradoxical finding that the exchange rate between pain and money varies dramatically over a time frame of minutes for participants as they shift from one block of trials to another.[2] This is yet more evidence for adaptive encoding (narrow framing) in decision making.

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[2]A full description of these results is available upon request.

A key implication of our results is that the assessment of pain and demand for pain relief are almost completely relative to the experience of pain in the recent past and the available cash in hand. Participants were willing to pay a constant fraction of the money available on each trial, even if the monetary sums they were paying differed by a factor of 2. If people do not have well-defined fundamental values for subjective experiences such as pain, their willingness to pay to obtain, or to avoid, goods for which there is an existing market (e.g., cups of coffee, theater tickets) may be driven primarily by knowledge of market prices, rather than by reference to some underlying fundamental values. People may indeed know the price of everything but the value of nothing.

The absence of a stable valuation metric suggests also that the dynamic behavior of health markets is not predictable from the static behavior of individuals. Our findings are consistent with, and follow the dynamics of, economic models of habit formation. Note that the origins of habit models can be traced as far back as Smith (1759) and Veblen (1899), and Duesenberry (1949) provided microeconomic foundations for such models.[3] Effects of habit can be seen even at the macroeconomic level—where the compensation for risk has remained unchanged in the Western world despite a huge increase in aggregate wealth (Abel, 1990; see also Carroll, Overland, & Weil, 2000, for evidence on the effects of habit on savings and economic growth). More recently, Fuhrer (2000) found that 80% of the effect of habit on consumption utility should be attached to past consumption, which means the hypothesis of time-separable preferences should be rejected. There is not much documented experimental work on habit formation in health economics, however. Thus, this article provides the first solid experimental evidence in favor of introducing habit in preference modeling. Our habit-based analysis also suggests that principles underlying pain judgments may be based on relative judgments, and therefore stands in contrast to judgment models such as the range-frequency theory (Parducci, 1965, 1995), which assume long-term representations.

Our results do not necessarily imply that the brain does not have stable representations of pain, but they do suggest that it cannot readily translate such representations into monetary terms. However, although the neurophysiological basis of aversive valuation is complex (Dayan & Seymour, 2008), there is evidence that relativistic effects may indeed exist at an underlying biological level. Neurophysiological recordings in both monkeys and humans have shown evidence of relative reward coding in neural substrates (e.g., via dopamine projections to the striatum and the orbitofrontal cortex) strongly implicated in simple choice behavior (Nieuwenhuis et al., 2005; Tobler et al., 2005; Tremblay & Schultz, 1999). These findings suggest that value relativity may exist at a fundamental level in the brain.

Explicit judgments concerning pain, and other subjective experiences, are typically expressed in complex social and economic contexts. Such judgments require one to make abstract comparisons between experienced or imagined primary affective states and secondary rewarding ones, such as receipt of money. Furthermore, equating such diverse quantities to control purchasing behavior is particularly difficult in the case of health care, because health products are naturally inhibitory, in that one pays to avoid a certain aversive symptom, rather than to receive a positive good. In embodying the positively valenced property of relief, effective health care purchase has interesting parallels with the phenomenon of avoidance, studied in animal learning. In avoidance, states that are associated with omission or termination of otherwise aversive events acquire, through inhibitory processes, rewarding valence (Dinsmoor, 2001; Morris, 1975; Rescorla, 1969; Seymour et al., 2005; Weisman & Litner, 1969). Whereas increasing experience might mitigate relative valuation effects, allowing the inhibitory value of states to become better learned, it cannot easily do so for products that buy relief from never-experienced symptoms, central "commodities" in modern preventive health care markets.

Explicit judgments are also required when economists and policymakers quantify adverse clinical states (e.g., in judging compensation for injury), and inform decisions regarding pricing strategy (e.g., the market price of analgesics), investment in research, cost-effectiveness of clinical treatments, and the response to public hazards. Pain, in particular, is a major public health issue, especially given the fact that the prevalence of clinically significant pain is approximately 20% in the general population, and the global annual cost of analgesics is £40 billion (around $60 billion; Eriksen, Jensen, Sjogren, Ekholm, & Rasmussen, 2003; Macfarlane, Jones, & McBeth, 2005; NFO World Group, 2007). Pain rarely occurs in isolation, and is usually experienced in the general symptomatic and temporal context of an illness. Thus, our findings on the structure of human value representations, and specifically their susceptibility to relativistic judgment biases shaped by context, are likely to have substantial economic implications. Future research might usefully explore the stability of valuation for other clinical symptoms, as well as the impact of knowledge of other people's valuations, which may play an equally important role in dynamic health care markets.

[3]An additional type of reference consumption is based on an external criterion expressed in terms of the past consumption of some outside reference group, typically the average consumption of the overall economy; this criterion is often referred to as "keeping up with the Joneses."

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