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Working Paper Series
2017/06/MKT
(Revised version of 2015/01/MKT)

Pain of Paying? — A Metaphor Gone Literal: Evidence from Neural and Behavioral Science

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Dec 16, 2016

How do individuals consider the price of a good when making purchase decisions? Standard economic theories assume an analytical process: Individuals consider the opportunity cost. Recent behavioral economic theories suggest an additional, hedonic process: Individuals consider the immediate displeasure or "pain of paying" the price. This paper is the first to present direct empirical evidence that the metaphor is more than a theoretical concept; it stands for a literal pain experience. In addition, the authors characterize its quality as an affective pain experience in three incentive-compatible experiments. First, an fMRI experiment suggests an affective pain experience and rejects a somatosensory (i.e., physical) pain experience. Second, the facilitation of affective pain perception through conceptual priming decreases willingness to pay (WTP). Third, misattributions of pain perception to placebo drugs increases versus decreases WTP for affective pain enhancers versus affective pain relievers. Conversely, facilitation and misattribution of somatosensory pain perceptions do not alter WTP.

Keywords: Affective Pain-processing Pathways; Purchasing; Microeconomic Theory; Mental Accounting; Consumer Neuroscience; Pricing

Acknowledgements
We thank Antonio Rangel for his generous support with experiment 1 and Christof Koch for letting us use his lab's shock stimulator equipment for experiment 1. For experiment 2, we thank Linda Li and Julia Sydorenko for support with the data collection. For experiment 3, we thank Anja Istel from the Kosmos Apotheke in Bonn, Germany, for providing us with placebo pills, Girish Malkarnenkar for programming the task, and Ana Lucia Fernandez Cruz, Sarah Mieskes, and Susanna Weber for collecting the data. We also thank the members of the Society of Neuroeconomics for their comments, which helped to advance this work. This work was financed through a grant awarded to N.M. by the Desautels Centre for Integrative Thinking at the Rotman School of Management, University of Toronto and through INSEAD start-up funds given to H.P.

Author Contributions

The authors are listed in descending order of contribution. The first two authors, NM and HP, contributed equally to this research project and are listed in alphabetical order. Conceived experiments: NM HP. Designed experiments: NM HP NR AL. Performed the experiments: HP NR. Analyzed the data: NM HP. Wrote the paper: NM HP. Edited the manuscript: NM HP NR AL.

Competing Financial Interest

The authors declare no competing financial interest.

Recent behavioral economic theories of purchases have postulated a hedonic process associated with spending money: the experience of a "direct and immediate displeasure" (Zellermayer 1996, p. 2), coined the "pain of paying." The idea that individuals consider such an emotional vexation when deciding whether to purchase a product is in stark contrast to the standard economic assumption that a product's price is considered emotionlessly (i.e., purely analytically) in terms of opportunity cost—that is, the value of the best alternative product that could have been purchased with the money instead (Buchanan 1999).

Interestingly, evidence for the existence of a pain of paying is limited. This may be because individuals don't necessarily have good insight into their emotional states when asked directly to self-report (e.g., Berridge and Winkielman 2003), hedonic processes are difficult to directly articulate, and explicit tests of emotional perceptions may introduce biases in attitudes and behavioral intentions (Camerer, Loewenstein, and Prelec 2005; Feldman and Lynch 1988). Interdisciplinary evidence employing physiological measures or functional magnetic resonance imaging (fMRI), for example, can therefore provide a unique and useful perspective for addressing some of these challenges. In particular, fMRI can be used to track the neural correlates of key decision elements implicitly and "online" during the decision process without interrupting it. That is why in this paper, we combined behavioral measures with neuroimaging.

The goal of this paper is to provide interdisciplinary direct evidence for the existence and quality of a pain of paying. To reach this goal, we followed a two-step approach. In a first step, we conducted a neuroimaging (i.e. fMRI) study to track the neural correlates of purchasing decisions for different products at varying price levels (Experiment 1). Importantly, our participants were sometimes offered the opportunity to pay for the products with money (i.e., cash) and sometimes in exchange for tolerating an electric shock. This was done to investigate to

what extent the brain systems recruited in both types of purchasing decisions overlap, which in turn allows for inferences about the similarity of their underlying mechanisms. The results from this study led to a new hypothesis about the pain of paying: Paying with money indeed recruits pain processing brain regions but only those pathways that are involved in higher-order, affective aspects of feeling pain, not the somatosensory pathways of experiencing pain.

Thus, in a second step, we conducted two behavioral purchasing experiments in which we manipulated pain processing to add *causal* evidence to the correlational evidence from the first experiment, testing the new hypothesis that paying with cash is affectively (but not somato-sensorily) painful. First, we facilitated affective and somatosensory pain processing through conceptual priming (Experiment 2). Second, we conducted a placebo experiment to induce misattribution effects to either affective or somatosensory pain experiences (Experiment 3).

With these three experiments taken together, the current paper is the first to systematically and directly examine the existence of the pain of paying and to characterize its quality (affective vs. somatosensory pain experience). The paper does so by assessing participants' WTP with incentive-compatible experimental designs across a variety of different products (food items and gift cards), price ranges ($.50–€30), and national cultures (United States, Canada, and Germany).

THEORETICAL BACKGROUND

Behavioral Science Evidence of a "Pain of Paying"

Ofer Zellermayer (1996) was the first to describe "pain of paying," the emotional experience of distress caused by the prospects and acts of spending money, as an important

additional source of consumers' (dis)utility when paying or anticipating paying for products. He went on to say that "the pain of paying plays an adaptive role. By providing the consumer with an instant emotional signal about the payment's potential negative ramifications, it impedes excessive immediate indulgence" (Zellermayer 1996, p. 2). Thus, the pain of paying is intimately linked with mental accounting (Thaler 1985, 1999) and mental budgeting (Heath and Soll 1996).

Over the course of the past two decades, however, research has provided only mixed and indirect evidence for the pain-of-paying hypothesis. There is no direct evidence for its existence or, if it does exist, for which pain pathways it affects. For example, in his study 4 Zellermayer (1996) exposed participants to 50 hypothetical bill payments and asked them to indicate how each would make them feel on a scale from -5 (painful) to +5 (pleasurable) and how they would like to pay: by cash, check, bank deduction, or credit card. Only 35 percent of his participants predicted that payment would be a painful experience. In addition, he found that the preference to pay with either cash (most painful payment mode) or credit card (least painful payment mode) increased with a decrease in the anticipated pain of paying. More supportive evidence (Prelec and Loewenstein 1998) showed that in hypothetical scenarios people prefer to prepay for purchases and decouple spending from consumption, and suggested that this is so they can fully enjoy the immediate pleasure derived from the product untainted by the immediate displeasure of paying its price.

Since then, other scholars (e.g., Raghubir and Srivastava 2008; Soman 2001) have demonstrated that people are more likely to spend money in the form of gift cards than in cash, and theorized that this is because non-cash modes of payment are less transparent and therefore dull the pain of paying (see also Ariely and Silva 2002 for a similar effect of subscription payments versus micro payments in an incentive-compatible setting). In related research Shah

and colleagues (2016) showed that individuals who pay with a mode of payment that is generally assumed to be relatively more painful (e.g., cash or check rather than debit or credit card) increase their post-transaction connection to the product they purchase. The authors theorized that this is because painful experiences have been demonstrated to lead to increased value and commitment. Finally, Thomas, Desai, and Seenivasan (2011) explicitly asked consumers to indicate how it felt to spend money in form of cash versus credit card in a hypothetical purchasing simulation (study 3). The response was given on a five-point non-verbal faces scale anchored with a happy face at one end (coded as 1) and a sad face at the other end (coded as 5). The authors found that on average consumers randomly assigned to paying with cash indicated feeling more sad (M = 3.36), and those paying with credit cards indicated feeling more happy (M = 2.67). While the happy–sad difference between the two modes of payment was significant, it is noteworthy that the means were very close to the neutral midpoint (the authors did not report whether these means were different from the midpoint, 3). Furthermore, it is unclear to what extent the happy–sad scale can be interpreted in terms of an actual experience of pain (rather than mood) and if so, of what type (somatosensory and/or affective).

Together these findings are suggestive of some form of hedonic experience while anticipating paying. However, given the self-report scales used in previous studies (from negative- to positive-valenced affective states and experiences: happy/pleasurable to sad/painful) and their problem with revealing true internal states and experiences (Berridge and Winkielman 2003)—as well as given the mixed results of these previous studies (e.g., Thomas, Desai, and Seenivasan 2011; Zellermayer 1996)—it is not clear whether paying indeed involves a *negative* (as opposed to positive) experience, and if so, of what quality (i.e., whether paying causes some type of pain, and if so, whether that pain is somatosensory and/or affective). In addition, none of

the reported studies examines the degree of pain experienced with different magnitudes of payment (i.e. purchase price) or manipulates pain perceptions to test causal effects on purchase decisions.

Going beyond preferences for and consequences of different modes of payment as well as hypothetical scenarios, in their seminal paper Knutson and colleagues (2007) examined the neural correlates of purchasing decisions in an incentive-compatible paradigm. Using fMRI, the authors (Knutson et al. 2007) showed that when people decided to purchase (vs. not purchase) a product, the decision was preceded by a *decrease* in neural activity in the insula, among other neural correlates. The authors noted that previous research implicated the insula in the anticipation of negative hedonic experiences, such as physical pain and financial losses (Kuhnen and Knutson 2005; Wager et al. 2013). Thus, through backward reasoning (reverse inference; Poldrack 2011) they concluded that "the findings support the historical notion that individuals have immediate affective reactions to potential gain and loss, which serve as input into the decision about whether or not to purchase a product" (p. 153).

In addition to the shortcoming of making inferences based on backward reasoning about the role of the insula, the authors also did not investigate or report a correlation between activity changes in the insula and the magnitude of the price of the products. That is, they did not find evidence that paying greater prices was more aversive than paying lower prices. Finally, the insula can be divided into different parts that have been linked to different dimensions or qualities of pain processing: the anterior insula, which is involved in higher-order, affective pain processing, and the posterior insula, which is involved in lower-order, somatosensory pain processing (see Figure 1 and details about this distinction below). The authors, however, did not

distinguish between these different dimensions in pain processing of the insula, and thus, they did not distinguish the quality of the hypothesized pain experience.

Cognitive Neuroscience Model of Pain-Processing Pathways

Pain-processing pathways have been studied quite extensively in the neuroscience literature in recent decades (Craig 2003; Lieberman and Eisenberger 2009; Price 2000; Rainville et al. 1997; Zaki et al. 2016). Like other sensory processes, including taste, olfaction, and visual processing, pain processing has been proposed to follow a specific hierarchy of brain processes (see Figure 1 for a simplified model from cognitive neuroscience of the pathways involved in pain perception and their neural correlates): First, during physical or psychological pain stimulation based on, for example, electric shocks, thermal pain, or social rejection, sensory inputs are processed in the lower-order, somatosensory brain systems such as the thalamus, the periaqueductal gray somatosensory cortices, and the posterior part of the insula cortex. They result in a painful bodily or physical pain sensation (i.e., somatosensory pain). Second, this somatosensory pain usually leads to an increased arousal and alertness perceived as an implicit threat, which is processed primarily in the amygdala. Third, both, arousal and somatosensory pain are subsequently "interpreted" in a higher-order process by the brain as an unpleasant, affective, and subjective feeling of pain. The dorsal and rostral part of the anterior cingulate cortex and the anterior insula are involved in this subprocess (i.e., affective pain).

Insert Figure 1 about here

Affective pain systems are not only involved when determining how unpleasant it is to, for example, touch an electric fence; they are also involved when having a broken heart or

feeling socially excluded. Thus, affective pain pathways are always recruited in pain processing, whether it is physical or psychological pain. Conversely, psychological pain (such as having a broken heart or feeling socially excluded) can be processed without recruiting somatosensory pain pathways (Eisenberger 2003, 2012). However, in extreme cases, psychological pain will recruit somatosensory pathways in the brain (e.g., a social rejection leading to an upset stomach) (Kross et al. 2011; Woo et al. 2014).

For a behavioral economic theory of purchases to become broadly accepted, it is crucial to provide empirical evidence that goes beyond self-reports and backward reasoning for one of its core concepts: the pain of paying. To our knowledge, our manuscript is the first to directly examine the *existence* and in particular the *quality* (lower-order somatosensory and/or higher-order affective) of a potential painful experience that guides purchase decisions. The quality of pain, particularly, is a differentiation that no previous article has examined. However, qualifying the type of pain experience (if it exists) is important for a better understanding of the psychological mechanism underlying paying or the anticipation of paying, and thus, for the more effective design of marketing and public policy interventions to improve consumers' financial decision making.

EXPERIMENT 1: FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI)

In Experiment 1 we directly compared purchase decisions made when anticipating paying with money in the form of cash to those made when anticipating paying with an alternative negative non-monetary "currency" that is known to trigger the different pain-processing systems (affective and somatosensory) in the brain: the acceptance of an electric shock. The goal was to

investigate to what extent these two payment currencies share similar neural signatures within the same participants. We had three hypotheses:

(1) Brain systems involved: We hypothesized that if paying the monetary price was indeed (affectively and/or somatosensorily) painful, we would find overlapping brain systems (subsystems associated with arousal and affective and/or somatosensory pain) to be involved in the anticipation of paying in both currencies.

(2) Direction of effects for trials involving payments in voltage trials: Accumulated findings in the pain literature have consistently shown that brain areas involved in pain anticipation respond with higher activation the larger the magnitude of the anticipated pain (Koyama et al. 2005). Thus, for purchases in exchange for accepting electric shocks we predicted that brain areas involved in pain anticipation would show *higher* activation in response to the voltage price when participants decided to purchase (i.e., anticipated tolerating the receipt of an electric shock in exchange for buying the product) than when participants decided not to purchase, because in that case the anticipated pain was zero.

(3) Direction of effects for trials involving payments in money trials: Based on the accumulated findings in the pain literature mentioned above, the intuitive prediction would be that if there exists a pain of paying, we should find that brain areas involved in its anticipation would show higher activation in response to the monetary price when participants decide to purchase than when they decide not to purchase. And indeed, the anticipation of a monetary loss without a decision-making context was shown to positively correlate with activity in the insula and related areas (Breiter et al. 2001; O'Doherty et al. 2001; Yacubian et al. 2006), and the higher the loss, the higher these activation patterns.

Curiously, in a decision-making context, the activation has been found to be in the opposite direction. In particular, most closely related to our work, Knutson and colleagues (2007) found a *deactivation* pattern in the insula and related areas for purchased versus non-purchased items (see also Knutson et al. 2008). Interestingly, these authors did not find a correlation between the size of the monetary loss and neural activity. However, similar deactivation patterns that did reveal a correlation with the size of the monetary loss have been found for the anticipation of monetary losses during financial decision-making tasks (Canessa et al. 2013; Kuhnen and Knutson 2005; Samanez-Larkin et al. 2007; Tom et al. 2007). As a consequence of these findings in more related decision-making contexts, we expected to find that brain areas involved in pain anticipation would show *lower* activation in response to the monetary price when participants decided to purchase (i.e., anticipated parting with money in exchange for buying the product) than when they decided not to purchase.

Experimental Design

Participants. Twenty-one female (see the Web Appendix for rationale and more details), healthy, and right-handed students and staff from the California Institute of Technology (aged 18–42, M_{age} = 23.83 years, SD = 4.65 years) participated in the study in exchange for $80 (based on a priori determined exclusion criteria, two participants were excluded from analyses). All were screened for the typical fMRI inclusion criteria: liking and at least occasionally eating the types of foods used in the fMRI task. Participants were told that the goal of the experiment was to study the neural correlates of consumer decision making.

Procedure. The experiment consisted of six tasks spread over two days about a week apart (see Figure S1A). On day 1, participants first underwent an individual pain calibration task

(task 1 in Figure S1A; see Web Appendix for details). Individual pain calibration was important not only to account for individual differences in pain sensitivity but also to ensure that no electric shocks were administered outside each participant's tolerable range of pain. Participants next took part in a monetary value-matching task (task 2 in Figure S1A; applying a modified version of the Becker, DeGroot, and Marschak (1964; BDM) procedure; see Web Appendix for more details) to transform various electric shock pain stimulation levels into monetary units. This individual transformation allowed us to compare money and electric shocks during the purchasing task conducted on day 2 by determining for each participant the electric shock levels corresponding in monetary value to $0.50, $1.00, and $1.50 (applying a quadratic regression as fitting function). That is, for each participant, we matched the monetary price levels and electric shock levels to be equal in subjective value to get a personalized exchange rate.

Participants came back to the lab for day 2 of the experiment about a week later. Upon arrival in the lab on day 2, participants were first administered a previously experienced electric shock level and were reminded of their day 1 willingness to pay (WTP; from the monetary value-matching task 2) to avoid receiving a shock of that same intensity but 10 times the length. Participants then performed two tasks: a valuation task to determine how much they subjectively valued 40 appetitive sweet and salty food items (task 4 in Figure S1A; using a BDM auction mechanism; Becker, DeGroot, and Marschak 1964; see Web Appendix for more details) followed by an fMRI purchasing task (task 5 in Figure S1A) in which their brains were scanned using fMRI while they made incentive-compatible decisions about whether to purchase each of those 40 foods (for the timing and procedure of a sample trial, see Figure S1B). Importantly, participants were asked to have only a light meal and to refrain from eating four hours prior to the start of their experimental session to increase the likelihood of purchasing.

The main fMRI purchasing task consisted of a total of 280 purchasing decisions. In 120 trials the 40 foods were offered for purchase in exchange for cash (at three price levels: $0.50, $1, $1.50; 3 price levels x 40 food items), and in 120 trials the same 40 foods were offered for purchase in exchange for receiving an electric shock (i.e., voltage "prices" that represented the individually differing subjective equivalents of $0.50, $1, and $1.50; 3 voltage "prices" x 40 food items). Note that previous research on the pain of paying has used similarly small prices for consequential choices, with items priced at 0.5 cents and 3 cents (Ariely and Silva 2002), $1 (Raghubir and Srivastava 2008, study 4), and $2 (Shah et al. 2016, study 1).

We also implemented 40 trials in which the same 40 foods were offered for free. These trials served two purposes: (1) to detect participants who behaved anomalously and (2) to serve as a condition with no pain of paying, allowing us to test the specificity of our brain imaging results. Trials with anomalous behavior were a priori defined as fMRI trials in which participants declined to purchase a food item at a price of $0 despite having stated a WTP > $0 for the same product in the previous valuation task (task 4) (i.e., participants in the fMRI purchasing task did not purchase a product for $0 despite a positive subjective net value). Based on this criterion, we excluded two participants from subsequent analyses because they behaved substantially more anomalously then anyone else: Each of their share of anomalous trials (41.9% and 50%, respectively) was outside of the range very conservatively defined as the median share (13.0%) plus or minus three times the median absolute deviation (MAD = 8.9%) (Leys et al. 2013). Thus, our analyses are based on observations from N = 19 participants who made a total of 280 purchase decisions for 40 liked foods while their brain activity was scanned using fMRI.

After each participant completed the purchasing task in the scanner, one of the purchasing decisions was implemented at random, participants answered several questions about themselves,

including a somatosensory pain sensitivity scale (see Web Appendix for more details), and they were debriefed (task 6 in Figure S1A).

fMRI data acquisition and analysis. The functional imaging was conducted using a Siemens 3.0 Tesla Trio MRI scanner to acquire gradient echo T2* weighted echo-planar (EPI) images with BOLD (blood oxygenation level dependent) contrast. Image analysis was performed using SPM5 (Wellcome Department of Imaging Neuroscience, Institute of Neurology, London). For details, see the Web Appendix.

Results and Discussion

Behavioral data analysis. We conducted the behavioral data analysis to answer two questions. First, we investigated differences in participants' behavior during money versus voltage trials in the fMRI purchasing task on day 2 (task 5). This confirmed that our monetary value-matching procedure conducted on day 1 (task 2) was successful. Second, we used mixed-effects multilevel logistic regressions to analyze whether participants' subjective values (i.e., WTP) for each of the food items (as elicited in the pre-scanning valuation task 4 on day 2) and the food items' purchasing prices (as displayed in the purchasing fMRI task 5 on day 2) were indeed predictors of participants' purchasing decisions. For all of these analyses we excluded the zero-price trials because they did not have equivalents in both currencies.

The behavioral results for differences in money versus voltage trials of the fMRI purchasing task 5 are displayed in Figures 2A–2C. Figure 2A shows the average purchasing frequencies by currency type when the food items were for sale at a price > 0. A paired *t*-test revealed no significant difference for purchasing frequencies (number of trials out of 240 in which participants decided to purchase) between money and voltage trials ($T(18) = -0.270$, $p =$

0.79; $M_{\$}$ = 49.42, $SEM_{\$}$ = 4.37; M_{Vol} = 48.58, SEM_{Vol} = 5.28). Figure 2B shows the average reaction times for purchasing decisions by currency type. A paired *t*-test revealed no significant difference for reaction times between money and voltage trials ($T(18) = -0.67$, $p = 0.52$; $M_{\$}$ = 1072.70, $SEM_{\$}$ = 28.62; M_{Vol} = 1083.80, SEM_{Vol} = 25.97). Figure 2C shows the average accepted purchase prices by currency type. A paired *t*-test revealed no significant difference for average accepted price when an item was purchased in money and voltage trials ($T(18) = -0.45$, $p = .657$; $M_{\$} = .81$, $SEM_{\$} = .02$; $M_{Vol} = 0.80$, $SEM_{Vol} = .03$).

Finally, we analyzed to what extent the subjective values (i.e., WTP) that were elicited *before* the fMRI purchasing task (i.e., in valuation task 4 on day 2) and the prices that were displayed in the fMRI purchasing task (task 5 on day 2) predicted purchases in the money versus voltage trials in the fMRI purchasing task. For this purpose we entered participants' subjective food item valuations and the purchasing prices in money and voltage trials with purchase decision (0 = no, 1 = yes) as dependent variable into a mixed-effects logistic regression analysis. The model showed a good overall fit (likelihood ratio test: χ^2 = 1003.09, $p < .000$, AIC = 3775.44), and each individual predictor had a significant regression coefficient that was positive for subjective values and negative for prices in money and voltage trials. That is, for both modes of payment participants' subjective valuation of the food items and the food items' price significantly predicted participants' purchasing decisions in the fMRI task 5. In addition, we tested differences in the regression coefficients between money and voltage trials for subjective values and price predictors and found no significant differences (see Figure 2D, $\chi^2_{value} = 1.66$, $p = .198$; $\chi^2_{price} = 1.05$, $p = .305$).

Insert Figure 2 about here

Together these behavioral results support the notion that our monetary value-matching task performed in task 2 on day 1 was successful: We could not detect differences in behavior (purchasing decisions) involving giving up money or enduring a painful electric shock in exchange for a food item in the fMRI purchasing task 5 on day 2.

fMRI purchasing task data analysis and results. We were interested in whether brain areas involved in pain processing correlated with the anticipation of paying a price for purchased versus non-purchased food items in money and voltage trials, and what the overlapping neural systems were. We first investigated the overall brain activity in all areas involved in pain processing according to a meta-analysis (Yarkoni et al. 2011). We found that the overall activity across all pain-processing regions showed significant differences in neural activity correlating with the magnitude of both monetary and voltage prices for purchases versus non-purchases (see Table 1; for detailed analysis and details about the parametric modulation with price see the Web Appendix).

As hypothesized, and in line with previous pain research, for voltage trials we found a positive correlation with price magnitude when the item was purchased and a negative correlation for non-purchased items. For money trials, as hypothesized based on previous findings in similar decision contexts (Knutson et al. 2007; Knutson et al. 2008), we observed the opposite: a negative correlation with the size of the price when the item was purchased versus a positive correlation for non-purchased items. That is, in line with previous research (Knutson et al. 2007; Knutson et al. 2008), we found deactivation patterns for money trials when items were purchased versus non-purchased. However, unlike in the previous research, our patterns also

satisfied the criterion that they showed a correlation with the magnitude of the price; see the Web Appendix for further analysis investigating the opposite activation patterns).

Insert Table 1 about here

Next, we investigated whether all pain-processing areas described above were similarly responsive to price during purchases. Using an independent region-of-interest analysis corrected for multiple comparisons at a false discovery rate (FDR, Benjamini and Hochberg 1995) thresholded at $p = .05$, we contrasted the extent to which different areas of pain processing were involved in the differential encoding of each of the two price modalities for purchases versus non-purchases (Table 1; see the Web Appendix for details). As predicted, for voltage prices, we found that areas linked to both pain qualities (higher-order affective and lower-order somatosensory) as well as to arousal predicted purchasing decisions and were responsive to price (i.e., the higher the voltage price, the higher the activation for purchased vs. non-purchased items, a so-called parametric modulation approach). In contrast, for monetary prices we found that only neural activity in areas linked to higher-order, affective pain processing predicted purchasing decisions and were responsive to price. Importantly, the activity patterns in the money condition were in the opposite direction to those in the voltage condition and in line with the direction of Knutson and colleagues' (2007) findings. In addition, extending those authors' previous findings, we found that *the higher the monetary price*, *the lower the activity* for purchased vs. non-purchased items (see Figure 3 and Table 1).

Insert Figure 3 about here

In the next set of analyses we investigated the specificity of these neural activity patterns by conducting two additional analyses: First, we examined how specific these differences in activity patterns in money versus voltage trials were to pain-processing regions by doing an independent region-of-interest analysis of regions correlating with price in regions known to code value in various meta-analyses (i.e., the ventromedial prefrontal cortex [vmPFC] and the striatum; Bartra, McGuire, and Kable 2013; Clithero and Rangel 2014; Levy and Glimcher 2012). If our findings were specific to pain-processing regions, value-coding regions should not be responsive to price. And indeed, in both types of trials we found no significant correlation with price and no differences for purchased versus not-purchased items (see Table 1; see also Figures S2A and S2B in the Web Appendix). Note that we also ran an additional analysis showing that in both types of trials value-coding regions correlated positively with WTP from the pre-scanner subjective valuation task and predicted purchases, replicating previous findings (Plassmann, O'Doherty, and Rangel 2007, 2010; see Table S1 and Figures S2C and S2D in the Web Appendix for details.

Second, we investigated whether we would find the same activity patterns in pain-processing regions in the free trials. In free trials there should be no pain of payment, so we should not find pain-processing regions implicated in the free trials. And indeed, we found that in free trials neither affective nor somatosensory pain-processing regions were involved (see Table S2 and Figure S4 in the Web Appendix).

Together, the results of Experiment 1 show that paying money recruits overlapping higher-order, affective pain-processing brain areas that are also involved when paying in exchange for electric shocks. In addition, unlike Knutson et al. (2008) we found that the size of

the activation correlated with the size of the price. Thus, these results suggest that the anticipation of paying with money indeed triggers an affective pain experience, and the magnitude of that pain experience varies with the magnitude of the price one anticipates paying.

EXPERIMENT 2: CONCEPTUAL PRIMING

Experiment 2 set out to test the novel hypothesis derived from Experiment 1: that people perceive monetary payments for purchases like they perceive pain, and more specifically like a higher-order, affective pain rather than a lower-order, somatosensory pain. To do so we employed a non-conscious conceptual priming task, a scrambled-sentences task using somatosensory or affective pain words to make corresponding pain-related concepts more accessible in memory. The intention of the affective (somatosensory) pain prime was to make people more sensitive to any affective (somatosensory) pain they may perceive during their subsequent purchasing decisions. Thus, if making a monetary payment is indeed affectively (but not somatosensorily) painful, the affective (but not the somatosensory) pain prime would facilitate the perception of the anticipated pain of paying and therefore reduce people's willingness to pay.

Effect of Conceptual Priming on Willingness to Pay

A non-conscious priming task, such as the scrambled-sentences task, has been shown to activate emotion-specific *knowledge* without affecting subjective emotional experiences (i.e., mood or arousal) (Silvia et al. 2006; Zemack-Rugar, Bettman, and Fitzsimons 2007). In fact, research on affective conceptual primes (affect as information; Clore and Colcombe 2003)

argues that while unconscious priming is *not experienced* as such, the meaning it activates is experienced as an attribute of the next thing to occupy attention. This translates in our case to facilitating pain perception with respect to WTP. Building on the findings from Experiment 1, we therefore hypothesized that using a conceptual prime that makes affective pain more accessible would increase the aversion to pay and thus decrease people's willingness to pay, while making somatosensory pain more accessible would have no effect. If our conceptual priming task, contrary to previous research, were to affect—in particular, decrease—people's mood or arousal, we would expect to find results in line with the "retail therapy" literature (and opposite to what we hypothesize above): an increased (instead of a decreased) willingness to pay caused by the priming task (for more details on mood induction manipulations and their influence on WTP, see the Web Appendix).

Experimental Design

Participants. One hundred forty-two students from the University of Toronto (90 females, M_{age} = 23.04, SD = 5.48) participated in exchange for $5 in an experimental session that was advertised as lasting for 30 minutes and consisting of several unrelated tasks. Participants were instructed to pay careful attention because in one of the questionnaires they would be participating in an auction in which they could purchase a product for real, with their own money in the form of cash.

Procedure. Participants were first asked to read an explanation of the Becker, DeGroot, and Marschak (1964) (BDM) procedure—an incentive-compatible auction method to elicit people's true valuations that was also used in Experiment 1 (see Web Appendix). Next, participants completed three questions to test their comprehension of the BDM procedure:

"Imagine the above-described BDM auction procedure for an Apple iPod. You bid $200; the computer randomly selects a price of $175." (1) "Do you get to buy the iPod?" [correct answer: yes] (2) "What price do you have to pay for the iPod?" [correct answer: $175] (3) "What if the computer's generated price is $225? Do you get to buy the iPod?" [correct answer: no]

Following this first part of the experiment, participants were informed that they would participate in a word-comprehension task that tested word relationships based on participants' immediate impressions. They were given 15 sets of five words, and heir task was to construct grammatically correct sentences using four of the five words. In reality this scrambled-sentence task (Srull and Wyer 1979) was used to implicitly prime the concepts of affective pain and somatosensory pain. Specifically, participants were randomly assigned to one of three between-participants conditions: affective pain, somatosensory pain, or control condition. In the affective and somatosensory pain conditions, 13 of the 15 sets contained pain-related words (affective pain: e.g., "today are shops *sorrow* open," "carpet *grief* the soft was"; somatosensory pain: e.g., "*muscles* her are green *sore," "cramps* she *stomach* has night"), and the remaining two sets contained no pain-related words and were the same across all three conditions. In the control condition none of the 15 sets contained pain-related words (e.g., "carpet *pen* the soft was," "young the architect is *towel*"; for all sets, see Table S3 in the Web Appendix).

Immediately following the scrambled-sentence task participants took part in a consequential BDM procedure to elicit their valuation for a product with a clear and known face value: a $20 Amazon.ca gift card. They were asked to indicate for each dollar value ranging from $1 to $20 whether they would buy the gift card for that amount (yes/no). They were told that the highest dollar amount at which they circled yes (maximum WTP) would be used as their bid and that at the conclusion of the experimental session the experimenter would activate a random

number generator to find out whether they would get to buy the gift card for real with their own money and for what price.

After that, participants indicated their liking of the $20 Amzon.ca gift card as well as their current mood and arousal as potential mediators of the effect. Liking was elicited on a 10-point scale (0: not at all to 9: very much). Each of the four mood (bad/good, disappointed/satisfied, sad/happy, displeased/pleased; Cronbach's α = 0.91) and arousal (calm/excited, tired/energetic, down/elated, sedated/aroused; Cronbach's α = 0.71) items was elicited on a 17-point scale ranging from –8 to 8. In addition, participants answered the four questions of the spendthrift/tightwad (ST-TW) scale (Rick, Cryder, and Loewenstein 2008), which we intended to use as a potential moderating variable.

Finally, participants were told that they would take part in a memory task. They were asked to think of a past situation in which they had experienced pain and to describe it briefly. This open-ended question served as a manipulation check to determine whether participants implicitly primed with the concept of somatosensory (affective) pain would be more likely to recall somatosensory (affective) pain experiences. Afterward, we asked participants their age and gender, four questions to assess their English comprehension, and whether they had previously participated in similar tasks. The session ended with a funneled debriefing questionnaire (Chartrand and Bargh 1996) to examine whether participants were aware of the purpose of the experiment (see Web Appendix).

After all participants in that session completed the questionnaires, a random number was generated for each participant (i.e., the randomly generated selling price), and depending on the results participants either purchased (when their maximum WTP >= randomly generated selling

price) the $20 Amazon.ca gift card for real with their own money (cash only) or did not have to pay anything and did not receive the gift card.

Results and Discussion

Based on a priori determined exclusion criteria, 33 participants ended up being excluded from analyses, leaving N = 109 observations. In addition, our manipulation check results suggest that the scrambled-sentences task did have the intended effect of making the particular pain concepts more accessible (for details of both, see the Web Appendix).

First, we examined the effect of the conceptual priming conditions on participants' maximum WTP. The results of an ANOVA revealed a significant difference. As can be seen in Table 2, in line with our hypothesis derived from the observations in Experiment 1, participants conceptually primed with affective pain revealed a significantly lower willingness to pay for the gift card than those conceptually primed with somatosensory pain ($t(106) = –2.00$, $p = .048$) or control participants ($t(106) = –2.42$, $p = .017$). There was no significant difference between the latter two conditions ($t(106) = –.46$, $p = .643$). That is, willingness to pay was reduced only when we facilitated affective pain perception. In addition, while self-reported liking showed a trend similar to that of maximum WTP, there was no significant effect of priming on liking.

Insert Table 2 about here

The observed decrease in WTP caused by priming affective pain is in line with our hypothesis and in the opposite direction of a mood manipulation. In addition, as can be seen in Table 2, there was no significant effect of condition on participants' self-reported mood or

arousal (there were also no significant correlations between mood/arousal and WTP; see Web Appendix). These findings are in line with previous research suggesting that the sentence-unscrambling task (Srull and Wyer 1979) represents an implicit or subtle means to activate more cognitive aspects of judgment and decision making, such as particular goals, motivations, or values, rather than a means to induce mood (e.g., DeSteno et al. 2004; Fitzsimons and Shah 2008).

One concern that would affect our conclusions from Experiment 2 is that the affective and somatosensory pain words in our priming manipulation (Table S3 in the Web Appendix; e.g., grief, heartbreak, misery, despair vs. stomach cramps, arm injury, irritated skin, knee twinge) were not matched on their intensity. In particular, that concern could be that the affective words were more intense than the somatosensory words, and that it is this difference that caused the changes in willingness to pay. To test this possibility we conducted a follow-up experiment with N = 210 participants recruited on Mechanical Turk in exchange for $1.50. The experiment used the same between-subjects conceptual priming task, but instead of measuring WTP we elicited participants' perceived intensity (scale from 1: not at all to 5: extremely) for each of the sets from our conceptual priming manipulations. Across two analyses, examining the effect of condition on the average intensity rating of the 15 scrambled sentences (ANOVA: $F(2, 207) = 8.84$, $p < .001$) and also running a MANOVA ($F(2, 207) = 8.84$, $p < .001$), we did find a significant difference in intensity, but the difference was in the opposite direction: The intensity was rated to be significantly higher for our somatosensory words (M = 2.53, SD = .63) than for the neutral (M = 2.06, SD = .79; $t(207) = 4.08$, $p < .001$) and affective words (M = 2.19, SD = .64; $t(207) = 2.91$, $p < .01$); the latter two were not significantly different ($t(207) = 1.15$, $p = .25$).

Thus, this difference cannot explain our findings in Experiment 2, in which affective pain primes (and not somatosensory primes) affected WTP.

Based on previous research, we also examined the potential moderating role of participants' ST-TW scores (Rick, Small, and Finkel 2011) on the effects of our priming conditions on WTP and did not find any evidence for moderation (for details see Table S5 in the Web Appendix). Finally, because Experiment 1 was conducted with females only, we re-ran all analyses from Table 2 controlling for gender. The results (see Table S6) show that in terms of the effect of our priming conditions we continue to find only a significant effect on WTP (p = .04) (for details see the Web Appendix).

Experiment 2 demonstrated that willingness to pay was reduced when using conceptual primes to facilitate affective pain perception. Using conceptual primes to facilitate somatosensory pain perception did not influence willingness to pay.

EXPERIMENT 3: PLACEBO DRUG MISATTRIBUTION

Experiment 3 was designed to provide additional evidence in support of the existence of a higher-order, affective displeasure of paying using another methodology to manipulate pain perception. In addition, we attempted not only to decrease but also to increase participants' willingness to pay. To do so, we used a placebo drug manipulation described either as a somatosensory pain (headache, muscle, joint pain) enhancer or reliever, an affective pain (anxiety, sadness, social discomfort) enhancer or reliever, or a dietary supplement (for the rationale behind using pain enhancers in medical treatments see the Web Appendix).

Standard Placebo Effects Versus Reverse Placebo Effects

An extensive review on the effects of placebos (Ross and Olson 1981) suggests two types of placebo effects: (1) standard placebo effects, in which a "drug" seems as if it works for its intended purpose, and (2) reverse placebo effects, in which individuals misattribute their experiences to the drug instead of to their actual feelings. Standard placebo effects are typically found for measures that participants believe are directly related to the alleged effects of a described placebo, so-called primary assessments (e.g., Wager and Atlas 2015), and reverse placebo effects are typically found when measuring seemingly unrelated, secondary assessments. For example, in the case of administering a placebo pain enhancer, asking participants how much pain they feel is a primary assessment, which measures "the direct effect of expectancies associated with the placebo" (Ross and Olson 1981, p. 408). If participants believe the "drug" to work, they will ultimately reveal an increase in self-reported feelings of pain (standard placebo effect; (e.g., Gracely et al. 1985). On the other hand, asking participants about their willingness to pay for a product after having taken a pain enhancer is a secondary assessment, which measures "inferences about underlying dispositions that are not believed to be directly affected by the placebo" (Ross and Olson 1981, p. 408). In this case, if participants experience a displeasure of paying, they will infer that it is from the placebo drug (misattribution) and not from their personal experience (Storms and Nisbett 1970). Therefore, we would expect that as a consequence of experiencing less pain of paying, participants' would have a greater willingness to pay (i.e., a reverse placebo effect). Similar findings have been suggested in the misattribution literature investigating the calibration of expectancies outside the domain of placebo effects (Pham 1998; Schwarz and Clore 1983).

Accordingly, building on our previous findings and the literature on reverse placebo effects, we formulated three hypotheses: First, if the displeasure of paying exists and if it is an affective pain, we would observe a difference in willingness to pay only for participants in the affective pain-enhancer and -reliever conditions. Second, participants in the affective pain-enhancer condition would misattribute their experienced displeasure to the drug and not to the payment and thus infer a higher valuation of the gift card than control participants. Third, participants in the affective pain-reliever condition would infer a lower valuation of the gift card than control participants, as they experienced displeasure despite having taken a pain reliever.

Experimental Design

Participants. Two hundred sixteen individuals (123 females, 93 males, M_{age} = 24.89, SD = 5.13) were recruited to participate in a clinical drug test at a hospital in Germany to assess the effects of an already approved over-the-counter drug on perception and general well-being. They were paid €25 for one hour.

Procedure. Upon arrival, participants (one at a time) were first screened for not being medical students, for not having a history of psychotropic medication use or substance abuse, for not having emotional psychiatric disorders (DSM-IV-TR axis I disorders), and for not being pregnant or breastfeeding. Following this screening, participants were randomly assigned to five between-participants conditions in which we varied the description of the "drug" that participants were supposed to test: affective pain enhancer or reliever, somatosensory pain enhancer or reliever, or dietary supplement. In actuality and unbeknownst to the participants, the same placebo drug (a starch tablet) was given in all conditions. The experimenters did not know to

which condition the computer had assigned the participants and were blind to the hypothesis of the experiment.

After random assignment to one of the five conditions, participants first read a short description of the drug (see Table S8) and the procedure. In particular, participants were informed that after taking the drug they would have to wait 15 minutes for the drug to take effect, after which they would participate in various computerized studies and questionnaires to assess the drug's effect on their perception and general well-being. As part of this test, participants were informed that some of them would be participating in a few control tests, such as product judgments. In actuality, all participants were assigned to the same four behavioral tasks: First, an incentive-compatible BDM auction for an Amazon gift card (similar to the one in Experiment 2), followed by three additional tasks in randomized order that were not of focal interest of the experiment but were added to mimic the setting of a typical affective and/or somatosensory pain-related drug test: a cold pressor task, a Cyberball task, and an emotional pictures rating task (see the Web Appendix for details).

As in our previous experiments, before the start of the BDM auction (during the 15-minute wait time) participants were asked to read an explanation and a concrete example of the Becker, DeGroot, and Marschak (1964) procedure. Next, participants completed the same three questions as in Experiment 2 to test their comprehension of the procedure; unlike in Experiment 2, however, participants could proceed to the BDM task only if they answered all three questions correctly (as soon as participants made a mistake, the description of the BDM procedure and the three comprehension questions were repeated from the start). After that, individuals were informed that they would be participating for real in a BDM auction for a €30 gift card from Amazon.de and were asked to confirm that they understood that their answers in the subsequent

BDM auction would be binding and that they would have to spend their own money in the form of cash. Finally, we took a photo of each participant for the upcoming Cyberball task and invited the participants to sit back and relax until the waiting time was over.

Once the BDM auction task started, as in Experiment 2, for each Euro value ranging from €1 to €30, participants were asked whether they would be willing to buy the gift card for that amount (yes/no). The highest amount at which they answered "yes" was coded as their maximum WTP. After that, participants indicated their liking (potential mediator) of the €30 Amazon gift card on a scale from 1: not at all to 9: very much.

Considering the descriptions of the drugs given to participants (see Table S8), the BDM auction's WTP measure represented a secondary assessment of the alleged effects of the placebos (i.e., a measure not directly related to the alleged effects). Thus, given previous research, we expected to find reverse placebo effects (Ross and Olson 1981; Storms and Nisbett 1970). The additional three tasks (Cyberball, cold pressor, and emotional pictures rating) could not be uniquely assigned to either primary or secondary assessments, and thus their results need to be interpreted with care (for details see the Web Appendix).

After participants completed the four behavioral tasks, we collected some typical primary assessments of the alleged effects of the pain placebos (i.e., measures directly related to the alleged effects). In addition, at the end of the experiment, we added questions that were meant to serve as manipulation checks as well as potential mediators and moderators.

Specifically, first, we asked about what effect participants thought the drug had on their affective and somatosensory well-being (nine-point scales each from 1: much worsened to 5: no effect to 9: much improved) and how much somatosensory and affective pain they felt in the current moment in comparison to the beginning of the study, before they took the drug (nine-

point scale from 1: much more to 9: much less). These questions served as a primary assessment of the alleged effects of the described placebos, for which we expected to find standard placebo effects (Ross and Olson 1981).

We also asked participants whether they believed the drug to be effective at all (1: not effective at all to 9: very effective). We used this question as an exclusion criterion if answered with a 1.

Next, we asked participants to rate their mood (bad/good, disappointed/satisfied, sad/happy, displeased/pleased; Cronbach's $\alpha = 0.86$) and arousal (calm/excited, tired/energetic, down/elated, sedated/aroused; Cronbach's $\alpha = 0.64$) on nine-point scales. As in Experiment 2, we thought these measures could serve as potential mediators (together with liking, which was elicited during the BDM task).

Subsequently, we administered two personality scales as potential moderator variables (for details, see the Web Appendix). First, we administered a variant of the hurt feelings scale (e.g., "My feelings are easily hurt"; seven statements on a five-point scale from 1: not at all characteristic of me to 5: extremely characteristic of me; Cronbach's $\alpha = 0.82$), (Leary and Springer 2001). Second, we administered the same somatosensory pain sensitivity scale used in Experiment 1 (Cronbach's $\alpha = 0.74$). These measures were followed by a few control questions (for details, see the Web Appendix).

At the end of the entire experimental session, before debriefing, a random number was generated for each participant. Depending on their WTP and that random number, participants either purchased the €30 Amazon.de gift card for real with their own money (cash only) or they did not have to pay anything and did not receive the gift card.

Results and Discussion

Based on a priori determined exclusion criteria similar to those used in Experiment 2 (see the Web Appendix), 43 participants ended up being excluded from analyses, leaving N = 173 observations. The results of the one-way ANOVAs (with five levels) for the main variables are displayed in Table 3 (for all other variables, see Table S9 in the Web Appendix).

Insert Table 3 about here

BDM auction (secondary assessment). Figure 4 displays participants' maximum WTP by placebo drug condition. As can be seen in Table 3, participants' maximum WTP differed according to the condition they were in, $F(4, 168) = 2.69$, $p = .03$. In line with our hypotheses and previous research on reverse placebo effects (Ross and Olson 1981; Storms and Nisbett 1970), affective pain-enhancer participants had a significantly higher WTP than affective pain-reliever participants ($t(168) = 3.25$, $p = .001$) and a marginally higher WTP than control participants ($t(168) = 1.87$, $p = .06$, one-tailed: $p = .03$) (affective pain reliever vs. control participants: $t(168) = 1.41$, $p = .16$, one-tailed: $p = .08$). The WTP of somatosensory pain-enhancer participants did not significantly differ from the WTP of the somatosensory pain-reliever participants ($t(168) = .30$, $p = .76$) or control participants ($t(168) = .37$, $p = .71$). Excluding the control participants and running a 2 (type of placebo: enhancer vs. reliever) x 2 (type of pain: affective vs. somatosensory) ANOVA (N = 137) further supports these findings with a significant interaction effect, $p = 0.04$ (and a main effect type of placebo: $p = 0.01$; see Table S10).

Insert Figure 4 about here

In contrast to the priming Experiment 2, in this placebo Experiment 3, condition did have a significant effect on liking; the results of a 2x2 ANOVA excluding control participants showed a marginal interaction ($p = .09$) between type of placebo (reliever vs. enhancer) and type of pain (somatosensory vs. affective) and a significant main effect of type of pain: $p < 0.01$; see Table S10. Follow-up analysis with a test of mediation (Baron and Kenny 1986) with control placebo as baseline and dummies for each of the other placebo conditions revealed that liking fully mediated the relationship between the affective pain-enhancer dummy and WTP (see Table S11 in the Web Appendix for details).

Self-perceived changes in affective and somatosensory well-being and pain (primary assessment). In line with the hypothesis that primary assessments result in standard placebo effects, as can be seen in Table 3, across all four measures pain-reliever participants seemed to feel better than pain-enhancer participants, regardless of whether the placebo targeted their somatosensory or affective state (Kross et al. 2011). This was confirmed by separate 2x2 ANOVAs that excluded the control participants (see Table S10); there was only a main effect of type of placebo (reliever vs. enhancer; for all four measures $p < 0.01$).

Self-rated mood and arousal (potential mediators). As can be seen in Table 3, ANOVA analyses revealed a significant effect of placebo condition on aggregated arousal but not on aggregated mood, with affective pain-enhancer participants being significantly less aroused than the other participants. However, follow-up analysis with a test of mediation (Baron and Kenny 1986) with control placebo as baseline and dummies for each of the other placebo conditions showed that there was no mediation by aggregated arousal (the affective pain-enhancer dummy

continued to have a marginally significant effect on WTP; see Table S11 in the Web Appendix for details).

Hurt feelings and pain sensitivity scales (potential moderating variables). We also examined the potential moderating roles of both scales on the effects of our placebo conditions on WTP and did not find any evidence for moderation (for details see Table S12 in the Web Appendix).

Gender. Finally, because Experiment 1 was run with females only, we re-ran our main analyses (effect of placebo conditions on WTP, liking, and aggregated mood and arousal) controlling for gender and did not find any meaningful changes in the effects of our placebo conditions (for details see Table S13 in the Web Appendix).

GENERAL DISCUSSION

Our findings support and extend recent behavioral economic theories of purchases by providing more direct evidence for the existence of a negative hedonic experience of paying and qualifying the displeasure as an *affective* pain. More specifically, Experiment 1 revealed that paying with money indeed recruits pain-processing brain regions but only those pain pathways that are involved in higher-order, affective aspects of pain processing and not in lower-order, somatosensory aspects. Next, in Experiment 2 we manipulated pain processing by facilitating the perception of one's experienced pain during paying (making people more likely to notice it) through a conceptual priming task, and found that priming of affective pain decreased WTP. Finally, in Experiment 3 we manipulated beliefs about the source (i.e., the drug vs. the purchasing situation) of one's experienced pain during paying (secondary assessment), and found

that in line with a misattribution of pain perception to the placebo drugs, affective pain enhancers versus affective pain relievers increased versus decreased WTP. We did not expect our prime in Experiment 2 to lead to a misattribution effect because misattribution requires conscious awareness of the alternative source (and our priming effect was non-conscious; see, e.g., Schachter and Singer 1962; Storms and Nisbett 1970), or, in order for the misattribution to be implicit, it requires evaluative conditioning (and we did not use a conditioning procedure; see, e.g., Jones, Fazio, and Olson 2009). Finally, in both Experiments 2 and 3, manipulations of somatosensory pain perceptions did not alter WTP.

A number of areas for potential future research emerge from our findings. First, in line with previous research, we found opposite activation patterns for voltage and money trials in the purchasing decision task in Experiment 1. While our follow-up experiments were not designed to speak to the psychological underpinnings of *why* the activation patterns flipped between these two payment modalities, we speculate that upon seeing a product's price, the pain of paying experienced by individuals influences their decision about whether or not to purchase the product. That is, in money trials, individuals are using their feelings as a source of information (Schwarz 2012): The more affective pain they experience, the less likely they are to buy. For the voltage trials, on the other hand, it seems that once decision makers have decided to purchase, they anticipate the pain that they agreed to tolerate. These different psychological mechanisms may be triggered by two conceptual differences between the two payment conditions: First, in the money trials, participants make a decision about *giving up* something, while in the voltage trials, participants make a decision about *receiving* something. In addition, by itself, money is a reward that induces approach behavior, while an electric shock is a punishment that induces avoidance behavior. Future research may want to examine to what extent our speculations are

accurate and why money trials and voltage trials may result in such different foci and potentially different mechanisms.

Another potential avenue for future research lies in the fact that throughout our three experiments we did not find any evidence for somatosensory pain experiences in paying. Because psychological pain, if intense, can spread beyond affective pain processing to recruit brain areas involved in somatosensory pain processing (Kross et al. 2011), analogously, there may be situations with very high monetary prices (outside the range of typical everyday purchases) in which the affective pain-of-paying experience may spread to also involve a somatosensory pain experience.

Yet another potential avenue for future research is to study to what extent people adapt to the pain of paying over time. For example, research on happiness has shown that humans are remarkably good at adapting to painful misfortunes of most kinds (e.g., becoming quadriplegic or suffering a breakup), except for chronic pain (Frederick and Loewenstein 1999). If adaptation also applies to the pain of paying, we would expect that the more people gain experience with purchases the less important the pain of paying becomes as an additional source of consumers' (dis)utility when paying, and thus, the lower its ability to impede excessive immediate indulgence over time.

Future research may also want to examine a potential mediating role of liking. We found a mediating role of liking only in Experiment 3, not in Experiment 2. Thus, it is likely that the significant effect of our manipulation on liking is linked to the placebo design setup of Experiment 3. Supporting this idea is recent evidence in the clinical pain-reliever placebo literature showing that not only do placebo treatments cause a decrease in subjective pain experience ratings (primary assessments) and their neural signatures (the regions reported in

Experiment 1), but that these effects are also mediated by an increase in activity in value-coding regions (i.e., vmPFC, striatum see Wager and Atlas 2015). These recent findings suggest a functional link between pain processing and liking during placebo responses (most likely due to the positive prospect of pain relief). However, further research is needed to better understand the psychological basis for this functional link and whether, even though we did not find any evidence for it, it may also apply to the pain of paying more generally (i.e., outside of a placebo context).

Finally, future research may want to examine the potential moderating role of gender. In particular, because previous research has reported gender differences in pain sensitivity (with females being more sensitive to pain; e.g., Riley et al. 1998; this is one of the reasons we conducted Experiment 1 with females only), it is possible that this translates to females being more sensitive to the pain of paying than males. Explorative analyses of the effects of our priming (Experiment 2) and placebo (Experiment 3) conditions by gender (see Tables S7 and S14 in the Web Appendix) suggest that their effects on WTP could indeed be muted for males. However, because our Experiments 2 and 3 were not set up to examine that question, we lack the statistical power to draw any reliable conclusions. Future research may want to examine this aspect more systematically.

Together, the knowledge that paying induces a feeling of affective pain can guide the more effective design of choice architecture (Johnson et al. 2013) and nudges (Thaler and Sunstein 2008) to improve individual and economic well-being. In particular, our findings have implications for interpreting and addressing common, societally disadvantageous consumer behaviors such as overspending and undersaving through adequate marketing and policy interventions. They call, for example, for a departure from a sole focus on analytical process

improvements via financial literacy education or cognitive decision aids and instead for a focus on interventions targeting affect.

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TABLE 1

EXPERIMENT 1: BRAIN IMAGING RESULTS: MEANS, STANDARD ERRORS, AND T-STATISTICS OF REGIONS CORRELATING WITH PRICE (PARAMETRIC MODULATION).

	Voltage Prices			**Monetary Prices**		
	Purchased	Not purchased	DF = 18	Purchased	Not purchased	DF = 18
Brain Regions	M (SEM)	M (SEM)	T (*p*-value)	M (SEM)	M (SEM)	T (*p*-value)
Left insula	.59 (.20)	–.24 (.19)	4.22 (.001)*	–.32 (.20)	.49 (.18)	–3.06 (.007)*
Right insula	.96 (.20)	–.39 (.21)	5.1 (.001)*	–.54 (.16)	.23 (.17)	–3.58 (.002)*
All pain-processing regions	0.27 (.19)	–.60 (.19)	3.72 (.002)*	–0.41 (.16)	0.22 (.12)	–3.12 (.006)*
Affective pain processing						
Dorsal ACC	.59 (.20)	–.24 (.19)	4.22 (.001)*	–.47 (.24)	.45 (.17)	–2.91 (.009)*
Rostral ACC	.52 (.18)	–0.31 (.18)	3.26 (.004)*	–.52 (.21)	.03 (.22)	–2.02 (.059)
Anterior insula	.75 (.18)	–0.48 (.19)	3.86 (.001)*	–.28 (.14)	.38 (.19)	–2.86 (.010)*
Sensory pain processing						
Somatosensory cortex	.53 (.19)	–.13 (.21)	2.52 (.014)*	–.23 (.17)	.11 (.21)	–1.17 (.258)
Posterior insula	.81 (.28)	–.15 (.20)	3.47 (.003)*	–.20 (.22)	.32 (.23)	–1.69 (.110)
Thalamus	.50 (.15)	–.099 (.19)	2.58 (.019)	–.58 (.23)	–.03 (.20)	–1.79 (.101)
Arousal						
Amygdala	.82 (.19)	–.33 (.19)	3.89 (.001)*	–0.12 (.16)	.43 (.18)	–2.23 (.033)
Value coding						
vmPFC	.55 (.20)	.02 (.30)	1.46 (.16)	.06 (.21)	.21 (.21)	–.53 (.600)
Bilateral striatum	.50 (.27)	0.13 (.26)	0.80 (.43)	–0.08 (.28)	.29 (.23)	–1.01 (.32)

Note: *Survives correction for multiple comparisons using false discovery rate at $p = .05$.

TABLE 2

EXPERIMENT 2: BETWEEN-PARTICIPANTS RESULTS BY CONDITION

Measures	ANOVA $F(2, 106)$ (p)	Conceptual Priming Conditions: Affective pain (N = 33)	Somatosensory pain (N = 39)	Control (N = 37)
			M (SD)	
(1) Maximum WTP	3.28 (.04)*	\$6.21[A] (4.26)	\$8.49[B] (5.11)	\$9.00[B] (4.94)
(2) Liking	1.01 (.37)	3.91 (2.16)	4.26 (2.67)	4.72 (2.38)
(3) Aggregated mood	1.69 (.19)	1.90 (3.01)	3.01 (2.74)	3.04 (3.00)
(4) Aggregated arousal	1.36 (.26)	–.04 (2.02)	.47 (1.82)	.91 (3.10)

Note: *$p < .05$. In each ANOVA row, means connected by different superscripted letters are significantly different from each other, with $p < .05$ based on two-tailed student's t-tests. Rows without superscripted letters indicate no statistically significant difference ($p < .05$) between the conditions.

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TABLE 3

EXPERIMENT 3: BETWEEN-PARTICIPANTS RESULTS BY CONDITION, N = 173

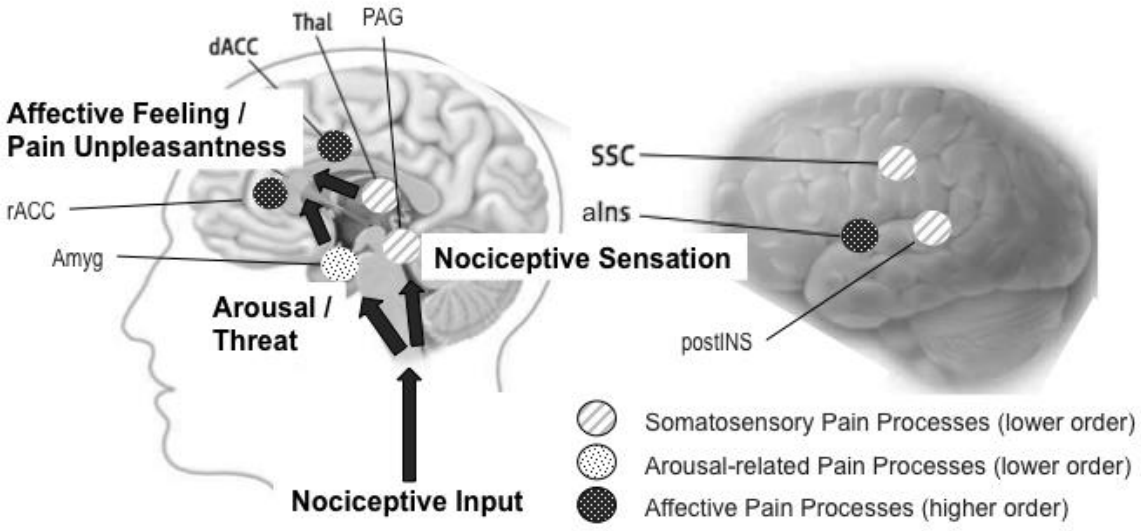
		Placebo Conditions				
		Affective pain reliever (N = 35)	Affective pain enhancer (N = 34)	Somatosensory pain reliever (N = 34)	Somatosensory pain enhancer (N = 34)	Control: dietary supplement (N = 36)
Measure	ANOVA $F(4, 168)$ (p)			*M* (*SD*)		
DV: Purchasing task (BDM); secondary assessment						
(1) Maximum WTP	2.69 (.03)*	€11.89 [A] (8.32)	€18.12 [B] (8.34)	€14.68 [A, B] (6.72)	€15.26 [A, B] (8.45)	€14.56 [A, B] (7.79)
(2) Liking	3.75 (<.01)*	4.71 [A] (2.33)	6.26 [B] (1.96)	5.50 [A, B] (1.96)	5.88 [B] (2.20)	4.75 [A] (1.96)
DV: Self-perceived changes in affective and somatosensory well-being and pain; primary assessment						
(1) Somatosensory well-being	4.12 (<.01)*	5.31 [A] (.76)	4.82 [B] (1.00)	5.41 [A] (.86)	4.71 [B] (1.03)	5.31 [A] (.98)
(2) Affective well-being	4.52 (<.01)*	5.54 [A] (.86)	4.76 [C] (.99)	5.32 [A] (.98)	4.88 [B, C] (.81)	5.25 [A, B] (.77)
(3) Change in somatosensory pain	3.41 (.01)*	5.31 [A] (1.05)	4.65 [B] (1.04)	5.35 [A] (.81)	4.82 [B] (.80)	5.06 [A, B] (1.09)
(4) Change in affective pain	3.84 (<.01)*	5.63 [A] (1.06)	4.94 [C] (.60)	5.21 [B, C] (.88)	4.97 [C] (.83)	5.39 [A, B] (.90)

Measure	ANOVA $F(4, 168)$ (p)	Placebo Conditions: Affective pain reliever (N = 35)	Affective pain enhancer (N = 34)	Somatosensory pain reliever (N = 34)	Somatosensory pain enhancer (N = 34)	Control: dietary supplement (N = 36)
				M (*SD*)		
Potential mediators: Self-rated mood and arousal						
(1) Aggregated mood	1.94 (.11)	6.86 [A] (1.16)	6.40 [A, B] (1.59)	6.61 [A, B] (1.22)	6.11 [B] (1.32)	6.18 [B] (1.22)
(2) Aggregated arousal	2.59 (.04)*	5.06 [A] (1.28)	4.33 [B] (1.11)	4.99 [A] (.96)	4.91 [A] (.98)	4.93 [A] (.94)
Manipulation check						
Believed in drug Effectiveness	2.95 (.02)*	4.60 [A, B] (2.02)	3.88 [B, C] (1.85)	4.91 [A] (1.93)	4.53 [A, B] (2.21)	3.56 [C] (1.56)

Note: *$p < .05$. In each ANOVA row, means connected by different superscripted letters are significantly different from each other, with $p < .05$ based on two-tailed student's *t*-tests. Rows without superscripted letters indicate no difference between the conditions. The main pattern of results for maximum WTP ($F(4, 137 = 2.55$, $p = .04$) and liking ($F(4, 137 = 4.22$, $p < .01$) of the Amazon gift card hold if we exclude N = 34 participants who did not display a rational response pattern in our choice-based BDM (i.e., switching more than once between their yes and no answers). Manipulation check measure: The general pattern of results reported in this row holds if we don't exclude participants who did not believe in the effectiveness of the drug (N = 198). If we don't exclude these participants, the overall ANOVA for WTP is no longer be significant ($F(4, 193) = 1.57$, $p = .18$), but the difference between the two affective pain placebos remains significant (reliever: M = 13.21, SD = 8.82 vs. enhancer: M = 17.55, SD = 8.63, $t(193)=2.42$, $p =.02$).

FIGURE 1

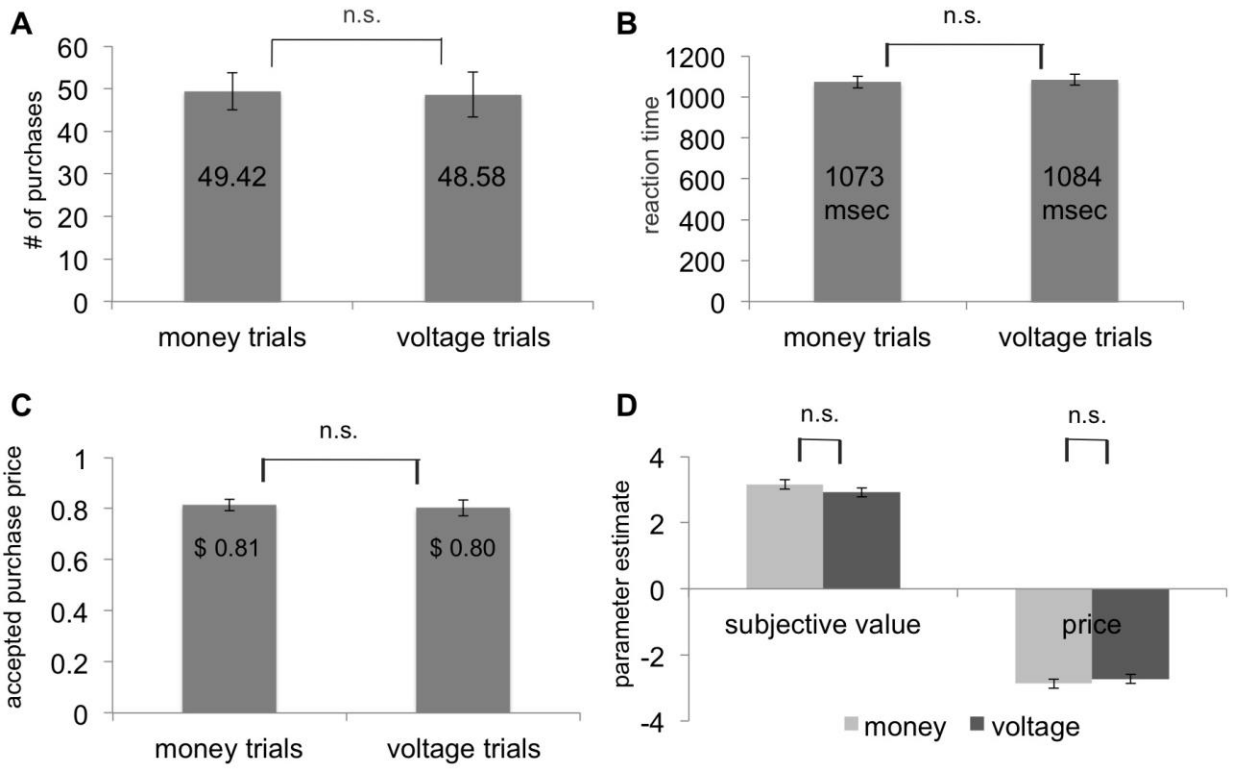
SIMPLIFIED PAIN PROCESSING PATHWAY MODEL FROM COGNITIVE NEUROSCIENCE



Note: Amyg =Amygdala, rACC = rostral Anterior Cingulate Cortex, dACC = dorsal Anterior Cingulate Cortex, Thal = Thalamus, PAG = Periaqueductal Grey, aINS = anterior Insula, postINS = posterior Insula, SSC = Somatosensory Cortex; adapted from Lieberman and Eisenberger 2009 and Price 2000.

FIGURE 2

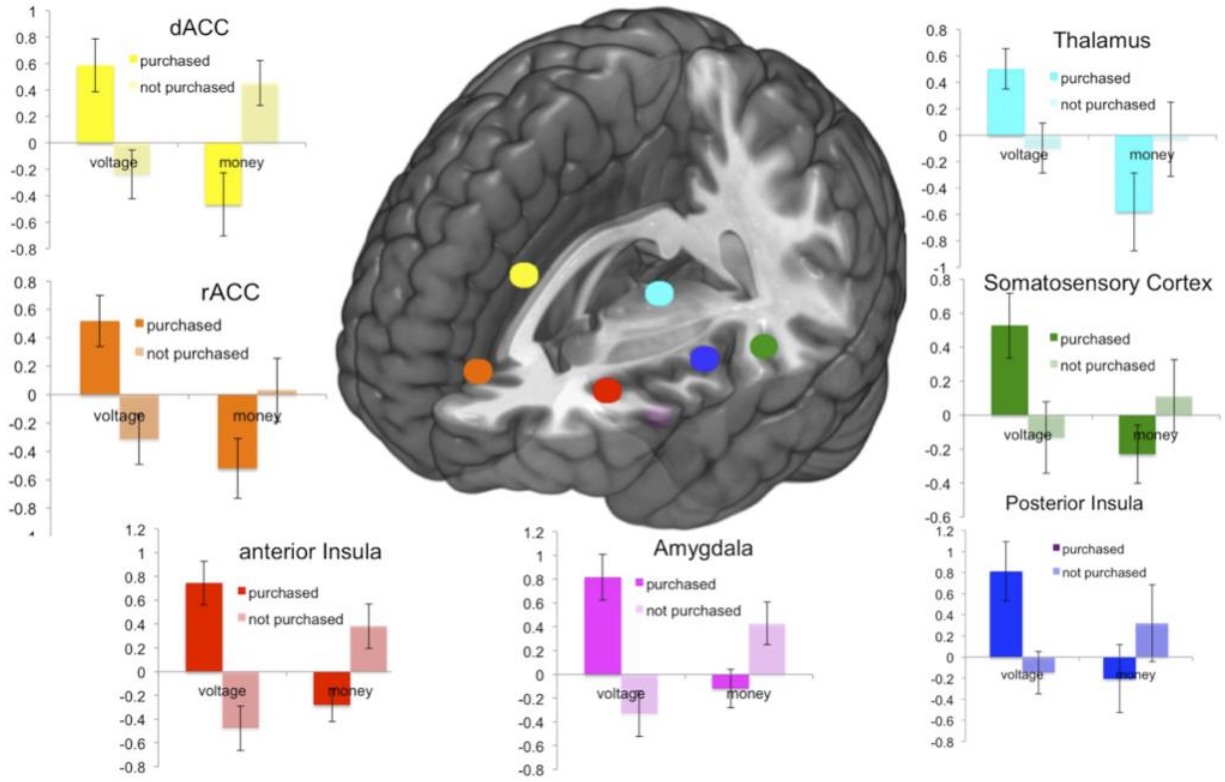
EXPERIMENT 1: BEHAVIORAL RESULTS



Note: (A) Purchasing frequencies in money and voltage trials. (B) Reaction times for purchasing decisions in money and voltage trials. (C) Average accepted purchasing prices in money and voltage trials. (A)–(C) $p > .05$ based on paired *t*-tests. (D) Parameter estimates from the logistic regression for participants' subjective values (WTP from valuation task 4 on day 2) of the food items and the food items' prices in money and voltage trials (in fMRI purchasing task 5 on day 2). Error bars represent SEM.

FIGURE 3

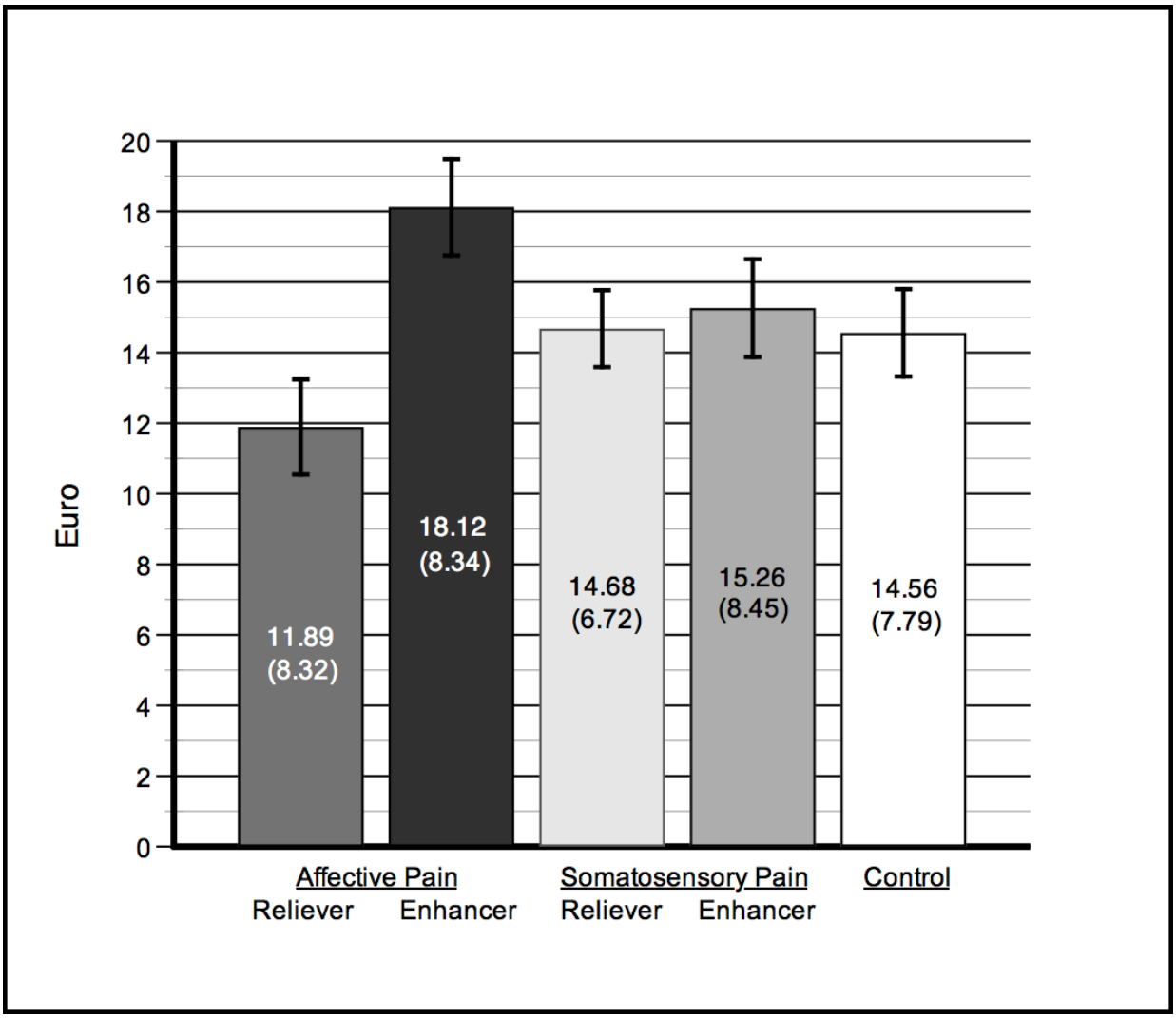
EXPERIMENT 1: NEURAL ACTIVATION PATTERNS OF PURCHASING DECISIONS IN PAIN-PROCESSING REGIONS WHEN PAYING IN CASH VS. TOLERATING ELECTRIC SHOCKS



Note: Anticlockwise from top left: regions linked to affective pain processing: dorsal anterior cingulate cortex (dACC), rostral anterior cingulate cortex (rACC), anterior insula; region linked to arousal during pain processing: amygdala; regions linked to somatosensory pain processing: posterior insula, somatosensory cortex, thalamus.

FIGURE 4

EXPERIMENT 3: MEAN MAXIMUM WILLINGNESS TO PAY



Note: Standard deviations are in parentheses. The error bars display standard errors of the means.