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Consumer Choice Bias Due to Number Symmetry: Evidence from Real Estate Prices

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ABSTRACT

Rational Consumers strive to make optimal purchasing decisions based on quality and price. However, a growing body of evidence indicates that innate psychological biases may thwart consumers in their attempts to make such decisions. One such bias is the human preference for objects that possess vertical mirror symmetry; such symmetry is exhibited by many man-made and natural objects, including the human body and, most particularly, the human face. Here we study whether this symmetry bias extends also to number sequences that possess vertical mirror symmetry. Specifically, we use a laboratory setting to study whether home buyers are biased toward real estate prices that possess relatively higher degrees of vertical mirror symmetry. We find a statistically significant result, indicating that such a bias does indeed exist. Thus, although such a bias is well established in the evolutionary psychology literature, we show that it extends into the arena of consumer preferences based purely on visual representation of product price. Although the present study looks just at real-estate price preferences, the statistically significant results clearly have implications for all consumer choice decisions based, at least in part, on the physical representation of product price.

ARTICLE

Introduction

Understanding consumers' mental processing of price and product information is an important avenue of consumer and psychology research (Fitzsimons, Tanya, and Fitzsimmons 2008; Brunel, Tietje and Greenwald 2004). Indeed, the fact that consumers may deviate from strictly rational purchase decisions is now well established (Greenwald and Banaji 1995; Kahneman and Tversky 1979; Thaler 1992). The burgeoning fields of consumer psychology and behavioral marketing have identified a broad array of behavioral biases, which are often categorized into biases associated with motivation, cognition, and emotion (Shapiro 1999). However they all share a common neurological origin: brain evolution has conditioned certain unconscious responses that override our conscious attempts to make rational decisions.

In the present study we focus on the unconscious human bias toward objects that possess vertical mirror symmetry. The obvious example of such an object is the human face and, as we discuss below, there is a broad body of evidence showing a clear preference for facial symmetry

in mate selection; and a highly evolved ability among humans to discern even very slight asymmetries in facial features.

We test whether this preference for symmetry extends beyond facial features into the realm of number sequences. Just about all purchase decisions are made, at least in part, on the basis of observing numbers: the product price. Often these decisions are made in situations where a large array of price information has to be processed rapidly. Therefore it is our contention that unconscious biases – such as a bias for number symmetry in the product price – may impact such decisions.

To test our hypothesis we conduct a series of simple laboratory experiments on business school students, in which students select real-estate properties based partly on price. We find that, even if the identical property is slightly more expensive, students prefer the property that displays a price in which the number sequence possesses vertical mirror symmetry (i.e., \$810,018 versus \$801,118). We thus provide evidence that, at least under certain conditions, the human unconscious preference for mirror symmetry extends into the realm of number sequences in product prices.

Hopefully, our identification of this bias in real-estate selection will educate consumers. By becoming aware of this innate bias, consumers will be better prepared to make strictly rational purchase decisions based on price information. We conclude the paper with a discussion of the implications of our results for public policy and consumer education.

Symmetry Bias

Our understanding of the underlying mechanisms behind various unconscious biases has increased markedly in recent years. For example, Salvador and Folger (2009) note that the number of published studies in neuroscience has increased from around 100 in 1991, to over 1,000 by 2006. One of these more recent areas of neuroscientific study focuses on ‘aesthetic biases’. In essence, humans are unconsciously attracted to stimuli that they perceive as possessing high aesthetic value (i.e., that they perceive as beautiful), and are unconsciously repelled by stimuli that they perceive as possessing low aesthetic value (i.e., that they perceive as ugly). As Hofel and Jacobsen put it: “Aesthetic processing is a uniquely human faculty that makes for a very interesting, albeit complex research topic” (2007, p. 9). One obvious reason for this complexity is the problem of objectifying aesthetic judgment. Aesthetic criteria are notoriously subjective: ‘beauty is in the eye of the beholder’. However, one aesthetic characteristic that does appear to be relatively objective, and therefore quantifiable, is symmetry.

Several recent studies have found that humans possess a strong preference for symmetrical objects, particularly objects characterized by vertical mirror symmetry; the obvious example of which is the human face. Hofel and Jacobsen note that “*aesthetic distraction* can be observed when a person involuntarily switches attention toward the aesthetic processing of an entity” (2007, p. 9). They go on to show that symmetry and complexity are the most important cues for aesthetic judgment. Just how fast humans can process facial stimuli was determined by Olson and Marshuetz (2005) in their laboratory study. Human subjects were shown a human face for a mere 13 milliseconds – too rapid for the subjects to be consciously aware that they had seen a face. They found that positive words [a word was displayed for 260 milliseconds after the face] were associated with upright, attractive faces. This potentially demonstrates the generation of an implicit attitude to the attractive face. As Wagemans notes in his review article on *Detection of Visual Symmetries*: “perception of mirror symmetry...is effortless, rapid, and spontaneous” (1995, p. 10). He also echoes the findings of Olson et al. with the observation that there is a

general implication that symmetry can be detected preattentively. Thus there is considerable evidence that the recognition of symmetry occurs effortlessly and automatically in a wide variety of conditions.

Evolutionary Psychology

Wagemans concludes his review by observing that the human visual system attributes special status to mirror symmetry, which brooks the question of why the human brain is so predisposed to this rapid, accurate, effortless, and unconscious identification of vertical mirror symmetry. The answer is generally thought to reside in evolutionary biology. In the natural world, most biological objects (prey, predator, mate) are symmetrical. In such an environment it is advantageous to have an alert system that quickly identifies symmetry; thus allowing for timely appropriate action (Ramachandran and Rogers-Ramachandran 2008). In his book, *Symmetry* (2008), Du Sautoy makes a similar observation. He notes that the ability to spot symmetry in the chaotic tangle of the jungle is a factor of survival: Symmetry behind the bushes is either something to eat or something to be eaten.

In addition to the detection of predator/prey, humans may have evolved their symmetry-detection neurology to aid mate selection. The prominent theory of sexual selection is known as the parasite theory. This theory holds that features advertising resistance to parasites are preferred in sexual selection. Therefore the beauty of bodily form seen by animals choosing mates is based on perception of high parasite resistance (Grammar and Thornhill 1994). This propensity for high parasite resistance is termed immunocompetence. A given individual's level of immunocompetence may be determined by the level of genetic diversity possessed by that individual, termed heterozygosity. This is where symmetry comes in: Symmetry of bilaterally represented traits is positively correlated with heterozygosity in many animals, including humans. Thus, facial symmetry...may display underlying heterozygosity and parasite resistance.

Non-facial Symmetry

Evidence for aesthetic distraction, particularly as it relates to symmetry, is not isolated to facial features. In the introduction to their study of optimal website design, Bauerly and Liu note earlier findings that “users of an automated teller machine perceived the system to be easier to use based solely on its aesthetic appearance...attractive things work better” (2008, p. 275). Bauerly and Liu conclude their study by noting that symmetry is one of many principles that contribute to good screen design: including balance, regularity, predictability, economy, unity, proportion, and simplicity. Symmetry is an especially important element as it brings a sense of balance unifying the other display elements and creating a cohesive appearance. This supports psychophysical theories that maintain the idea that the presence of symmetry serves as a compositional element that can be preattentively processed and guides the viewer's gaze. This is labeled by Reber as “perceptual fluency” (2002, p. 415), which he defines as the subjective ease with which an incoming stimulus can be processed. This suggests that preference for symmetry is a by-product of general properties of visual systems. Szlyk, Rock, and Fisher (1995) tested the degree to which perceptual fluency is enhanced by the symmetry of various visual patterns, even when the patterns are viewed from oblique angles. They find that symmetry of the object, even when viewed obliquely, considerably enhances perceptual fluency. In particular, subjects were consistently more perceptually fluent with symmetrical rather than with asymmetrical patterns. Thus the human preference for, and ability to detect, the aesthetic quality of symmetry – particularly vertical mirror symmetry – extends beyond purely facial symmetry, although in evolutionary terms the latter may well have been the origin.

Number Symmetry

Contemporary humans, acting within modern industrial societies, clearly no longer need this symmetry detection neurology: predator/prey detection and heterozygosity detection are no longer pressing survival skills. However, as evidenced by the above studies, regardless of its redundancy, this neurological 'hard-wiring' still drives human preferences. The purpose of our study here, therefore, is to test for a symmetry bias when observing something that contemporary humans *do* devote a considerable amount of attention to – particularly in a product selection setting -- namely, price number sequences.

Consumers are continually bombarded with a mass of numerical stimuli in the form of product prices. Consciously, they look through the number to some meaning behind it: Is the price high or low? But unconsciously the above evidence from psychology indicates that consumers may also see the number simply as a physical shape, as an artifact, in the same way as they unconsciously view an inanimate shape or a human face. Might consumers, therefore, have an innate bias toward number sequences that possess vertical mirror symmetry?

Experimental Method

Subjects

Approximately three hundred undergraduate business students were surveyed, predominantly aged in their early twenties. There was a rough balance of male and female subjects from a broad array of ethnic backgrounds.

Stimuli

Each subject was handed a sheet of paper containing eight property listings, four on each side. Each listing comprised a photograph of the property, some basic data such as square footage, number of bedrooms (etc.), and a price. Approximately half the subjects were given the control sheet (Appendix A) and half were given the test sheet (Appendix B).

The one symmetrical price on the test sheet was the test element; it comprised the only difference between control and test sheets (Exhibit 1). All house prices were equally prominently displayed and each contained six digits, three each side of a symmetrical comma. A font was selected that ensured that each digit possessed the maximum integral symmetry (e.g., the number '1' comprised just a vertical line, the number '0' was a perfect oval, etc.).

Procedure

The subjects were handed the sheet and told to select, by putting a check-mark beside it, one property on each side of the sheet. The only background information they were given was that the house was to be used for investment purposes; this information was supplied merely to minimize the possible impact of other biases that the subjects might have relating to their personal living preferences.

The subjects were instructed not to confer with their neighbors in the classroom and to make the decision quickly, within about thirty seconds. The time constraint was placed in order to increase the likelihood that unconscious preferences would impact the decision. The sheets were then

collected. The subjects were not asked to supply any personal information on the sheet as specific personal biases, gender or otherwise, were not the focus of this study.

Exhibit 1: Test versus Control

REAL ESTATE TEST

MIRROR SYMMETRY

- House chosen for “Test” and “Control” Groups
- Test Price = \$810,018 Control Price = \$805,099
- All other information is the same



\$ 810.018	
vs.	
\$ 805.099	
Property Type:	Single Family
Bedrooms:	6
Baths:	10 Baths
Lot Size:	1.0 UP TO & INC 2.5 ACRES
Year Built:	2007
Area:	Houston, TX
County:	Harris

Statistical Analysis

We tested if students respond differently to symmetrical versus non-symmetrical prices. The front side of the sheet consisted of four properties void of symmetrical prices with identical prices for both the control and test group (see Appendices). These properties were there to give greater choice and therefore greater rigor for the symmetry test; however this side of the survey sheet is clearly irrelevant for our statistical analysis. Instead, our focus is on the second page, again consisting of four properties (identified as properties 5, 6, 7, and 8 in Exhibit 2) in which the control and test groups differ only in the price of property number 7 (\$805,099 versus \$810,018 respectively).

We test the hypothesis that the proportion of respondents who selected property 7 differs between the control and test. That is, we test the hypotheses

$$H_0: p_7^{\text{Control}} \leq p_7^{\text{Test}}$$

$$H_A: p_7^{\text{Control}} > p_7^{\text{Test}}$$

where p_7 represents the proportion of respondents who selected property 7. We employ a one tail test because a-priori we believe respondents would have a preference for the lower price of property 7 in the control group (\$805,099 versus \$810,018 respectively).

The Z-statistic tests the above hypothesis and is constructed as

$$Z = \frac{p_{Test} - p_{Control}}{\sqrt{\bar{p} \cdot (1 - \bar{p}) \cdot \left(\frac{1}{n_{Test}} + \frac{1}{n_{Control}}\right)}}$$

where p represents the proportion of respondents who selected property 7 within the test and control groups, n represents the total number of respondents in the test and control groups, and \bar{p} is defined as follows

$$\bar{p} = \frac{x_{Test} + x_{Control}}{n_{Test} + n_{Control}}$$

where x represents the number of respondents who selected property 7 in the test and control groups.

For our experiment, the statistic is computed as

$$\bar{p} = \frac{143 + 67}{303 + 173} = 0.4412$$

$$Z = \frac{0.4719 - 0.3873}{\sqrt{0.4412 \cdot (1 - 0.4412) \cdot \left(\frac{1}{303} + \frac{1}{173}\right)}} = 1.79$$

The p-value associated with the Z-statistic is 0.0368, and hence we reject the null hypothesis in favor of the alternative at the 95% level of significance.

With this result we conclude that our respondents have a significant preference toward purchasing properties with symmetrical prices, even if those prices are higher than non-symmetrical prices.

Exhibit 2: Relevant Sample

(N)	House #:	5	6	7	8	Total N
Group:						
Test		29	99	143	32	303
Control		16	67	67	23	173
Proportion	House #:	5	6	7	8	
Group:						
Test		0.0957	0.3267	0.4719	0.1056	
Control		0.0925	0.3873	0.3873	0.1329	
delta		0.0032	-0.0606	0.0847	-0.0273	

Conclusion

Our study indicates that the human aesthetic bias toward objects possessing vertical symmetry extends beyond just facial representations and inanimate shapes. It extends also to number sequences that possess greater visual symmetry. Although the study here looked just at real estate prices, the statistically significant result clearly has implications for many purchase decisions.

It is especially important for consumers to become aware of biases and subconscious preferences when the modern focus and goal of marketing professionals is considered. This goal is to understand and directly influence the consumer decision process particularly at the subconscious level. Consumers will be better prepared to make rational decisions despite marketing efforts if potential biases are understood. This preparedness is especially necessary in cases of habitual buying decisions where little or no conscious thought is employed. Consumers must be aware of the potential implications of symmetry bias when considering a product that may become a habitual purchase item. If the item is chosen first based on symmetry bias, then chosen in the future based on habit, many opportunities for rational consideration of the product may be lost.

Finding that symmetry bias is present in decisions made regarding durable, long-term investments such as houses, where considerable thought is often employed, shows the even greater implications present for habitual purchases. Habitual and impulse purchases are made quickly with little to no conscious thought. If symmetry bias can influence consideration of a durable goods purchase it follows that the purchase of disposable products on a whim will be affected more.

There is clearly considerable scope for future research here. In particular, the question remains of the strength and robustness of this preference for number symmetry. If the bias is found to be relatively strong and robust then it has clear implications, not just for pricing real estate, but for pricing a broad array of products where a slight preference for one price over another could impact demand.

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APPENDIX A



\$ 804.997

Property Type: Single Family

Bedrooms: 5
Baths: 6 Baths
Lot Size: .25 UP TO & INC .50 ACRES
Year Built: 1990
Area: Houston, TX
County: Harris



\$ 923.020

Property Type: Single Family

Bedrooms: 7
Baths: 7 Baths
Lot Size: 5.0 UP TO & INC 10 ACRES
Year Built: 1990
Area: Houston, TX
County: Harris



\$ 805.099

Property Type: Single Family

Bedrooms: 6
Baths: 10 Baths
Lot Size: 1.0 UP TO & INC 2.5 ACRES
Year Built: 2007
Area: Houston, TX
County: Harris



\$ 1.102.075

Property Type: Single Family

Bedrooms: 8
Baths: 9 Baths
Lot Size: 2.5 UP TO & INC 5.0 ACRES
Year Built: 1995
Area: Houston, TX
County: Harris



\$ 799.999

Property Type: Single Family

Bedrooms: 4
Baths: 6 Baths
Lot Size: .25 UP TO & INC .50 ACRES
Year Built: 1992
Area: Houston, TX
County: Harris



\$ 973.000

Property Type: Single Family

Bedrooms: 7
Baths: 7 Baths
Lot Size: 5.0 UP TO & INC 10 ACRES
Year Built: 1999
Area: Houston, TX
County: Harris



\$ 875.000

Property Type: Single Family

Bedrooms: 5
Baths: 5 Baths
Lot Size: 1.0 UP TO & INC 2.5 ACRES
Year Built: 2000
Area: Houston, TX
County: Harris



\$ 1.000.075

Property Type: Single Family

Bedrooms: 8
Baths: 9 Baths
Lot Size: 2.5 UP TO & INC 5.0 ACRES
Year Built: 2001
Area: Houston, TX
County: Harris

APPENDIX B



\$ 804.997

Property Type: Single Family

Bedrooms: 5
 Baths: 6 Baths
 Lot Size: .25 UP TO & INC .50 ACRES
 Year Built: 1990
 Area: Houston, TX
 County: Harris



\$ 923.020

Property Type: Single Family

Bedrooms: 7
 Baths: 7 Baths
 Lot Size: 5.0 UP TO & INC 10 ACRES
 Year Built: 1990
 Area: Houston, TX
 County: Harris



\$ 810.018

Property Type: Single Family

Bedrooms: 6
 Baths: 10 Baths
 Lot Size: 1.0 UP TO & INC 2.5 ACRES
 Year Built: 2007
 Area: Houston, TX
 County: Harris



\$ 1.102.075

Property Type: Single Family

Bedrooms: 8
 Baths: 9 Baths
 Lot Size: 2.5 UP TO & INC 5.0 ACRES
 Year Built: 1995
 Area: Houston, TX
 County: Harris



\$ 799.999

Property Type: Single Family

Bedrooms: 4
Baths: 6 Baths
Lot Size: .25 UP TO & INC .50 ACRES
Year Built: 1992
Area: Houston, TX
County: Harris



\$ 973.000

Property Type: Single Family

Bedrooms: 7
Baths: 7 Baths
Lot Size: 5.0 UP TO & INC 10 ACRES
Year Built: 1999
Area: Houston, TX
County: Harris



\$ 875.000

Property Type: Single Family

Bedrooms: 5
Baths: 5 Baths
Lot Size: 1.0 UP TO & INC 2.5 ACRES
Year Built: 2000
Area: Houston, TX
County: Harris



\$ 1.000.075

Property Type: Single Family

Bedrooms: 8
Baths: 9 Baths
Lot Size: 2.5 UP TO & INC 5.0 ACRES
Year Built: 2001
Area: Houston, TX
County: Harris