Exploring the Limits of Arbitrary Coherence

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In Behavioral Economics, "arbitrary coherence" is caused when an arbitrarily chosen number, known to be random, influences the amount potential purchasers are willing to pay for a product. From that initial arbitrary point, all evaluations of prices are coherent with the randomly chosen starting point. Marketers can use the anchor point to help set optimal prices and determine optimal price changes. An initial study was conducted to replicate research found in the literature and assess the arbitrary coherence effect on consumer pricing perceptions. The first study confirmed the effect, but led to a concern about the survey questions. A second study attempted to resolve the concern, but indicated a lack of arbitrary coherence. A third study was conducted to further investigate the issues arising from the first two studies. This paper presents the issues identified in the first two studies and reports on the results of a third study designed to resolve the questions that arose in the earlier research.

INTRODUCTION

A landmark article in *Science* (Tversky and Kahneman, 1974) reported a research track concerning decision-making that essentially created the field of Behavioral Economics. In that article, the authors noted that humans normally use heuristics ("rules of thumb") to interpret information and make decisions. Humans are especially prone to errors concerning representivity (judging instances more or less representative than they are; ignoring sample size, etc.), availability (e.g., bias of imaginability), and adjustment and anchoring (e.g., bias due to conjunctive and disjunctive events).

More recently the book Thinking, Fast and Slow (Kahneman, 2011) elaborated on forty years of research by describing two mental "systems." Kahneman appropriately cautions that thinking is not as simple as the two-system concept suggests, but the theory helps understand and describe the findings. System 1 is the heuristic-using operator that relies on bits of available data and draws conclusions; it is very good at perceiving patterns, even where there are none. System 2 is the thinking component – focus, concentration, work. System 1 only examines and operates on what is present. Kahneman summarizes its method with WYSIATI – an admittedly awkward acronym for "What You See Is All There Is". System 1 does not consider unseen possibilities. It makes quick, easy decisions, often accurate in everyday life.

System 2 is the analytical function. It can explore possibilities and elements that are not present, but this requires thinking, which is hard work. It is lazy. So, if System 1 makes a judgment and nothing

present (WYSIATI) conflicts with it, System 2 will likely "rubber stamp" it, taking the easy way out. Given this conclusion, decisions are subject to systematic biases.

The specific instance of bias of interest here is "arbitrary coherence." In a summary of six experiments, Ariely, Loewenstein, and Prelec (2003) describe an anchoring phenomenon wherein a random, arbitrary number that respondents know is irrelevant to the decision influenced their judgments of amounts willing to pay and reactions to hearing painful sounds. The authors' own words are the best succinct description of the phenomenon.

In six experiments, we show that the initial valuations of familiar products and some simple hedonic experiences are strongly influenced by arbitrary "anchors" (sometimes derived from a person's social security number). Because subsequent valuations are also coherent with respect to salient differences in perceived quality or quantity of these products and experiences, the entire pattern of valuations can easily create an illusion of order, as if it is being generated by stable underlying preferences. The experiments show that this combination of coherent arbitrariness (1) cannot be interpreted as a rational response to information, (2) does not decrease as a result of experience with a good, (3) is not necessarily reduced by market forces, and (4) is not unique to cash prices. The results imply that demand curves estimated from market data need not reveal true consumer preferences, in any normatively significant sense of the term.

The authors say this in a less precise but perhaps clearer way in their introduction.

In this paper, we show that consumers' absolute valuation of experience goods is surprisingly arbitrary, even under "full information" conditions. However, we also show that consumers' relative valuations of different amounts of the good appear orderly, as if supported by demand curves derived from fundamental preferences. Valuations therefore display a combination of arbitrariness and coherence that we refer to as "coherent arbitrariness.

Arbitrary coherence is also referred to in Predictably Irrational (Ariely, 2008), and is put in the broader context of anchoring in Priceless (Poundstone, 2010). The latter also points to numerous examples of anchoring and arbitrary coherence in setting market prices and determining price changes. One example is lowering the volume of peanut butter by indenting the bottom of the jar, since consumers will, by and large, fixate on the familiar price, not the volume. Once an anchor price is established, all other pricing in that particular arena can be coherent with that price in some way. Luxury goods can especially benefit from a high anchor price point.

In a literature search aimed specifically at finding work on "arbitrary coherence" only two articles specific to the topic appear. In a pilot project with 41 fourth year medical students, Pouthier (2009) found that having them write the last two digits of their mobile telephone numbers influenced their subsequent responses to a series of questions concerning surgical training. The questions required estimating numbers, and the mean results by students correlated ($r = 0.36$, $p \leq .05$) with the irrelevant telephone number digits. The author warns that steps should be taken to minimize this unexpected potential bias.

A second article with students at Cambridge (Scott and Lizieri, 2011) tested two hypotheses. Paraphrasing, they were (1) an arbitrary anchor will reliably influence judgment of a property's value, even when incentives are provided for accuracy; (2) subsequent judgments of property values will be influenced by the value immediately prior, so a single subject's valuation set will be coherent. After significant data manipulation ("eliminating noise") primarily by eliminating outliers, they more or less confirmed both hypotheses. Their research clearly has implications for pricing in real estate marketing.

INITIAL ATTEMPT TO REPLICATE PRIOR RESEARCH

In a study conducted by one of the authors in 2009, the effect was found to exist for higher-priced items where the actual price was uncertain, but not for the one item most subjects knew was inexpensive. The four items were selected at random from advertisements in a Sunday paper: Teleflora Spring Pitcher Floral Display, Dr. Scholl's Hand-Stitched Leather Loafers, Irish Spring 12-bar Value Pack and a bottle of Bailey's Irish Crème (Appendix 1).

In that study, the survey (Appendix 2) contained the three questions shown below.

1. In column A, next to each of the four items on the list below, please enter the last two digits of your Social Security number (SS#) as if it were a price in dollars. For example, if your SS# is 678-54-9876, you would put $76. If it is 123-45-0001, you would enter $01.
2. In column B, indicate if you would be willing to pay that amount for the item by writing in a Y for "yes" or an N for "no".
3. In column C, pretend there is an auction for the item. In whole dollars, write in the maximum amount you would be willing to pay for it.

The study was conducted with marketing research professionals, colleagues of the author at a large marketing research firm. If a group of 69 professionals were not "fooled" by the random number anchoring, was there something in the questions that produced the results. A second study was conducted about six months later with the same, but slightly larger group of 84 colleagues. For half the group the middle question "indicate if you would be willing to pay that amount for the item" was eliminated, but the other half completed all three of the original questions.

THE SECOND STUDY

For the second study conducted in June 2010, four different items, all of reasonable and unknown value, were used: Crocodile Wallet, Copper Cooking bowl, Necklace of Pearls from Tahiti, The Complete Works of Lewis Carroll (Appendix 3). These were again selected from newspaper ads, this time to have prices that would likely be unfamiliar to subjects, since uncertainty is a precondition. The lack of effect with the bar soap supported this hypothesis. Subjects were randomly assigned, so that half were asked the original three questions, and half were not asked the middle question (would they buy it for the specified amount – Appendix 4).

In the second study, there was no arbitrary coherence effect in either subgroup. This lack of effect meant that it was impossible to shed light on the effect of the decision-requiring second question. It also raised new questions about the limitations of arbitrary coherence.

Did the lack of effect in the test cell that received exactly the same questions occur because the same subjects were used? But prior research, reported in Priceless (Poundstone, 2010), found that experience did not impact arbitrary coherence. In this case, though, one wonders if these informed researchers were "inoculated?" Alternatively, did the lack occur because of the items used? Were the items of little interest, limiting the effect? Or, was it just the random assignment of subjects presenting an effect of its own?

A THIRD STUDY

This paper reports finding of a third study which attempted to resolve the questions above, specifically:

1. Is the arbitrary coherence effect present when each set of items is tested with naïve subjects?
2. Is making a purchase decision ("the middle question") causing a different effect?
3. Is there is an interaction, such that the making or not making of a purchase decision yields different results for each set of items?

   The third study was conducted among 84 university students. The age range for respondents was 18 to 47 years old and all had Social Security numbers. The mean age is 22 and the median is 21 with 71% between 18 and 22 years old. Thirty-two (38%) are female. There are 53 undergraduates (63%) and 31 (37%) graduate students.
   Since there are two types of questionnaires, one with two questions and the other with three questions, and two sets of items, there were four test cells or groups (Table 1). Four color coded surveys were created and distributed to four independent groups with between 19 and 22 different students per group. Group 3 (16) and Group 4 (14) contained almost all of the graduate students.
   Item Set #1 consists of three of the four original items from the first study. In deference to the fact that some subjects were underage for alcohol consumption, the original Bailey's Irish Crème was changed to "Sandy Flats Pure Maple Syrup – 250ml." Item Set #2 is the same four items used in the second study. To conduct the survey a one-page paper questionnaire, color-coded by cell, was handed out for subjects to complete. A picture of each item (see Appendix 3 and 4) was projected on a screen all at one time. Half the students in the room received the two-question survey and the other half received the three-question survey.

TABLE 1
ARBITRARY COHERENCE GROUPINGS FOR STUDY 3

	Item Set #1: • One Teleflora Spring Pitcher Floral Display • Dr. Scholl's Hand-Stitched Leather Loafers • Irish Spring 12-bar Value Pack • Sandy Flats Pure Maple Syrup – 250ml	Item Set #2: • Crocodile Wallet • Copper Cooking Bowl • Necklace of Pearls from Tahiti • The Complete Works of Lewis Carroll	Totals
No Purchase Decision (2Qs)	Group 2: 21 students	Group 4: 22 students	43
Purchase Decision (3Qs)	Group 1: 22 students	Group 3: 19 students	41
Totals	43	41	84

DISCUSSION OF RESULTS

   For each item, the "auction price" or the amount subjects were Willing To Pay (WTP) were examined in two different ways: by quartile grouping and by looking at the correlation between the SS$ and the WTP. If arbitrary coherence holds, the WTP should increase with increasing SS$.

Item Set 1 for Group 1 and 2009 Study

Group 1 shows a clear arbitrary coherence effect. The pattern parallels the original 2009 study. The Irish Spring 12-pack of bar soap shows stronger tendency to arbitrary coherence than it did in the first study, but the correlation is still not statistically significant ($p > .05$). Teleflora, which had the strongest correlation with the older researchers is somewhat weaker with these younger students.

TABLE 2
GROUP 1 - ITEM SET 1 WITH PURCHASE DECISION QUESTION

	Last 2 Digits Social Security Number as $ (SS$)				
	Under $25	$26 - $59	$60 - $80	$80+	Correlation
Bases	*6*	*6*	*5*	*5*	
Teleflora	$15.83	$25.50	$22.00	$25.00	+0.28
Dr. Scholl's loafers	$39.83	$43.83	$67.00	$56.80	+0.36
Maple Syrup-250ml	$5.17	$5.50	$10.00	$23.60	+0.39
Irish Spring 12 pack	$8.00	$10.00	$11.80	$10.80	+0.24

One question this research addressed was whether results would be replicated with new subjects. They were. The respondents in the 2009 study were experienced marketing researchers, which may explain why the results with the more naïve students are overall stronger. The researchers not only were older, but also had more experience with questionnaire studies like this, which may have made them slightly less susceptible.

TABLE 3
2009 STUDY - ITEM SET 1 (THREE OF FOUR SAME ITEMS)
WITH PURCHASE DECISION QUESTION

	Last 2 Digits Social Security Number as $ (SS$)				
Products	Under $25	$26 - $50	$51 - $75	$76+	Correlation
Bases	*16*	*14*	*20*	*19*	
Teleflora	$22.13	$43.29	$38.70	$40.79	+0.33
Dr. Scholl's	$34.13	$34.07	$49.45	$51.53	+0.28
Bailey's Irish Creme	$15.50	$16.93	$16.75	$20.42	+0.16
Irish Spring 12 Pack	$5.63	$9.50	$6.10	$6.21	-0.05

Item Set 1 for Group 2

Note, there are no comparable results from the 2009 study since it contained only the three questions. The June 2010 study had both the two and three question survey, but only for Item Set 2. Table 4 thus compares the results of two questions versus three questions for Item Set 1 (Table 2).

While there was a clear effect with all four products when questioning with the three questions on Item Set 1, the arbitrary coherence effect largely vanishes when the Purchase Decision Question is removed. Three of the four items show an inconsistent "down-up-down-up" pattern across the quartiles, e.g., Dr. Scholl's $31.67↓, $45.00↑, $39.40↓, $40.80↑.

These three items have almost nonexistent correlations, near zero. Note, however, that the results are not consistent, since the effect is seen with the Teleflora display, which shows a statistically significant correlation ($p \leq .05$).

TABLE 4
GROUP 2 - ITEM SET 1 WITH NO PURCHASE DECISION QUESTION

	Last 2 Digits Social Security Number as $ (SS$)				
	Under $18	$19 to $41	$42 to $79	$80 to $99	Correlation
Bases	*6*	*5*	*5*	*5*	
Teleflora	$6.67	$23.00	$8.60	$26.40	+0.41
Dr. Scholl's loafers	$31.67	$45.00	$39.40	$40.80	+0.07
Maple Syrup-250ml	$6.67	$9.20	$3.80	$7.00	+0.02
Irish Spring 12-pack	$5.83	$9.00	$5.60	$6.20	-0.04

Item Set 2: Groups 3 and June 2010 Study

In reviewing the student survey results for the second set of products and three questions, it replicated the June 2010 experience; there was no arbitrary coherence effect. All the correlations are weak and three of four are negative. There is little consistency in WTP across the quartiles, though the pattern is "up-down-down-up" for both the wallet and the bowl.

TABLE 5
GROUP 3 - ITEM SET 2 WITH PURCHASE DECISION QUESTION

	Last 2 Digits Social Security Number as $ (SS$)				
Products	Under $23	$23 to $40	$41 to 70	$71 to $99	Correlation
Base-total/subgroup	*5*	*6*	*6*	*5*	
Crocodile Wallet	$48.00	$20.83	$19.50	$50.00	+0.13
Copper Bowl	$60.60	$25.83	$24.17	$34.00	-0.14
Necklace from Tahiti	$80.00	$249.17	$53.67	$86.00	-0.12
Complete L. Carroll	$18.20	$126.67	$27.50	$46.00	-0.04

Results from the June 2010 study with the marketing researchers are similar, and similarly chaotic. All the correlations are low (two are negative) and reversals in dollar amount occur across the quartiles with each of the products.

TABLE 6
JUNE 2010 - ITEMS SET 2 WITH PURCHASE DECISION QUESTION

	Last 2 Digits Social Security Number as $ (SS$)				
Products	Under $40	$40 to $59	$60 to $79	$80 to $99	Correlation
Base-total/subgroup	*9*	*10*	*10*	*13*	
Crocodile Wallet	$38.22	$42.50	$18.60	$22.69	-0.24
Copper Bowl	$90.56	$112.90	$158.40	$151.54	+0.10
Necklace from Tahiti	$26.33	$45.80	$25.50	$47.85	+0.12
Complete L. Carroll	$65.56	$34.20	$25.50	$75.38	-0.03

Item Set 2: Groups 4 and June 2010 Study

Given that there is no effect with these products when a SS$ purchase decision is required, it is not surprising that there is none when there is no purchase decision. With correlations hovering near zero and

many reversals across the SS$ quartiles, the pattern is consistent with that found with Group 2 - Item Set 1, No Purchase Decision (Table 4).

TABLE 7
GROUP 4 – ITEM SET 2 WITH NO PURCHASE DECISION QUESTION

	Last 2 Digits Social Security Number as $ (SS$)				
Products	$00-$25	$26-$60	$61-$70	$71-$99	Correlation
Base-total/subgroup	5	5	4	5	
Crocodile Wallet	$40.00	$26.00	$50.00	$33.00	+.05
Copper Bowl	$27.00	$20.00	$16.25	$24.00	-.05
Necklace from Tahiti	$128.00	$71.00	$128.75	$153.00	+.04
Complete L. Carroll	$22.00	$15.00	$22.50	$51.00	+.17

The conclusion, when the highest and lowest WTP is removed, is the same. No arbitrary coherence effect is found. The finding with the students in 2016 is similar to that found with researchers in 2010.

TABLE 8
JUNE 2010 – ITEM SET 2 WITH NO PURCHASE DECISION

	Last 2 Digits Social Security Number as $ (SS$)				
	Under $30	$30 - $59	$60 - $79	$80 - $99	Correlation
Bases	10	9	12	11	
Crocodile Wallet	$13.10	$20.22	$23.17	$20.64	0.08
Copper Bowl	$161.50	$189.89	$117.58	$135.45	-0.05
Necklace from Tahiti	$14.10	$36.00	$36.58	$15.91	0.04
Complete L. Carroll	$137.10	$97.44	$95.00	$64.36	-0.18

Interest as Measured by Willingness to Buy

In the Purchase Decision groups, an indicator of the willingness to buy is how many said "yes" to the second question, "In column B, indicate if you would be willing to pay that amount for the item." How do the proportions saying "yes" compare between this study and the earlier studies?

In Item Set 1, the overall interest in either Bailey's Irish Crème or Maple Syrup is low, as is interest in the Irish Spring soap. The interest among the 2016 students in Teleflora is not much higher than for the Irish Spring. About the only consistency is that the Dr. Scholl's loafers received more interest among the students than the researchers, and the correlation with SS$ is stronger with students than with researchers.

TABLE 9
ITEM SET 1 - PERCENT WHO WOULD BUY PRODUCT FOR SS$

Items	2010 researchers	2016 students
Bases	*69*	*22*
Teleflora	43.5%	18.2%
Dr. Scholl	49.3%	63.6%
Bailey's/Maple Syrup	18.8%	9.1%
Irish Spring	4.3%	13.6%

Interestingly, the percentages who would buy for the SS$ prices are very similar with Item Set 2. In neither study was there an arbitrary coherence effect.

TABLE 10
ITEM SET 2 - PERCENT WHO WOULD BUY PRODUCT FOR SS$

Items	2010 researchers	2016 students
Bases	*42*	*22*
Wallet	21.4%	22.7%
Bowl	38.1%	45.5%
Pearl Necklace	85.7%	86.4%
Carroll Book	38.1%	31.8%

Overall, there does not appear to be a strong relationship between interest and the presence of arbitrary coherence.

Research Questions Answered

1. Is the Arbitrary Coherence effect present when each set of items is tested with naïve subjects?

   No. It is present in Item Set 1 in three of the items with the researchers and, to some extent, with all four among the students. But it is not present anywhere with the products in Item Set 2, even though the actual cost of these is likely uncertain and, as nearly as can be assessed, levels of interest are similar.

2. Does making a purchase decision initially causes a different effect?

   While the similarities in the June 2010 study and groups 2 and 4 in this study (where no purchase decision was made) certainly suggest that eliminating the purchase decision eliminates arbitrary coherence, it is not certain how necessary the purchase decision is, since in one purchase decision-product set, Item Set 1, a weak effect appears and in the other (Item Set 2) it does not.

   Removing the highest and lowest "willing to pay" values in each group aids speculation that the purchase decision question is needed, since the arbitrary coherence effect appears in the three-question case when the data are so arranged. Perhaps those very uninterested in these items among the Bellarmine students are responsible for the total Group 3 results.

3. Is there an interaction, such that the making or not making of a purchase decision yields different results for each set of items?

> This seems to be the case. Making a purchase decision is in some way responsible for creating arbitrary coherence in Item Set 1, as the comparison between Group 1 (Item Set 1 with Purchase Decision) and Group 2 (Item Set 1 with No Purchase Decision) demonstrates. But the situation is more complex, since Groups 3 and 4 show the same "no arbitrary coherence" results regardless of the inclusion of the purchase decision question.

CONCLUSIONS

As originally found with the Item Set 1, there were relatively few reversals as one moves "up" the SS$ quartiles, and the correlations were impressive. For Teleflora, in the 2009 study $r = +.33$; in 2016 it is $+.28$, very similar. For Dr. Scholl's, it was $+.28$ in 2009 and $+.36$ in 2016 – slightly stronger in this study. For the Irish Spring, there was no effect in 2009, with an $r = -.05$, but there was a modest effect in 2016, $+.24$. One speculation is that, since the arbitrary coherence effect depends on a level of uncertainty, the Bellarmine students were less sure of the cost of these three items (and the syrup) to a greater extent than the earlier subjects.

Item Set 2 was selected judgmentally to be of uncertain pricing. One doubted whether people would know with certainty the cost of a crocodile wallet, a copper bowl, a pearl necklace or *The Complete Works of Lewis Carroll*.

The middle question, which forced subjects to decide whether they would buy the product for their SS$, seems important in creating an arbitrary coherence effect. The effect is not seen in either case where it was omitted, and is seen only in when it is included. It appears to be necessary, but not sufficient.

The results from Groups 1 and 3, the two Purchase Decision groups, replicate prior findings: Group 1 shows the effect; Group 3 does not. One hypothesis is that there is more "noise" with the Item Set 2 items, a conjecture the high-low removed analysis generates, since there is an effect in that truncated data set.
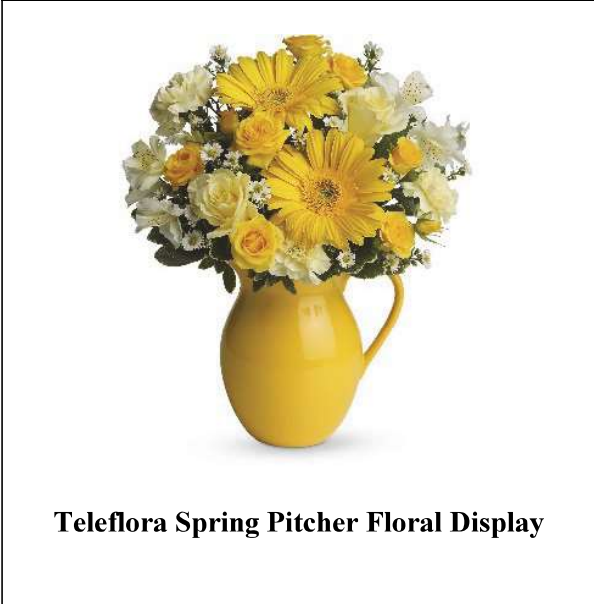
The original intent was to see if the effect showed with Group 3, which would imply that the prior failure to replicate was because knowledgeable subjects were used in that research. The June 2010 group's greater experience was obviously not the reason for the lack of effect. It also appears unlikely that lack of interest in Item Set 2 products is responsible. If it is not simply greater variability in interest, what it is about Item Set 2 that obliterates arbitrary coherence? Further research will examine if the quality of the images could be introducing biases in the responses. Surveys will be conducted with more complete descriptions of each item and no images.

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APPENDIX 1

Images for Item Set 1

Teleflora Spring Pitcher Floral Display

Dr. Scholl's Hand-Stitched Leather Loafers

Sandy Flats Pure Maple Syrup – 250ml

Irish Spring 12-Bar Value Pack
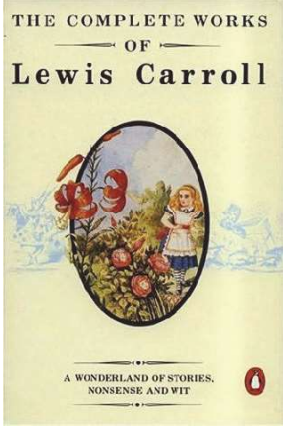
APPENDIX 2

3 Question Survey

Thank you in advance for your help with this project. There are three questions. When the project is complete, we will be happy to share the results with you.

A. In column A, next to each of the four items on the list below, please enter the last two digits of your Social Security number (SS#) as if it were a price in dollars.

B. For example, if your SS# is 678-54-9876, you would put $76. If it is 123-45-0001, you would enter $01.

C. In column B, indicate if you would be willing to pay that amount for the item by writing in a Y for "yes" or an N for "no".

D. In column C, pretend there is an auction for the item. In whole dollars, write in the maximum amount you would be willing to pay for it.

Item	A. SS# as $	B. Purchase for that price? (Y or N)	C. Max willing to pay:
Item 1			
Item 2			
Item 3			
Item 4			

APPENDIX 3

Images for Item Set 2

Crocodile Wallet	**Copper Cooking Bowl**
Necklace of Pearls from Tahiti	**The Complete Works of Lewis Carroll**

APPENDIX 4

2 Question Survey

Thank you in advance for your help with this project. There are two questions. When the project is complete, we will be happy to share the results with you.

A. In column A, next to each of the four items on the list below, please enter the last two digits of your Social Security number (SS#) as if it were a price in dollars.

B. For example, if your SS# is 678-54-9876, you would put $76. If it is 123-45-0001, you would enter $01.

C. In column C, pretend there is an auction for the item. In whole dollars, write in the maximum amount you would be willing to pay for it.

Item	A. SS# as $	B. Max willing to pay:
Item 1		
Item 2		
Item 3		
Item 4		