The relevance of coarse thinking for investors' willingness to pay: An experimental study

Siddiqi, Hammad

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The Relevance of Thinking-by-Analogy for Investors' Willingness-to-Pay: An Experimental Study

Hammad Siddiqi

Department of Economics

Lahore University of Management Sciences

hammad@lums.edu.pk

Abstract

People tend to think by analogies. We investigate whether thinking-by-analogy matters for investors' willingness to pay for a risky asset in a laboratory experiment. We find that thinking-by-analogy has a strong influence when the assets in question have similar (but not identical) payoffs. The hypothesis of thinking-by-analogy or coarse thinking clearly outperforms other hypotheses including the hypothesis of arbitrage-free or rational pricing. When the similarity between the payoffs is reduced, the risk neutral hypothesis outperforms the hypothesis of thinking-by-analogy. Regardless of the similarity between the payoffs, the arbitrage-free or rational pricing remains the hypothesis with the worst performance.

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The Relevance of Thinking-by-Analogy for Investors' Willingness-to-Pay: An Experimental Study

People think by analogies. It has been argued frequently in cognitive psychology literature that analogies provide the creative spark for innovation (see Holyoak J.K, & Thagard, P. (1995), and Sternberg and Lubart (1993) among others). Perhaps, analogies allow us to construct mental models which are useful in generating new inferences. Although making an analogy requires a mental leap, the leap does not have to be totally blind or random. In fact, research in cognitive psychology indicates that analogical reasoning is associated with mapping elements that are considered similar (see Holyoak J. K., and Thagard, P. (1995)).

Mullainathan, Schwartzstein & Shleifer (2008) formalize "thinking by analogy" in the context of a model of persuasion. Their model is based on the notion that agents use analogies for assigning values to attributes (the attribute valued in their model is "quality"). The idea is that people co-categorize situations that they consider similar and assessment of attributes in a given situation is affected by other situations in the same category. This way of drawing inferences, which is termed coarse thinking, is in contrast with rational (Bayesian) thinking in which each situation is evaluated logically (often deductively), in isolation, and according to its own merit. Research in psychology and economics indicates that coarse thinking appears to be the natural way of modeling how humans process information. See Kahneman & Tversky (1982), Lakoff (1987), Edelmen (1992), Zaltman (1997), and Carpenter, Glazer, & Nakamoto (1994) among others.

Anecdotal evidence of the role of coarse thinking is all around us. In fact, Mullainathan et al (2008) use the advertising theme of Alberto Culver Natural Silk

Shampoo as a motivating example to explain coarse thinking. The shampoo was advertised with a slogan "We put silk in the bottle." The company actually put some silk in the shampoo. However, as conceded by the company spokesman, silk does not do anything for hair (Carpenter et al (1994)). Then, why did the company put silk in the shampoo? Mullainathan et al (2008) write that the company was relying on the fact that consumers co-categorize shampoo with hair. This co-categorization leads consumers to value "silk" in shampoo because they value "silky" in hair (clearly not a rational response). That is, a positive trait from hair is transferred to shampoo by adding silk to it. Such transfer of the perceived informational content of an attribute across co-categorized situations is termed *transference*. Clearly, thinking-by-analogy or coarse thinking does not provide infallible deductions. However, it provides plausible inferences for people. Thinking-by-analogy is a double edged sword. It provides us with the creative spark for innovations; however, it may also lead to systematic judgment errors.

In this article, we raise the following question: Is coarse thinking or thinking-by-analogy relevant in determining how much people are willing to pay for an asset in a laboratory experiment? We conduct an experiment and find that it does matter. Since thinking-by-analogy requires that there must be a similarity between the situations, we vary the similarity in the experiment. We find that the performance of the coarse thinking hypothesis worsens as the similarity is weakened. This is exactly what one expects if coarse thinking matters in determining behavior in the experiment.

To fix ideas, consider a simple example. Suppose there is stock that has a price of $100 today. Tomorrow, with an equal chance, it can either go up to $200 or go down to $90. Let's call these possibilities Red and Blue states respectively. Suppose there is another asset with tomorrow's payoff equal to $140 in the Red state or $30 in the Blue state. A coarse thinker needs to decide how much to pay for the second asset today. He compares the asset with the stock and notices a pattern. He notices that if he subtracts 60 from the stock's payoff, the asset's payoff in the corresponding state is obtained (200-60=140 and 90-60=30). Having established the similarity between the stock and the asset, he proceeds to determine how much to pay for the asset in analogy with the stock: The stock has an expected return of 45% ($\frac{0.5(200-100)+0.5(90-100)}{100}$). That is, for every \$1 invested in the stock, the expected payoff is \$1.45 ($\frac{0.5(200)+0.5(90)}{100}$). He argues that as the asset is similar to the stock, for every \$1 investment in the asset, the expected payoff should also be \$1.45.

That is, the price he is willing to pay for the asset is obtained as follows:

$$\frac{Expected\ payoff}{Price} = 1.45$$

$$=> Price = \frac{0.5(140) + 0.5(30)}{1.45} = \$59\ approximately$$

If the investor is also allowed to borrow or lend up to \$100, let's say at the interest rate of 1.7% per day, a unique rational price can also be determined as follows: The asset pays \$140 in the Red state and \$30 in the Blue state. If the investor can create a portfolio that also pays \$140 in the Red state and \$30 in the Blue state, then the cost of setting up the portfolio to the investor must be equal to the price of the asset. Otherwise, an arbitrage opportunity arises, in which the investor can sell the more expensive item of the two (asset or the portfolio) while simultaneously buying the cheaper item (portfolio or asset). In our example, if the investor borrows \$59 at the interest rate of 1.7% per day for a day and buys the stock for \$100 by adding \$41 of his own money, he can exactly replicate the payoffs of the asset. If the Red state is realized, he will get \$200 for the stock and he will payback \$60 (loan of \$59 + interest at 1.7% per day), leaving him with \$140. If the Blue state is realized, he will get \$90 for the stock and will payback \$60 (loan of \$59 + interest at 1.7% per day), leaving him with \$30. So, the rational price of the asset must be equal to the cost of setting up this replicating portfolio. That is, the rational price of the asset is \$41, the amount of money it costs him to set up the replicating portfolio. It is important to realize that this is the price that a rational investor should be willing to pay irrespective of his risk preference.

If the investor is neither rational nor a coarse thinker but is risk neutral, the price he is willing to pay is equal to the present value of expected payoff (by definition).

That is, $Price = \frac{1}{(1.017)} \times \{0.5(140) + 0.5(30)\} = \$84\ approximately.$

If the investor is neither rational nor a coarse thinker, however is risk averse then the price he is willing to pay is equal to the price that a risk neutral investor is willing to pay discounted for risk. If the discount factor for risk is 0.9, then $Price = 0.9 \times 84 = \$76\ approximately.$

So, what price will an investor choose? Will he act like a coarse thinker and choose a price of $59? Will he be rational and choose $41? Or, will he choose $84 or $76 or some other price consistent with his risk preference?

We find that, in our experiment, the best predictor of behavior is the coarse thinking hypothesis. As the coarse thinking hypothesis requires that there must be a similarity between the stock and the asset, we find that the hypothesis loses ground to the risk averse as well as risk neutral pricing hypotheses when the similarity is reduced. Interestingly, the rational pricing or arbitrage free hypothesis remains the worst performing hypothesis in both the high similarity and low similarity treatments.

The situation described above involving the stock and the asset is a laboratory replication of a real world situation. The corresponding situation in the real world involves a stock and an in-the-money call option on the stock. A call option gives its buyer a right, but not the obligation, to buy the underlying stock at a specified price, called the striking price, on a future date, called the expiry date. A call is said to be in-the-money if the stock price is larger than the striking price. In our example, the asset is equivalent to a call option on the stock with the striking price of $60. As the stock price is larger than the striking price of $60 in both states, the asset (a call option on the stock) is in-the-money in both states.

The similarity between an in-the-money call and its underlying stock is often pointed out by investment advisors and professionals. In fact, often the advice is to consider an in-the-money call a replacement for the underlying stock.[1]

[1] Option traders and investment professionals often advise people to buy in-the-money calls rather than the underlying stocks. As one example, see the following: http://ezinearticles.com/?Call-Options-As-an-Alternative-to-Buying-the-Underlying-Security&id=4274772

In our experiment, the subjects were undergraduate student who did not receive any coaching from any investment professional regarding the similarity between an in-the-money call and its underlying. Moreover, value neutral labels such as asset A and asset B were used instead of stock and a call option. Still, coarse thinking turns out to be the best predictor of behavior in our experiment. Coarse thinking or thinking-by-analogy is likely to be even stronger in the real world situation where the similarity is actively pointed out.

Rockenbach (2004) presents an experiment in which individuals' willingness to pay for a call option is measured. The main finding is that a hypothesis that says *"a call option is priced in a manner that equates the expected return on the underlying with the expected return on the option"* outperforms other hypotheses. Rockenbach (2004) uses an in-the-money call in the experiment. The results are interpreted as supporting the behavioral portfolio theory of Shefrin and Statman (2000). The argument is that as a call option and its underlying stock are risky assets, they are considered jointly in a single mental account (the behavioral portfolio theory suggests that risky assets are placed in the same mental account). Consequently, a call option is priced so as to equate the expected return from the two assets.

In contrast, we argue that riskiness alone is not enough for equality of expected returns to hold. The two assets must have similar payoffs. The similarity in payoffs is a key feature behind the coarse thinking hypothesis. To disentangle coarse thinking from mental accounting, we introduce another treatment in our experiment in which the similarity is low between the two risky assets. We find that in the low similarity treatment, the performance of the hypothesis of equality of expected returns worsens. In fact, the risk averse and risk neutral pricing hypotheses outperform the hypothesis of equality of expected returns in the low similarity treatment. If people place risky assets in one mental account regardless of whether the payoffs are similar or not, then the performance of the hypothesis of equality of expected returns should not change between high similarity and low similarity treatments.

Rockenbach (2004) does not test for the risk averse pricing hypothesis. We test for the risk averse pricing hypothesis and find that it outperforms the hypothesis of equality of expected returns in the low similarity treatment. Hence, the risk averse pricing hypothesis should not be ignored even if its price prediction is irrational as it remains relevant for behavior.

2. The Model and the Hypotheses

A total of four hypotheses are tested in the experiment. If $X_1$and X_2represent the payoffs from a stock (with current price P) in Red and Blue states respectively (the states are equally likely), $C_1$and C_2 are the corresponding payoffs from a call option on the stock with the striking price K, and the interest rate on borrowing and lending r is assumed to be zero for simplicity, then the price predictions for the call option from the four hypotheses are shown in table 1. Here, we have assumed that the payoffs from the call option are positive. That is, $C_1 = X_1 - K, and, C_2 = X_2 - K$.

2.1 The Coarse Thinking Hypothesis

The call option is priced in such a manner so that the expected return from the call option is equal to the expected return from the stock. That is, the option is priced in analogy with the underlying stock:

$$\frac{0.5(C_1 - P_c) + 0.5(C_2 - P_c)}{P_c} = \frac{0.5(X_1 - P) + 0.5(X_2 - P)}{P}$$

$$=> P_c = \frac{C_1 + C_2}{X_1 + X_2} \times P$$

Where P_c is the price of the call option.

2.2 The Rational or Arbitrage Free Pricing Hypothesis

To determine the rational or arbitrage free price, a portfolio is created that exactly replicates the payoffs from the call option. In the high similarity treatment, the replicating portfolio can be created by borrowing $K$and purchasing the stock by paying the difference out of one's own pocket (the call is in-the-money in both states). The cost of setting up that portfolio is equal to the price of the call option. That is,

$P_c = P - K$

2.3 The Risk Neutral Pricing Hypothesis

A call option is priced such that its price is equal to the expected payoff from the call option:

$P_c = 0.5C_1 + 0.5C_2$

2.4 The Risk Averse Pricing Hypothesis

A call option is priced in such a manner that its price is equal to the expected payoff discounted by a risk aversion factor δ:

$P_c = \delta(0.5C_1 + 0.5C_2)$

If an investor is neither rational nor a coarse thinker but is risk averse than that's how he should behave.

3. Experimental Design and Procedures

The experiment was organized into four treatments. A total of 88 undergraduate students at ____ participated in the experiment. The students were either freshmen or sophomore and have no prior exposure to finance. The students were invited to participate, on first come first serve basis, through emails and flyers distributed on campus. To participate they were first asked to register online. On the day of the experiment, the students were equally and randomly allocated to each of the four treatments. That is, 22 students were allocated to each treatment randomly. The instructions to the experiment were orally explained to the participants in a 20 to 30 minute introductory session. A copy of instructions was also provided to each participant. Each person was seated at a separate computer terminal and participated in the experiment individually. There was no communication between the participants.

The experiment was programmed and conducted with the software z-tree.[2] There were 60 trials in each treatment. The first 10 trials were for learning purposes and were not counted in making payments. This was announced to each participant and was stated in instructions.

Payments were made in a fictitious currency called Francs. The exchange rate was fixed at Rs 0.001/Franc and was publicly announced and kept fixed throughout the experiment.

Four treatments were part of the experiment. They were High Similarity (HS), Low Similarity (LS), Baseline for High Similarity (BL-HS), and Baseline for Low Similarity (BL-LS).

In the High Similarity treatment (HS), each participant was shown payoffs in table 2. In the beginning of each round, every participant had 1000 Francs to allocate to the three assets labeled asset A, asset B, and asset C. The assets can also be sold to raise further cash. The prices of assets B and C were fixed at 100 Francs each and kept fixed in all 60 rounds. Assets A and B were risky whereas asset C was risk free. The payoffs from A were 140 and 30 in the Red and Blue states respectively. As can be seen, the payoffs from A were equal to payoffs from B minus 60. In other words, asset A was a call option written on asset B with a striking price of 60. The price of asset A was randomly drawn from a uniform distribution ranging from 30 to 140. This fact was known to everybody. Once the price had been drawn (displayed on the computer screen of each participant), each participant was asked to create a portfolio with these assets. Any leftover money is automatically allocated to asset C. There was no time limit in the experiment; however, on average a participant took between 1 to 2 hrs to finish all 60 rounds. Once the money had been allocated, a state was drawn (either Red or Blue with equal chance), and payoffs announced. Then a new round was started afresh,

[2] Urs Fischbacher (2007): z-Tree: Zurich Toolbox for Ready-made Economic Experiments, Experimental Economics 10(2), 171-178

the price of asset A was randomly drawn, portfolio created, a state was randomly drawn and payoffs announced. The procedure was repeated a total of 60 times for each participant. First 10 rounds were not counted towards payment as they were declared to be training rounds. While creating a portfolio, participants were required to follow the following two constraints: Firstly, the number of units of asset A that could be bought or sold were limited to 20. Obviously, a rational participant would want to trade an infinitely many units of asset A whenever its price was different from the arbitrage free price. So, a limit was necessary. Secondly, the payoff from the portfolio must be non-negative in both states. This constraint is needed to make sure that the each participant's earnings remain non-negative.

The procedure in the Low Similarity treatment (LS) was exactly identical to the procedure in HS. Table 3 shows the payoffs. The only difference was that the payoffs from asset A were 100 and 0 in the Red and Blue states respectively and the price of asset A was drawn from a uniform distribution ranging from 1 to 100. Clearly, the similarity between assets A and B was reduced as the payoffs from A were no longer equal to payoffs from B minus a constant (60 in HS). In other words, the call option (asset A) had a striking price of 100 and was no longer in-the-money in the Blue state.

In the Base Line to High Similarity treatment (BL-HS), only assets A and C were available for investment. There was no asset B. The payoffs from asset A were 140 and 30 in the Red and Blue states as in HS treatment. Asset C is risk free with a payoff of 100 in each state. The price of asset C is fixed at 100. In each round, the amount of money available to a participant was equal to the randomly drawn price of asset A in that round. That is, the choice before a participant was to either accept the gamble offered by asset A or reject the gamble and keep the money in asset C (the risk free rate was 0 as can be seen from the payoffs of asset C).

In the Base Line to Low Similarity treatment (BL-LS), the procedure was similar to the procedure in BL-HS, except for the payoffs of Asset A. The payoffs were 100 and 0 in the Red and Blue states respectively as in LS treatment and the price of A is drawn from a uniform distribution ranging from 1 to 100.

HS and LS were designed with an objective of measuring the difference in behavior as the similarity is reduced between assets A and B. BL-HS and BL-LS were the control treatments for the risk preferences corresponding to HS and LS respectively.

4. Results and Discussion

The experiment generates data consisting of the decisions of individual participants. From the data, one can see whether a participant had bought or sold asset A for a given price of asset A. From these decisions, one can infer a participant's willingness to pay for asset A as follows. Define a separating price as the price above each a participant sells asset A and below which he or she buys asset A. A separating price is a price at which an investor is indifferent between buying and selling. Such a price separates buying behavior from selling behavior and is equal to an investor's willingness to pay. The separating price in HS treatment is calculated as follows: For each participant, the following steps were performed:

1) For every price in the interval, $P_S €\{30,31,32, \dots \dots .., 138,139,140\}$, it was checked whether the behavior of the participant was consistent with the behavior associated with the separating price. For example, for $P_S = 50$, consistent behavior means buying asset A whenever the price was below 50 and selling asset A whenever the price was above 50. All the violations from consistent behavior were noted for each price in the interval.
2) For each violation, the squared deviation was calculated. Continuing with the example of 50, suppose a deviation was observed as the participant bought asset A when the drawn price of asset A was 55, rather than selling asset A at that price. The corresponding squared deviation is $(50 - 55)^2 = 25$. All such deviations were added.

3) The price with the lowest squared deviation was considered the separating price for the participant. Another way is to simply count the number of deviations and consider the price with the lowest numbers of deviations, the separating price. Qualitatively similar results were obtained through this procedure.

The average of 22 separating prices (one price for each participant) was calculated and considered the separating price obtained from the treatment. In this manner, separating prices from all treatments were obtained.

Table 4 shows the separating price from HS treatment and the price prediction from coarse thinking, rational, and risk neutral hypotheses. As can be seen the separating price from HS treatment is 65.68, which is closest to the coarse thinking price of 59, when compared with the other hypotheses.

To see which hypothesis is the best predictor of behavior if information from every participant is individually incorporated, the average squared deviation from each hypothesis's prediction is calculated as follows: Squared difference between each participant's separating price and the price prediction of the hypothesis is calculated. For example, participant with id#2 in HS treatment had a separating price of 69. The price prediction from coarse thinking hypothesis is 59. So, the squared difference is $(69 - 59)^2 = 100$. The squared difference is calculated for each participant. For a given hypothesis, all squared differences are added and an average is calculated by dividing by 22. In this manner, average squared deviation from each hypothesis's price prediction is calculated. Table 5 lists average squared deviations from coarse thinking, risk neutral, and arbitrage free pricing hypotheses. As can be seen, the best performing hypothesis is the coarse thinking hypothesis with an average squared deviation of 116.77, and the worst performing hypothesis is the arbitrage free pricing hypothesis with an average squared deviation of 731.68.

Table 6 shows the separating price from LS treatment and the price predictions from coarse thinking, arbitrage-free, and risk neutral pricing hypotheses. As can be seen, the separating price from LS treatment is closest to the risk neutral price, when compared with coarse thinking price and arbitrage free price. Table 7 shows the average squared deviation from the three hypotheses. This time, the risk neutral pricing hypothesis has the lowest average squared deviation of 87.14 followed by the coarse thinking hypothesis with the average squared deviation of 152.05.

Clearly, as the similarity between asset A and asset B is reduced, the performance of the coarse thinking hypothesis worsens. The risk neutral hypothesis outperforms the coarse thinking hypothesis in LS treatment, whereas coarse thinking hypothesis is the best performing hypothesis in HS treatment. If people were placing risky assets in the same mental account regardless of the similarity between the assets, then the performance of the coarse thinking hypothesis should not change between HS and LS treatments.

It is important to note that the arbitrage free or rational pricing hypothesis remains the worst performing hypothesis in both HS and LS treatments. In fact, not a single participant behaved rationally in the experiment.

4.1 Information from Base Line Treatments

If asset A is presented to the participants in isolation, that is, there is no opportunity to make a comparison between asset A and some other asset and the rational price does not exist, how much would an investor be willing to pay for it? The answer to this question provides a measure of how risk averse the investor is. In BL-HS treatment, asset A's payoffs were 140 and 30 in Red and Blue states respectively. In BL-LS treatment, payoffs were 100 and 0 respectively. Table 8 shows separating prices from these treatments. The separating price in BL-HS treatment is 76.05, and the separating price from BL-LS treatment is 44.36. This implies that the discount factor for risk in BL-HS treatment is 0.8947 $\left(\delta = \frac{76.05}{85}\right)$, and the discount factor for risk in BL-LS treatment is 0.8872 $\left(\delta = \frac{44.36}{50}\right)$. That is, out of 88 participants selected for the experiment, 44 randomly chosen participants have a discount factor for risk (on average) approximately equal to 0.89. It is almost a certainty that the remaining 44 participants have a similar discount factor for risk.

Table 8 also shows the average squared deviation from the risk averse hypothesis in the HS treatment with 76.05 as the price prediction from the hypothesis. The average squared deviation is 179.63, which is higher than the average squared deviation from the coarse thinking hypothesis. Hence, the coarse thinking hypothesis remains the best predictor of behavior in HS treatment. However, the average squared deviation from the risk averse hypothesis in the LS treatment is 79.21, which is lower than the average squared deviation from the coarse thinking hypothesis in the LS treatment.

If the hypotheses are arranged in the order of performance, in the HS treatment, coarse thinking is the best predictor of behavior, followed by the risk averse hypothesis, then by the risk neutral hypothesis, and the worst performing hypothesis turns out to be the arbitrage free pricing hypothesis. In the LS treatment, the list is as follows: the risk averse hypothesis, the risk neutral hypothesis, the coarse thinking hypothesis, and the arbitrage free pricing hypothesis. Clearly, the performance of the coarse thinking hypothesis worsens as we move from HS to LS treatment as it should if coarse thinking is an appropriate description of behavior.

5. Conclusion

We report results from an experiment showing that thinking-by-analogy or coarse thinking matters for behavior. The hypothesis of thinking-by-analogy is the best predictor of behavior when there is a clear similarity between the assets. However, when the similarity is eliminated, risk averse pricing hypothesis turns out to be the best predictor of behavior. In any case, the arbitrage free or rational pricing hypothesis remains the worst performing hypothesis.

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Table 1 **Price Predictions from Various Hypotheses**			
Coarse Thinking	*Arbitrage-Free (Rational)*	*Risk Neutral Pricing*	*Risk Averse Pricing*
$\frac{C_1 + C_2}{X_1 + X_2} \times P$	$P - K$	$0.5C_1 + 0.5C_2$	$\delta(0.5C_1 + 0.5C_2)$

Table 2 **Payoffs in the High Similarity (HS) Treatment**			
	Price	*Red State*	*Blue State*
Asset A	?	140	30
Asset B	100	200	90
Asset C	100	100	100

Table 3 **Payoffs in the Low Similarity (LS) Treatment**			
	Price	*Red State*	*Blue State*
Asset A	?	100	0
Asset B	100	200	90
Asset C	100	100	100

Table 4 **<u>Separating Price from the HS treatment vs. Price Predictions of Hypotheses</u>**			
HS Treatment	*Coarse Thinking*	*Arbitrage Free (Rational)*	*Risk Neutral*
65.68	59	40	85

Table 5 **<u>Average Squared Deviation b/w the Separating Price from HS Treatment and the Price from Each Hypothesis</u>**		
Coarse Thinking	*Arbitrage Free (Rational)*	*Risk Neutral*
116.77	731.68	445.32

Table 6 **<u>Separating Price from the LS treatment vs. Price Predictions of Hypotheses</u>**			
LS Treatment	*Coarse Thinking*	*Arbitrage Free (Rational)*	*Risk Neutral*
45.59	34	9	50

Table 7 **Average Squared Deviation b/w the Separating Price from LS Treatment and the Price from Each Hypothesis**		
Coarse Thinking	*Arbitrage Free (Rational)*	*Risk Neutral*
152.05	1356.59	87.14

Table 8 **Separating Prices from Base Line Treatments and their Average Squared Deviations from HS and LS Prices**			
Base Line-HS Separating Price	*Average Squared Deviation with HS Prices*	*Base Line-LS Separating Prices*	*Average Squared Deviation with LS Prices*
76.05	179.63	44.36	79.21