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TESTING THE RATIONALITY ASSUMPTION USING A DESIGN DIFFERENCE IN THE TV GAME SHOW *JEOPARDY*

by

Gabriella Sjögren Lindquist
Jenny Säve-Söderbergh

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Gabriella Sjögren Lindquist[‡]

Jenny Säve-Söderbergh[‡]

Abstract

This paper empirically investigates the rationality assumption commonly applied in economic modeling by exploiting a design difference in the game-show *Jeopardy* between the US and Sweden. In particular we address the assumption of individuals' capabilities to process complex mathematical problems to find optimal strategies. The vital difference is that US contestants are given explicit information before they act, while Swedish contestants individually need to calculate the same information. Given a rationality assumption of individuals computing optimally, there should be no difference in the strategies used. However, in contrast to the rational and focal bidding behaviors found in the US, the Swedish players display no optimal behavior. Hence, when facing too complex decisions, individuals abandon optimal strategies.

Keywords: Rationality, Bounded Rationality, Field Experiments

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[‡] Swedish Institute for Social Research, Stockholm University, SE-10691 Stockholm, Sweden; email: gabriella.sjogren.lindquist@sofi.su.se, jenny.save-soderbergh@sofi.su.se.

I Introduction

An enduring controversy in economics regards the conflict between the assumption of rationality and the fact that economic agents have limited capacities to process information. This type of limited ability to manage information is sometimes referred to as bounded rationality.[1] Rationality is often criticized for being too strong of an assumption since many maximization problems are quite difficult, which implies that people would not be able to carry them out in practice.[2] In rational decision theory individuals are assumed to compute their optimal strategy for a given situation, regardless of the extent of computational abilities necessary to reach the optimal decision. In theories of bounded rationality, on the other hand, agents' capabilities are assumed to be weaker as they may have, for example, too limited computational abilities to solve for the theoretical optimum.[3]

In this paper we explore the rationality assumption by taking advantage of a design difference in the game-show *Jeopardy* between the US and Sweden. The vital difference in the design is that in the US game contestants are given explicit information before they act, while in the Swedish version contestants need to perform calculations to possess the same information. Given the rationality assumption, in which case individuals are capable of computing optimally, there should be no difference in the strategies used in the two designs. Consequently, the difference in the design of the otherwise similar games can be used as a kind of natural experiment. Moreover, by using a television game show, we

[1] The pioneering works on bounded rationality include, for example, Simon (1955, 1982).
[2] In Aumann (1997) the use of rationality and bounded rationality in various models are overviewed.

obtain the advantage of a natural large-stake setting for decision making.[4] In addition, exploring the design difference our paper complements earlier research on rationality by using a control and treatment approach in which only one condition is changed – the need for individual calculation.

The game show *Jeopardy* works as follows. Three participants compete with one another in a quiz game. After two successive rounds, in which the players accumulate scores according to their ability to answer questions[5] correctly and their ability to signal that they want to answer by pushing a button, the contestants enter the *Jeopardy* final. In the final, the three players privately (i.e. hidden from the other players) bid any amount they like of their pre-final score on a *subject area* in which an unknown final question will be asked. If a contestant gives the correct answer to the final question, the bid is added to that person's pre-final score. If the answer is incorrect, the bid is subtracted from the pre-final score. The contestant with the highest final score becomes the "*Jeopardy Champion*" and keeps a sum in the countries' currency equivalent to the amount of the score (less tax). The champion is also invited back to play in a subsequent round of *Jeopardy* facing new

[3] Kahneman (2003) provides an excellent overview over the psychological foundations of individual behavior being limited by bounded rationality. For a discussion on the implications of individual irrationality for aggregate economic outcomes see Fehr and Tyran (2005).

[4] The maximum amount a contestant can gain is SEK (Swedish kronor) 283,200 (US $ 1≈ SEK 8) in one show and SEK 1,416,000 in five subsequent shows. This requires certain strong restrictions on the evolution of the game, however. The highest gain attained from a single show is SEK 88,200 and SEK 179,900 for five subsequent shows. The average gain per contestant is SEK 7,151 and the average gain per show is SEK 13,906 for all Swedish broadcasts, Jeopardy Historia (2003).

[5] A special feature of *Jeopardy* is that the contestants are given the answer to a question and they have to give the correct question to the answer. To avoid confusion, we will use the term correct "answer" to refer to the correct question that they give.

contestants.[6] The maximum number of games a winner can play is five successive rounds.[7] The first and second runners-up receive non-monetary prizes.[8]

The data on the US *Jeopardy* is directly based on Metrick (1995), which we compare against a sample we obtained from televised broadcasts of the Swedish show. The US sample serves as a type of control group with players having explicit information, to be compared with our treatment group of players having to compute the same information. Adopting this set up we can analyze if players differ in their betting strategy when introducing the need for basic calculations in the decision process.

In both countries' versions the contestants are told the score levels of the other contestants at the end of the first round. The significant difference between the US and the Swedish design comes from contestants' information of the other contestants' pre-final scores after the second round. In the US version this information is explicitly and publicly told after the second round is played. In the Swedish version the contestants have to derive the same information by adding and subtracting scores of other contestants' correct and incorrect answers while they actively participate in the game. Apart from the information aspect, and that the final score is converted into each countries' currency, the games are identical.[9] Given this similarity we may rely on the difference displayed in strategies to

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[6] If two (or all three) players tie, both (or all) keep their prize money and are invited back to the next show as *Jeopardy Champions*.

[7] The maximum number can in fact exceed five, if the winner is selected for the *Jeopardy Champion* contest that takes place every season. The selected contestants are the three players with the highest winning score attained that season. In the data we have one contestant who appears six times.

[8] The values of the non-monetary prizes are approximately the same for both runners-up.

[9] Note that US $ 1 is approximately equal to SEK 8, implying that stakes are higher in the US. However, empirical evidence from game-show data shows that the value of the stakes does not affect the probability of players using optimal behavior. For example, Tenorio and Cason (2002) find within the game show *The Price is Right* that the size of the stakes does not affect the individuals' probability to behave rationally. Similarly, Healy and Noussair (2004) find no difference when comparing outcomes from *The Price is Right*

come from the need for Swedish players to derive the same information that is explicitly given to US players.

In essence, we find no evidence of either rational behavior, as that found by Metrick, or any other typical behavior of betting strategies. For the pre-final leaders, a negligible percentage share adopted strategies which bear similarity to the US sample. Similar to Metrick we do not find that runners-up play strategically, but, in contrast to Metrick, we neither find that they use typical nor "focal" betting behavior. Our results thus suggest that even when faced with a relatively simple problem, in this case addition and subtraction, most contestants abandon an optimal strategy and exhibit bounded rationality.

Related papers are, apart from Metrick (1995), Bennett and Hickman (1993), Berk et al (1996), Tenorio and Cason (2002) and Healy and Noussair (2004) who use different sub-competitions of the game show *The Price is Right* to evaluate the rationality assumption.[10] In these papers the optimal strategy of a player is derived and the analytical predictions are evaluated empirically. It is found that players do not behave rational if the problem is hard to solve, which is interpreted in terms of bounded rationality. Our paper thus complements these findings but also differs by using a different setting. Moreover, the treatment-control group approach we use is similar to that used by Healy and Noussair (2004), although they use a laboratory setting. When conducting several treatments that simplify the game in the laboratory setting, they analyze the probability of rational

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with prizes ranging from US $ 1,000 up to US $ 60,000, with a laboratory setting of the same game having prizes ranging from US $ 2 and US $ 100. However, some laboratory experiments using other settings have shown that stakes may matter, see for example Kachlameier and Sheta (1992).

[10] There are several other papers which also use TV-game shows as field experiments but which test for other behaviors such as risk aversion or discrimination. See for example Antonovics et al (2005), Beetsma and Schotman (2001), Fullencamp, Tenorio and Battalio (2003), Gertner (1993) and Post et al. (2006).

behavior. Similarly, their results suggest that the lack of optimal behavior in *The Price is Right* stems from bounded rationality.

The paper is arranged as follows. In Section 2 the data is presented. Bidding behavior as that found in the US version of *Jeopardy* is compared with the strategies in our Swedish sample in Section 3. Section 4 offers concluding remarks.

II Data

The Swedish data was collected from video-recorded transmissions of *Jeopardy* during 2002.[11] The sample is comprised of 206 shows. In 11 of the shows, the second runner-up had a negative (or zero) pre-final score and could thus not play in the final round. Since the two remaining players find themselves in a different strategic situation from that of players in a three-player game, we exclude these 11 shows from our sample. Altogether, we have 585 observations.

Each game can end in different states depending on the number of correct answers in the show. These states differ if the pre-final leader is correct, A1=1, or wrong, A1=0, the runner-up is correct, A2=1 or wrong, A2=0 and the equivalent, A3=1, or A3=0, for the second runner-up. For all 195 games, each state of the game is summarized in Table I. Since we use Metrick's US sample as a control group, the corresponding statistics for the US sample are also reported.

[11] The transmissions are *Jeopardy* shows from the spring of 2002, the summer of 2002 (video-recorded reruns from the fall of 2001), and the fall of 2002.

Table I - Frequency of the States for Players in First, Second and Third Pre-final Positions

	Swedish sample		US sample	
State (a_1, a_2, a_3)	Number of games	Frequency	Number of games	Frequency
(1, 1, 1)	49	0.25	75	0.20
(1, 1, 0)	28.5	0.15	47	0.13
(1, 0, 1)	20.5	0.11	43.5	0.12
(1, 0, 0)	25.5	0.13	45.5	0.12
(0, 1, 1)	11	0.06	26.5	0.07
(0, 1, 0)	24.5	0.12	40	0.11
(0, 0, 1)	10	0.05	26.5	0.07
(0, 0, 0)	26	0.13	65	0.18

Note: The state indicates the number of correct answers in the *Jeopardy* final. The a_1 indicates the answer for the pre-final leader, a_2 indicates the answer for the runner-up, and finally, a_3 indicates the answer for the second runner-up. One denotes a correct answer and zero an incorrect answer. Observations from tied games are split between the two possible states.

There is a fair amount of variation in the different outcomes in both the US and the Swedish games. The frequency that the Swedish pre-final leader is correct is (147+85.5+61.5+76.5)/585 = 0.63 with the equivalent for US pre-final leaders being 0.54. For the Swedish (US) runners-up the frequency is 0.58 (0.48) and for the second runner-up it is 0.46 (0.44). In general, Swedish players have a higher frequency of correct answers to the final question than US players.

III Ruling out Best Response

In order to compare betting strategies between the two game designs, we replicate the analysis made by Metrick using our Swedish sample. Metrick foremost uses two different subsets of games to study betting strategies. The first subset is comprised of *runaway games*, where the pre-final leaders' can secure a victory through strategic bidding. The second subset includes *shut-out games* where the pre-final leader can make a bid ensuring a victory if he (or she) gives the correct answer to the final question.[12]

Pre-Final Leader Strategies

For pre-final leaders in the US *Jeopardy,* Metrick derives two best responses depending upon the amount they are ahead by. First, since the final bid, Y_1, cannot exceed the contestant's pre-final score, X_1, then at certain relative positions a pre-final leader can guarantee a victory. This applies when the pre-final leader has a pre-final score, X_1, twice as high as the pre-final score of the runner-up, X_2. In these *runaway games* the leader can be certain of winning as long as his bid does not exceed the difference between the own pre-final score and twice the pre-final score of the runner-up, i.e. $Y_1 \leq X_1 - 2X_2$, here defined as *runaway bids*.

Second, in games where the pre-final leader's score is not high enough to secure a victory, Metrick shows that the pre-final leader has the possibility of making a *shut-out bid*, which is the *smallest* possible bid that ensures a sole victory if he answers correctly, i.e. $Y_1 = 2X_2 - X_1 + 1$. An example of such a game is when the pre-final leader has 10,000 and the runner-up has 7,000 (and the third player only has 1,000 and can be ignored), whereupon the maximum amount that the runner-up can get is 14,000. The smallest

[12] As pointed out by Metrick the game-theoretical equilibria of the *Jeopardy* final are very complex. Like Metrick, we make no attempt to test any game-theoretical predictions. We refer the reader to Metrick (1995) where a stylized version of the US *Jeopardy* can be found.

possible bid the pre-final leader can make to secure a non-tied victory for a correct answer is 4,001.[13]

Runaway games

Metrick reports that in the US version of *Jeopardy*, none of the 110 pre-final leaders in *runaway games*, made a bid larger than the *runaway bid* threshold. Twenty-four of them made a bid exactly equal to, or US $ 1 less than, the *runaway bid* threshold. That is, all US pre-final leaders who had the opportunity secured their winning by basing their strategies on the precise score level of the runner-up.

In our Swedish sample, 64 of the 196 pre-final leaders had the opportunity to make *runaway bids*. The frequencies of *runaway bids* are summarized in Table II. None of the Swedish pre-final leaders made a bid at, or, like US players SEK 1 less than, the *runaway bid* threshold and only 17 made *runaway bids*. The distribution of bid deviations from the *runaway bid* threshold for pre-final leaders in *runaway games* is shown in Figure 1. At zero, the pre-final leader made a bid exactly at the *runaway bid* threshold. In the positive range the bid is higher than the *runaway bid* threshold and in the negative range all bids are *runaway bids*. The majority of bids, 73 percent, are in the positive range and among these the absolute deviations are high. The average deviation from the *runaway bid* threshold for the Swedish players is SEK 2,584, which is far above 0. In a one sided *t test*,

[13] In Metrick's analysis it is shown that the focal bid is to ensure a sole victory, not a tie. We hence follow Metrick and define a *shut out bid* as a bid that secures a sole victory.

Table II – Behavior of Pre-final Leaders in *Runaway Games* and *Shut-out Games*

***RUNAWAY GAMES*: $X_1 \geq 2X_2$**	Swedish sample		US sample	
	Obs.	Frequency	Obs.	Frequency
Bid ≤ *Runaway bid threshold*				
$Y_1 < X_1 - 2X_2 - 1$	17	0.27	86	0.78
$Y_1 = X_1 - 2X_2 - 1$	0	0.00	20	0.18
$Y_1 = X_1 - 2X_2$	0	0.00	4	0.04
Bid > *Runaway bid threshold*				
$Y_1 > X_1 - 2X_2$	47	0.73	0	0.00
Mean Bid Deviation	2,584*** (4,644.3)			
Total	64	1.00	110	1.00
Allowing for a SEK 500 error				
$Y_1 \leq X_1 - 2X_2 + 500$	22	0.27		
$Y_1 > X_1 - 2X_2 + 500$	59	0.73		
Total	81	1.00		
Allowing for a SEK 1,000 error				
$Y_1 \leq X_1 - 2X_2 + 1000$	24	0.24		
$Y_1 > X_1 - 2X_2 + 1000$	76	0.76		
Total	100	1.00		

***SHUT-OUT GAMES*: $X_1 \leq 2X_2$**	Swedish sample		US sample	
	Obs.	Frequency	Obs.	Frequency
Bid < *Shut-out bid-1*				
$Y_1 < 2X_2 - X_1 + 1 - 1$	16	0.12	8	0.03
$Y_1 = 2X_2 - X_1 + 1 - 1$ (accepting a tie)	2	0.02	26	0.09
Bid = *Shut-out bid*				
$Y_1 = 2X_2 - X_1 + 1$	0	0.00	135	0.48
Bid > *Shut-out bid*				
$2X_2 - X_1 + 1 < Y_1 \leq 2X_2 - X_1 + 1 + 100$	1	0.01	40	0.14
$2X_2 - X_1 + 1 + 100 < Y_1 \leq 2X_2 - X_1 + 1 +$	19	0.14	40	0.14
$Y_1 > 2X_2 - X_1 + 1 + 1{,}000$	94	0.71	34	0.12
Mean Bid Deviation	3,218*** (3,270.7)			
Total	132	1.00	283	1.00

Note: Note that in the Swedish sample there are 196 pre-final leaders in 195 games. In one game there is a tie between the first player and the runner-up and hence there are two pre-final leaders in this game. Standard deviations are given in parenthesis.

we can also reject that the average deviation is zero, or negative, at the 1 percent level.[14] Hence, in our sample where players had to perform calculations to receive information on which they could form their strategy, only 27 percent secured a victory, while 100 percent did so in Metrick's sample where the players have explicit, instead of derived, information.

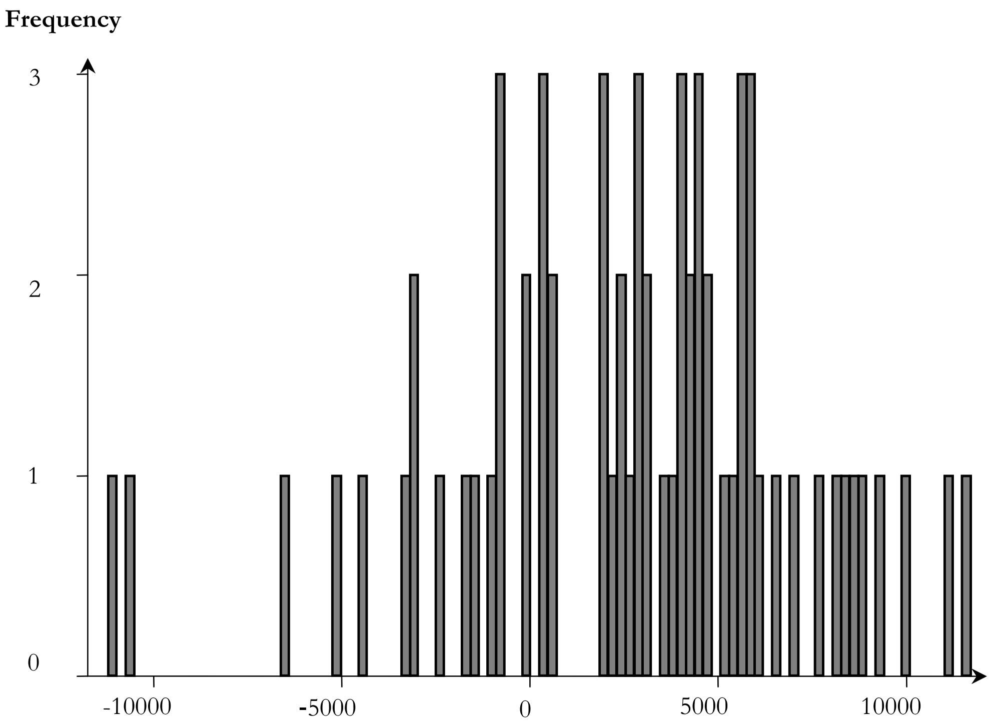

Figure 1. The distribution of bid deviations from the *runaway bid* threshold for pre-final leaders in *runaway games*

[14] If we allow the pre-final leader to make an error of SEK 500 in calculating the runner's-up score due to the need for deriving the information on the other players' scores, the percentage who made *runaway bids* does not increase. Allowing for an error interval of SEK 1,000 we obtain a percentage of 24. Note that the percentage falls, since the number of individuals who made *runaway bids* increases by 2, but the number of individuals with the possibility of making *runaway bids* increases by 19.

Shut-out games

In the games where the pre-final leader's score is not high enough to secure a victory, Metrick finds that the modal bid for pre-final leaders is the *shut-out bid* and that this is made in over half of the games. Metrick defines this as a focal bid. In our sample of *shut-out games*, none of the 132 pre-final leaders chose an exact *shut-out bid*, and 2 percent placed a bid within a negative deviation of SEK 1, accepting a tie. The statistics are given in Table II. In addition, Metrick finds that 85 percent of the *shut-out bids* in US *Jeopardy* are played between a perfect *shut-out bid* and a positive deviation of 1,000. In contrast, 17 percent of the Swedish players made a bid within this interval.

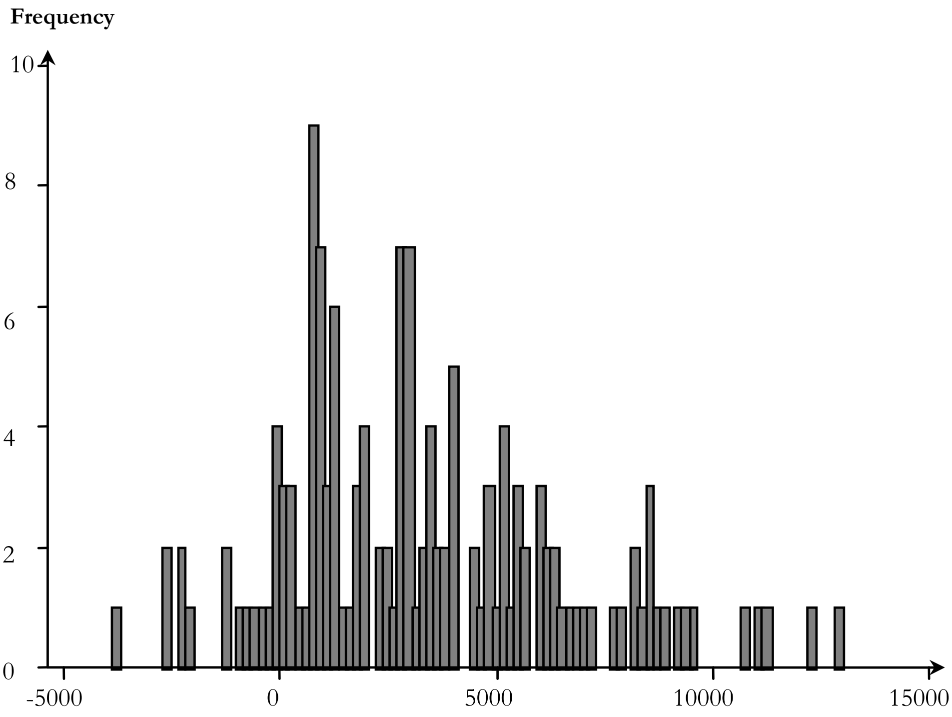

Figure 2. The distribution of bid deviations from the *shut-out bid* for pre-final leaders in *shut-out games*

Figure 2 shows the distribution of deviations from a *shut-out bid*. As in the *runaway bids'* distribution, we find that the majority of the players bet more than the *shut-out bid* and that the absolute deviations from it are large. The average deviation from a *shutout bid* found for the Swedish players is SEK 3,218 which is clearly far from 0. Moreover, by a one sample *t test*, we can reject that the average deviation is equal to zero at the 99 percent level.

Analyzing the pre-final leaders' lack of rationality

In *runaway games*, the pre-final leader can win with certainty given that he uses the information on the runner's-up score. However, only 26 percent who had the possibility in our sample behaved rationally and made *runaway bids* compared to 100 percent in the US *Jeopardy*. In *shut-out games*, only 2 percent used the modal strategy made by 57 percent of the US players.

When analyzing *The Price is Right*, Bennett and Hickman (1993), Berk et al. (1996), Healy and Noussair (2004), and Tenorio and Cason (2002) find that more experienced individuals behave more "rationally" than non-experienced (the learning effect in Tenorio and Cason's is though modest). They interpret this as evidence for the presence of bounded rationality. Estimating a logit regression on the probability to do *runaway bids*, we do not find a learning effect in *Jeopardy* as the coefficient on experience on the show, CHAMP, is insignificant, see Table III. A similar regression but on the probability to do a bid equal to the *shut-out bid* or larger, defined as a *shut-out interval bid*,

Table III Logit Regression on the probabilities to bid *Runaway Bids* or a *Shut-out Bid* or higher

	Runaway Dummy[A]	*Shut-out Interval Dummy*[B]	*Runaway Dummy*[A]	*Shut-out Interval Dummy*[B]
	(1=YES, 0=NO)	(1=YES, 0=NO)	(1=YES, 0=NO)	(1=YES, 0=NO)
CHAMP [a]	**-0.19**	**-0.050**	**-0.20**	**-0.073**
	(0.32)	(0.26)	(0.31)	(0.27)
RATIO [b]	**-10.72*****	**-5.51*****	**-11.19*****	**-5.45*****
	(3.54)	(2.00)	(3.53)	(1.99)
A2=1 [c]	**0.19**	**-0.42**		
	(0.66)	(0.58)		
EASY GAME [d]			**0.44**	**-1.08**
			(0.76)	(0.79)
CONSTANT	**2.58***	**6.47*****	**2.74****	**5.97*****
	(1.37)	(1.72)	(1.23)	(1.71)
Pr (> Chi)	0.004	0.020	0.004	0.009
No of Obs.	64	132	64	132

Note: Standard errors are given in parentheses.
[A] Only the pre-final leaders with the possibility to do r*unaway bids* are included. Note that the *Runaway Dummy* takes the value 1 for players who played *runaway bids*.
[B] Only the pre-final leaders with the possibility to do a s*hut-out* bid and who did not have the possibility to do *runaway bids* are included. Note that the variable *Shut-out Interval* Dummy takes the value 1 for players who played an exact *shut-out bid* or higher. Note that none of the players played an exact *shut-out bid*; only 2 players were close with bids yielding a tie.
[a] CHAMP is the number of consecutive shows the contestant has participated in.
[b] The ratio between X2 and X1.
[c] A dummy variable equal to 1 if the runner-up answered correctly in the final and 0 otherwise.
d A dummy variable equal to 1 if the game is "easy" such that all players answered the final question correctly and 0 otherwise.

obtains the same conclusion. We interpret this absence of a learning effect as the players finding the problem too complex to solve even when they become more experienced.

Further, we explore if *runaway bids* or *shut-out interval bids* are used more often by pre-final leaders when the rational strategy is easier to compute. When the pre-final leader is far ahead it is easier to place *runaway bids* or a *shut-out interval bid* since the interval in which the bid can be placed is larger relative to when the score spread is smaller. Using the variable RATIO, which is the ratio between X_2 and X_1, we see that, as expected, when the score spread becomes narrower, the less likely pre-final leaders are to do *runaway bids* or *shut-out interval bids* when given the opportunity.[15]

If the pre-final leader believes the runner-up has a large probability to give the correct answer to the final question, he should have large incentives to do a *runaway* or *shut-out interval bid* since he then expects the runner-up to place a large bid, and thereby needs to shut him out in order to win the game. To test this hypothesis two dummy variables are created. First, we create a dummy variable A2=1, which is equal to 1 if the runner-up answered the final question correctly (and 0 otherwise), corresponding to a proxy of the ex ante expectation of the runner-up's probability to answer correctly.[16] Second, a dummy variable EASY GAME is created, which is equal to 1 when all contestants answered correctly (and 0 otherwise), suggesting the final question to be considered easy by the panel. No support however is found for these arguments as the coefficients on A2=1 and EASY GAME are insignificant for both strategies.

Is there any other focal betting behavior of pre-final leaders?

In this section we divert from Metrick's study and analyze whether players are bidding according to some typical or "focal" wagering strategy. Analyzing the distribution of

[15] If we contemplate that it is easy to compute the score differences, then strategic play ought to be more likely in the games with only two players. In these games the second runner-up performed so bad that the score can be ignored. In our 11 two-player games the probability to use *runaway bids* is 0. For the *shut-out games* the probability to do a *shut-out interval bid* is 0.11. Hence even when faced with an easier calculation, players still do not play according to *runaway* or *shut-out* strategies.

[16] There are 5 games with a tie between the runner-up and the second runner-up. Out of these, 3 games had the state (1,1,0) or (1,0,1) as one second runner-up was correct and one was incorrect. These games are coded as 1 in the A2=1.

deviations from “strategic play”, i.e. deviations from *runaway bids* and *shut-out bids* shown in Figures 1 and 2, we observe that the distributions are skewed to the right. If players were simply making calculation errors, then the new distribution of deviations from the *runaway bid* threshold should be left of zero with the errors symmetrically distributed and the distribution of deviations from the *shut-out bid* should be symmetric around zero. The right skewed distributions indicate that players abandon the optimal strategy for some other strategy when the need for deriving information by calculation is introduced.

To analyze this further, different bid distributions of the pre-final leaders are summarized in Table IV. In the first column we report bid deviations from strategic play. In the case of deviations from the *runaway bid* threshold we observe no modal bid. The most common bid deviation is made by three individuals, and is occurring at three different bid levels. The second most common bid deviation has a frequency of two with eleven different bid levels. In the *shut-out games* we neither find a modal bid, nor at the *shut-out bid* or at any deviation from it; the most frequent bid deviations were made by five players each on three different levels.

But could there be any other typical betting behavior which may explain the pre-final leaders’ betting behavior? Could it be so simple that players just bet their score less some fixed amount such that other players can expect them to only have the fixed amount left if they give the wrong answer?

Table IV – Betting Behavior of the Pre-final Leader in *Runaway Games* and *Shut-out Games*

	Strategic Play		Other focal betting behavior			
	Bid Deviation from the *Runaway bid* threshold or a *Shut-out bid*		Absolute Difference		The Relative Bid	
			$X_i - Y_i$		$\frac{Y_1}{X_1}$	
	RW	*SH*	*RW*	*SH*	*RW*	*SH*
Mean	2,584.4***	3,217.7***	4,975.0	1,408.1	0.60	0.85
Standard deviation	(4,644.3)	(3,270.7)	(4,513.9)	(2,301.8)	(0.313)	(0.223)
Skewness	-0.66	0.66	0.77	2.59	-0.33	-2.01
Kurtosis	3.77	3.28	2.64	9.61	1.80	6.18
Most common bid	[400, 5,600, 5,800]	[800, 1,000, 2,700]	[600]	[100]	[1]	[1]
Frequency	3	5	4	19	3	16
2nd Most common bid	[11 levels]	[8 levels]	[0, 200]	[0, 500]	[0.77, 0.95]	[0.91]
Frequency	2	3	3	16	2	4
Min	-11,200	-3,900	0	0	0.006	0.029
Median	3,050	2,750	4,100	500	0.652	0.936
Max	11,700	13,000	17,000	12,000	1	1
No of Obs	64	132	64	132	64	132

Note: *RW* refers to *runaway games* and *SH* refers to *shut-out games*. *** denotes statistical significance at the 99 level in a t-test of the hypothesis that the average deviation from the *runaway bid* threshold or *shut-out bid* is equal to zero.

In the second and third column of Table IV we summarize “other betting strategies”. First, if we study the absolute differences between the score and the bid, $X_1 - Y_1$, for each of the games respectively, we find an average difference of SEK 4,975 for the *runaway games* and SEK 1,408 for the *shut-out games*. For both games there is a large spread in the absolute differences. Furthermore, the most common absolute difference in the *runaway games* is made by 4 individuals, with a bid yielding a difference of 600. Yet, as only 6 percent made such a bid, we cannot argue that this is a focal bid or a common strategy. For the *shut-out games*, the distribution has some absolute differences which are more frequent. The most frequent bid yields a difference of 100, played by approximately 14 percent while the second most frequent yields a difference of 0 or 500 played by 12 percent each.

What if players just wager a certain percentage of their score? For a relative bid, given by $\frac{Y_1}{X_1}$, we again find no specific bid level which is more common for the *runaway games*, only three individuals applied the most common bid of 100 percent. The distribution is also skewed towards high levels of relative bids at around 95 percent and up. For the *shut-out games*, there is a larger likelihood that players wager most of their score but not at a typical level. For example, at the exact levels of 90 percent and 95 percent, there are only 1 and 2 observations respectively. The most common is to wager all, which is made by 12 percent.

In general, there is a difference between pre-final leaders in the *runaway games* and the *shut-out games*. There is a higher relative betting in the *shut-out games*. Using a nonparametric Kolmogorov-Smirnov test for the equality of the distributions of bets between the two types of games, the hypotheses of equal distributions of the absolute wagers and the relative bids are both rejected with p-value=0.000. This may come from the fact that *shut-out games* have a lower spread in scores between the pre-final leader and the runner-up. Consequently, we do not argue that players necessarily are totally unable to keep track of each others scores, instead they may get a sense of being far behind or very close, just that they do not base their strategies on the exact score level of the other players. This may well explain the difference within the Swedish games.

II. Runner-up strategies

Metrick analyses the runners'-up strategies in a subset of the *shut-out games* where the pre-final leader and the runner-up can ignore the second runner-up and instead bid against each other. Metrick's objective is to "see whether the players are playing best responses to the observed "empirical frequency" of strategies played by their opponents in my sample of similar games. I call such bids "empirical-best-responses"", (p. 241).

As stated above, the focal bid for pre-final leaders in the US Jeopardy was a *shut-out bid*. Runners-up would hence assume that the pre-final leader has a high probability to play a *shut-out bid.* Responding to the *shut-out bid* the runner-up has three options: to play *Low*, *High* or *All*.

The crucial point is that if the pre-final leader plays the *shut-out bid* but gives the wrong answer, then for some relative positions the runner-up can guarantee winning independent of his answer. This strategy, *Low*, is played when the bid is equal to or lower than a certain threshold, $Y_2 \leq 3X_2 - 2X_1 + 1$. Following the example given above, the pre-final leader will obtain an amount of 10,000-4,001=5,999 if he is wrong. To obtain a score above this (or accepting a tie), irregardless of his final answer, the runner's-up bid should not exceed 1,001 (i.e. $7{,}000 - Y_2 \geq 5{,}999$). This option should be used when the probability that the pre-final leader may be incorrect is high and regardless of the contestant's own knowledge of the question. To analyze this, we need two restrictions on the games. First (i) $3X_2 \geq 2X_1$, otherwise the runner-up does not have a score high enough to secure against the *shut-out bid*. Second, (ii) $X_2 > 2X_3$, such that the third player is so far behind that the runner-up can play without jeopardizing his victory with a *Low* strategy. This subset of games is denoted *restricted shut-out games*.

The next option is to play *High*, i.e. $Y_2 > 3X_2 - 2X_1 + 1$ and $Y_2 < X_2$, which is played, following the example above, when $Y_2 > 1001$ and $Y_2 < X_2$. Note that the runner-up wins with this bet only if his answer is correct and the pre-final leader is incorrect. Consequently, playing *High*, the runner-up sacrifices a guaranteed victory (given that the pre-final leader is wrong) against obtaining a larger amount when he answers correctly. A third strategy is to play the *All* strategy such that $Y_2 = X_2$.

In our data 35 games are *restricted shut-out games*. First we can note that in Metrick's data 67 percent of the pre-final leaders played within US $ 1 from the *shut-out bid* in these types of games. In our sample of *restricted shut-out games* the same number is

Table V – Behavior of Pre-final Leaders and Runners-up in "Restricted *Shut-out Games*"

Restricted *Shut-out Games*: (i) $3X_2 \geq 2X_1$**, (ii)** $X_2 \geq 2X_3$				
Pre-final Leaders	Swedish sample		US sample	
	Obs.	Frequency	Obs.	Frequency
Bid ≤ *Shut-out bid* -1				
$Y_1 < 2X_2 - X_1$	8	0.23	2	0.03
$Y_1 = 2X_2 - X_1$ (accepting a tie)	2	0.06	7	0.09
Bid = *Shut-out bid*				
$Y_1 = 2X_2 - X_1 + 1$	0	0.00	44	0.58
***Shut-out bid* < Bid ≤** X_1				
$2X_2 - X_1 + 1 < Y_1 < X_1$	20	0.57	22	0.29
$Y_1 = X_1$	5	0.14	1	0.01
Total	35	1.00	76	1.00
Runners-up	Swedish sample		US sample	
	Obs.	Frequency	Obs.	Frequency
LOW				
$Y_2 \leq 3X_2 - 2X_1$	5	0.14	18	0.24
HIGH				
$3X_2 - 2X_1 < Y_2 < X_2$	21	0.60	26	0.34
ALL				
$Y_2 = X_2$	9	0.26	32	0.42
Total	35	1.00	76	1.00

Note: Only the restricted games are included.

6 percent, as given in Table V. A great majority of the pre-final leaders in our sample bid much higher than the *shut-out bid*.

Metrick shows that playing *Low* is the empirical best response for the runners-up in the US sample. He further shows that playing *All* first-order stochastically dominates *High*. Metrick then finds a puzzle since most of the runners-up play *High*. In our sample, the pre-final leaders do not play *shut-out bids* with any regularity. Further we found no other focal pre-final leader bid either. Similarly we do not find any typical response of the runner-up based on an expectation of the pre-final leader playing a *shut-out bid*. Only 14 percent played within the *Low* interval and none really close. Instead, the most frequent bids for runners-up in our restricted sample are $Y_2 = X_2 - 100$ and $Y_2 = X_2$ which are each played by 25 percent of the runners-up.

Still, since the pre-final leaders bid between a *shut-out bid* and the total score, we should expect runners-up to play *Low* with a high frequency. The only strategic alternative available to the runner-up to secure a victory is to play *Low* such that he can win when the pre-final leader is wrong. In contrast, there is no strategic play by playing *High* or *All*, which are the most frequently adopted strategies. Moreover, if the runner-up were to have the strategy to play *High* then it must always be better to play *All* instead. However, this is not what we find in the data as 26 percent play *All* and 60 percent play *High*. This is the same result as Metrick finds.

Analyzing the runners'-up lack of rationality

Metrick concludes that "one can safely conclude that, as a group, first-place players are having no problem finding their empirical-best-responses" (p.250). Despite this regularity of play the US runners-up do not respond correspondingly. Metrick explains that this may be caused by the runners-up having a strategic problem which is more difficult to calculate than the pre-final leaders. In the case of the Swedish game we should expect it to be even more difficult. We perform an analysis similar to that of Metrick to try to explain the behavior of the runners-up. We regress a dummy variable, *LOW*, which is set to 1 if the runner-up played *Low* and 0 otherwise, on different explanatory variables using the

Table VI – Logit Regression on the Runners-up Probability to Play a *Low* Strategy in "Restricted *Shut-out Games*"

	Sweden	US	Sweden	US	Sweden	US	Sweden	US
$X_2/100$	**0.034**	**0.00**	**0.040**	**-0.00**	**0.032**	**-0.02**	**0.032**	**-0.01**
	(1.49)	(0.17)	(1.60)	(0.04)	(1.22)	(1.15)	(1.23)	(0.71)
A2=1[a]			**-0.86**	**0.49**	**-1.31**	**0.31**	**-1.24**	**0.18**
			(0.76)	(0.84)	(1.02)	(0.50)	(0.91)	(0.28)
RATIO[b]					**14.78***	**9.13*****	**15.04***	**8.02****
					(1.81)	(2.54)	(1.79)	(2.16)
CHAMP[c]							**-0.09**	**0.46***
							(0.15)	(1.88)
CONST.	**-4.25****	**-1.33**	**-4.19****	**-1.44**	**-16.01****	**-7.89*****	**-16.15****	**-7.73*****
	(2.31)	(1.37)	(2.23)	(1.46)	(2.22)	(2.79)	(2.19)	(2.62)
Pr(> Chi)	0.12	0.87	0.22	0.68	0.04	0.04	0.08	0.02
No of Obs.	35	76	35	76	35	76	35	76

Note: Restricted *shut-out games* are restricted by: (i) 3*X2>2*X1, (ii) X2>2*X3. *LOW* refers to the use of a *Low* strategy by the runner-up where *LOW*=1 if player 2 plays *Low* and *LOW*=0 otherwise. Numbers in parentheses are asymptotic *t* statistics.

[a] A dummy variable equal to 1 if the runner-up answered correctly in the final and 0 otherwise.

[b] The ratio between X_2 and X_1.

[c] CHAMP is the number of consecutive shows the contestant has participated in.

restricted shut-out games. Table VI contains the results from four different logit regressions for *LOW* with Metrick's regression results included for comparison. In the first model we regress *LOW* on the pre-final score $X_2/100$ in order to estimate whether players did not play *Low* as a result of them preferring to forego the increased chance of winning for a higher pay-off if winning. In none of the four specifications do we find support for this claim. The coefficients on $X_2/100$ are all insignificant which is the same result as that found by Metrick.

If instead behavior is explained by the fact that players have private information on their knowledge of the question then they should be less likely to play *Low* when they are more likely to be right. The regression estimates does not show this to be the case. The coefficient on A2=1 is negative as predicted, but not significant. For US players, Metrick finds the coefficient to be positive and insignificant.

Further the variable CHAMP is included to analyze if the *Low* strategy is used more after learning and with experience of the game. For the US *Jeopardy* Metrick finds that more experienced players have a significantly higher probability to play *Low*. In our games without explicit information we find no support for this.

Finally, we test whether runners-up are more likely to play *Low* if they are in a game in which the possibility of playing *Low* is easier to notice and to compute. Metrick argues that this would be the case when the pre-final leader and the runner-up are relatively close in pre-final scores. We also find support for the claim; the coefficient on RATIO is positive and significant.[17] The same pattern is also found in Metrick's US sample.

Is there any other focal betting behavior of runners-up?

Could it be so simple that runners-up also bet their score less some fixed amount? We do find a fairly typical wagering of the runners-up in *runaway* and *shut-out games* in terms of an absolute difference, see Table VII. First, the most common option is to wager all, which is made by 49 of the 199 runners-up, i.e. 25 percent (18 of 67 in *runaway games* and 31 of 132 in *shut-out games*). The second most common bet is to wager all but 100 which is

[17] Similarly a t-test yields the same prediction. The 5 games in which the runner-up played *Low* are much tighter games. The average ratio in these games is 0.91 (0.03) while in the other 30 games the ratio is 0.79 (0.02) with a significant difference at the 99 percent level.

Table VII – Betting Behavior of the Runners-up in *Runaway Games* and *Shut-out Games*

	Other Focal Betting Behavior			
	Absolute Difference		The Relative Bid	
	$X_i - Y_i$		$\frac{Y_1}{X_1}$	
	RW	***SH***	***RW***	***SH***
Mean	495.1	642.3	0.88	0.89
Standard deviation	(1,131.1)	(1,186.4)	(0.243)	(0.190)
Skewness	3.28	2.48	-2.86	-2.46
Kurtosis	12.86	8.79	9.95	8.90
Most common bid	[0]	[0]	[1]	[1]
Frequency	18	31	18	31
2^{nd} Most common bid	[100]	[100]	[0.9]	[0.986, 0.983]
Frequency	14	28	4	3
Min	0	0	0.0001	0.048
Median	100	100	0.96	0.976
Max	5,199	5,900	1	1
No of Obs	67	132	67	132

Note: There are 67 runners-up in the *runaway games* since in 5 games there was a tie between the runner-up and the second runner-up. *RW* refers to *runaway games* and *SH* refers to *shut out games*.

made by 21 percent of all runners-up. Hence, both these bids are fairly typical for runners-up, but are not related to the level of the score of the pre-final leader.

With relative bids we find that the runners-up wager a fairly high percentage of their score with means of 0.88 and 0.89 in the two games. The most common wager is equal to 1 and is made by 25 percent. But apart from *All* being fairly typical there is no other exact bid level which could be assumed to be focal.

Using a two-sample Kolmogorov-Smirnov test to test for the equality of the relative wager distribution functions between runners-up in *runaway* and *shut-out games* the hypothesis is not rejected at a p-value of 0.185. Hence we see no difference between runners'-up wagering in the two different settings. Using the same test we cannot reject the equality of the absolute bidding differences between the two groups either at a p-value of 0.837. Furthermore a two-sided t test does not reject the equality of the means of relative respectively absolute wagering in the two different games. Overall it appears that runners-up, even if faced with different strategic set-ups, do not change their strategies between the games. Consequently we cannot argue that there is strategic play by the runners-up which is contingent on the knowledge of the pre-final leader's score.

IV Concluding Remarks

We conclude that assuming perfect individual capacity to calculate optimal strategies is a strong assumption of rationality in general. Considering the fairly noncomplex mathematical skills, mainly addition, required for the *Jeopardy* games, the assumption of perfect rationality seems even more difficult to justify for more complex economic decisions taken in a short time frame. When individuals obtain information they should have a larger probability to use optimal strategies, than when lacking this information. Given a classical rationality assumption, in which case individuals are capable of computing optimally, we should see no difference in the strategies used in the two designs. By analyzing the strategies adopted in the two otherwise similar games we obtained a test whether the Swedish contestants behaved as those participating in the US show. Our results indicated that they did not. Thus, even though the sole difference between the groups of players is the need for self-deriving the information which is given to the players in the US game, we cannot replicate Metrick's findings.

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