Foresight, risk attitude, and utility maximization in naturalistic sequential high-stakes decision making

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ABSTRACT

We explore three research questions related to risky sequential choice: (1) Does adherence to expected utility theory increase or decrease over sequential choices? (2) Does risk attitude vary systematically over sequential choices? and (3) To what extent are sequential choices influenced by future possible choices? We selected the game show, *Deal or No Deal (DOND)*, as a context to study sequential decision making under risk with high stakes. We obtained data from complete game episodes involving 1421 players in three versions of the DOND (UK, US primetime, and US syndicated), aired between October 2005 and May 2010. In all three versions of the game, players make a binary choice between accepting a sure-thing offer that ends the game ("deal") or continuing to play the game under risk ("no deal"). Separate stochastic choice models are constructed for each round of each of the three versions of the game to assess both risk attitude and adherence to expected utility theory. Players were found to be quite risk averse across all rounds and tended to be less risk averse and less rational over rounds in all three versions of the game. Results also suggest that players tend to consider the expected value for different sets of remaining cases one round ahead, but do not consider different possible sure-thing offers one round ahead.

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1. Introduction

Sequential decisions are pervasive and important in our daily lives. Examples include decisions about daily food consumption, exercise, medical testing, financial investing, and career path. All of these decisions are sequential in the sense that they occur repeatedly, and decisions made at each point in time affect the choices available and outcome probabilities for future decisions. To better understand sequential decisions, it is important to understand how people frame possible outcomes of each available alternative at any given point in time. In this study, we examined sequential decision making under risk involving high stakes in a naturalistic domain and constructed a choice model to compare decision frames for subsequent choices.

Differences between risky choice in the laboratory and in realistic situations has been observed for over half a century. The former involves hypothetical decisions or decisions with extremely low stakes. Slovic, Lichtenstein, and Edwards (1965) found that participants felt bored and unmotivated with imaginary choices or choices with very tiny payoffs and tended to use different strategies when facing bets for consequential amounts of money. Researchers began to study risky choice in naturalistic gambling and game show contexts that involve substantial monetary outcomes. Naturalistic study of risky choice can be traced back to the early 1970s when Edwards and his students collected data from gamblers on the floor of the 4 Queens Casino in downtown Las Vegas (e.g., Lichtenstein & Slovic, 1973; Snapper, Edwards, & Peterson, 1972). More recent studies used archival data from various TV game shows, including *Card Sharks* (e.g., Gertner, 1993), *Jeopardy!* (e.g., Metrick, 1995), *Lingo* (e.g., Beetsma & Schotman,

2001), *Deal or No Deal* (DOND; e.g., Andersen, Harrison, Lau, & Rutström, 2008; Blavatskyy & Pogrebna, 2008; Bombardini & Trebbi, 2012; Brooks, Faff, Mulino, & Scheelings, 2009; Deck, Lee, & Reyes, 2008; Post, van den Assem, Baltussen, & Thaler, 2008; de Roos & Sarafidis, 2010), *Joker* (e.g., Matsen & Strøm, 2010), and *Golden Balls* (e.g., van den Assem, van Dolder, & Thaler, 2012) etc.

The current study utilizes archived data from the DOND game show. There are several desirable features of the DOND game that have made it a popular naturalistic study domain for economists for the past decade. The DOND game involves sequential binary choices between a sure-thing amount and a complex, risky alternative (continue game play) at each round of play. Players in the game are selected based on attributes unrelated to any decision making skill or knowledge. Since the DOND involves actual payouts to players in the tens or hundreds of thousands of rewards (up to $1 million), players are highly motivated to consider their choices at each round carefully and deliberately.

Previous DOND studies mainly aggregated data for all players across all rounds of the game, constructed different risky choice models, and evaluated risk attitudes implied by the estimated model parameters (e.g., Aissia, 2016; Andersen et al., 2008; Blavatskyy & Pogrebna, 2010a; Bombardini & Trebbi, 2012; Botti, Conte, Di Cagno, & D'Ippoliti, 2008; Deck et al., 2008; Mulino, Scheelings, Brooks, & Faff, 2009; Post et al., 2008; de Roos & Sarafidis, 2010). Some of the DOND choice modeling studies also compared different decision models (e.g., Botti et al., 2008; de Roos & Sarafidis, 2010). Yet other studies were designed to detect framing effects (e.g., Baltussen, Post, & van den Assem, 2008; Brooks et al., 2009) or an endowment effect (Blavatskyy & Pogrebna, 2010b) in the DOND game. One DOND study found that advice from the studio audience had little or no impact on the players' decisions (Pogrebna, 2008). Another DOND study reported that players' attitude toward risk is not influenced by the likelihood of winning a large amount (Blavatskyy & Pogrebna, 2008).

We constructed different choice models to account for risky choice behavior in the DOND game. Moreover, compared to previous DOND studies, our study analyzed data aggregated at each round rather than data aggregated across multiple rounds. The by-round analysis enabled us to explore whether choice behavior changed over time. By comparing models based on different decision frames for how players evaluated possible outcomes of the subsequent choices at each round, we were also able to discover how players framed choices at each round in the DOND game.

In the following sections, we briefly describe the DOND game show as well as the archived data used in this study. We report summary descriptive statistics to characterize the game context and observed choices in the game. We then motivate and describe the choice models used under different assumptions of decision frame for subsequent choices and outcomes. Following, we report results from maximum likelihood estimation of model parameters, including a comparison of competing model frames. The final section includes a discussion of our findings and concluding remarks.

2. Description of the DOND game show

The DOND game show originated in the Netherlands in November 2000 and rapidly grew in popularity to eventually air in about 80 countries around the world. The show continues to air in several countries (as of June, 2018), including Algeria, Greece, Macedonia, Moldova and the Netherlands. The original game has morphed into different versions for different audiences, varying the number of cases, amounts of money at stake, number of rounds, and number of cases opened in each round. All versions of the game begin with several sealed cases (over 20) and a single identified player. Each case contains a number indicating a different amount of money sealed inside, which varies from nearly nothing (e.g., $0.01) to

Table 1
Amount sealed in each case shown on the screen for each game version.

UK (22 Cases)		USP (26 Cases)		USS (22 Cases)	
1p	£1,000	$.01	$1,000	$.01	$1,000
10p	£3,000	$1	$5,000	$1	$2,500
50p	£5,000	$5	$10,000	$5	$5,000
£1	£10,000	$10	$25,000	$10	$7,500
£5	£15,000	$25	$50,000	$25	$10,000
£10	£20,000	$50	$75,000	$50	$25,000
£50	£35,000	$75	$100,000	$100	$50,000
£100	£50,000	$100	$200,000	$200	$75,000
£250	£75,000	$200	$300,000	$300	$100,000
£500	£100,000	$300	$400,000	$400	$250,000
£750	£250,000	$400	$500,000	$500	$500,000
		$500	$750,000		
		$750	$1,000,000		

Table 2
Number of cases revealed at each round before final round for each game version.

Round	Number of cases opened		
	UK	USP	USS
1	5	6	5
2	3	5	5
3	3	4	4
4	3	3	2
5	3	2	2
6	3	1	1
7		1	1
8		1	
9		1	

as much as $1,000,000. The player first chooses one case that is identified as the "player's case", which is removed as an option for opening during the game. Each game involves up to nine rounds, in which the player is required to select a specified number of cases to reveal reward values in each round. The player then faces a choice between either accepting a sure monetary amount offered by a banker ("deal") or continuing the game with the remaining unopened cases ("no deal"). All players are paid the actual amount of the banker's offer when they choose "deal"; in the event that the player never chooses to deal through the final round, the player is paid the amount in the (unopened) case selected at the beginning of the game.

This study utilized archival data from the UK and two US versions of the DOND game, including the US primetime (USP) and the US syndicated (USS) versions.[1] Fig. 1 displays the specific details of the UK version of the DOND game structure. The USP and USS versions of DOND are similar in format, but each version uses a different total number of cases, monetary amounts in each case, total possible number of rounds, and the number of cases opened at each round (see Tables 1 and 2 for game format details).

3. Data and preliminary analysis

Archival data of the UK and two US versions of the DOND game show was obtained from separate game fan sites.[2] The UK data in this study consists of 1097 games that aired from October 31, 2005 to July 24, 2009. The USP data encompasses 272 games that aired from December 19, 2005 to May 18, 2009. The USS data includes 300 games that aired from September 8, 2008 to May 28, 2010. Games with non-monetary offers or with non-standard (usually larger) amounts sealed in the cases for special themed shows were

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[1] Two US versions: the primetime game show was always one-hour long and typically aired twice a week in the evening; the syndicated game show was a daily show, always one-half hour in length, and aired weekdays during the day.

[2] UK fan site: http://www.dond.co.uk/deal_or_no_deal_stats.php US fan site: www.heelsrule1988.tripod.com/dealornodeal. (This site is not available anymore.)