

# ToM and Strategic Games: Pre-analysis Plan

May 2020

## 1 Introduction

## 2 Experiment Design and Hypotheses

### 2.1 Design Overview

Our experiments have two parts. In the first part, subjects complete 36 eye-gaze tasks. For each task, they are shown a picture of a set of eyes of a person on the screen. They are also provided 4 adjectives. They need to choose and select the word that best describes the person in the picture is thinking or feeling. This test is used to assess the subject's theory of mind ability.

In the second part, the subjects play various versions of the ring games. There are three sets of the ring games. The first set consists of 8 Kneeland's (2015) original ring games (as shown in Figure 1). In Kneeland's experiment, 23 percent are classified as first order rational (R1), 27 percent are R2, 22 percent are R3 and 22 percent are R4 types. Before introducing altered ring games, we first test whether we can replicate Kneeland's results.

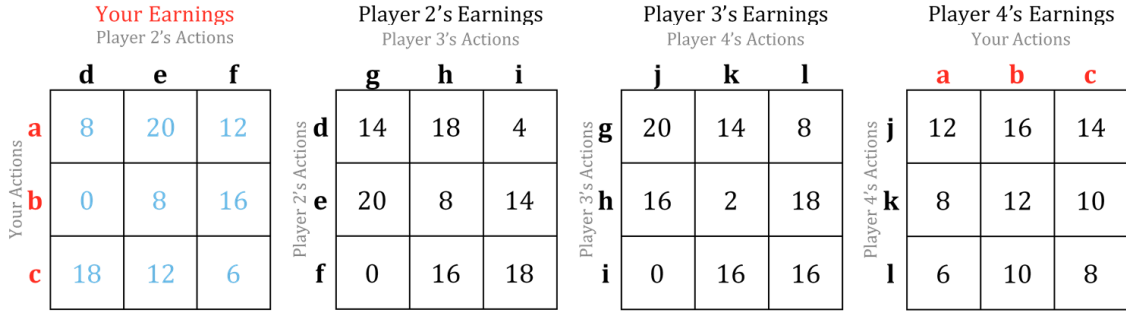
In the second set of 8 games, We introduce some alternations to Kneeland's games. In these games, we create a "focal" strategy for each player at each position. The focal strategies are the ones with the highest averaged payoff and avoiding the zeros (Figure 2). These focal strategies are appealing for each respective payoff box, however, they are never the payoff dominance strategies (except for player 1's position). Our assumption is that if the subject limits his attention only at his own payoff matrix, he will choose the focal strategy. However, if he pays attention to other player's payoff matrix, he will choose a strategy corresponds to the best response based on the payoff matrix that has his attention. Using this method, we will have a stricter separation of the types. For example, an R2 (rational level 2) subject does not only need to be rational at player 4 and player 3's positions, but also need to be second level rational at player 2 and player 1's positions. This will be the main difference between ours and Kneeland's design. The details on identification strategy will be explained in the following section. The first two sets are alternated and randomized in the same block. Subjects are told to play 16 games. They play each player position for each game exactly once.

The third set of ring games consists of 4 ring games. Subjects play against the computers in these games. The computer is set to play R4 strategy. Subjects play as each player role exactly once. The payoff matrix has exactly the same structure as our altered version ring games, except for each cell the payoff number is reduced by 1 (as shown in Figure 3).

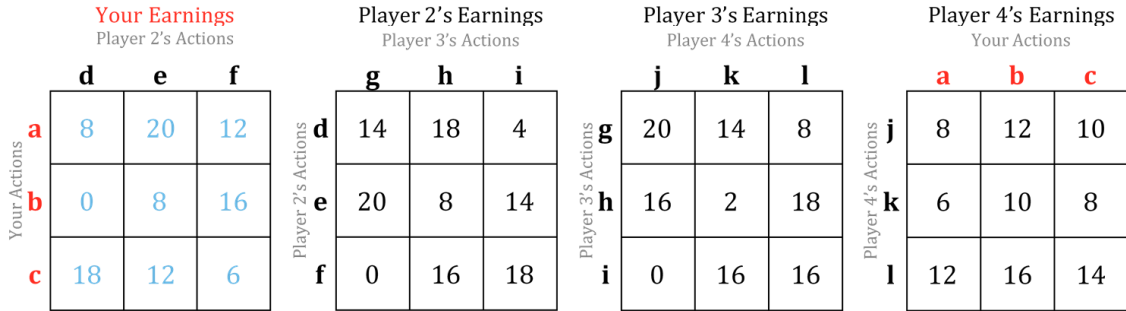
### 2.2 Identification Strategy

#### 2.2.1 For Kneeland's Ring Game

We use the same method described in Kneeland (2015) to identify subject's order of rationality through their choice data in the eight original ring games. The action profile (x,y) represents player's choices in games G1 and G2. The predicted action profiles for each of the types, R1 to R4, is listed in table 1. The subject is assigned to R1 - R4 types if their actions have no more than 1 deviations from the exact matches to the corresponding types. Otherwise, the subject is assigned to R0 type.

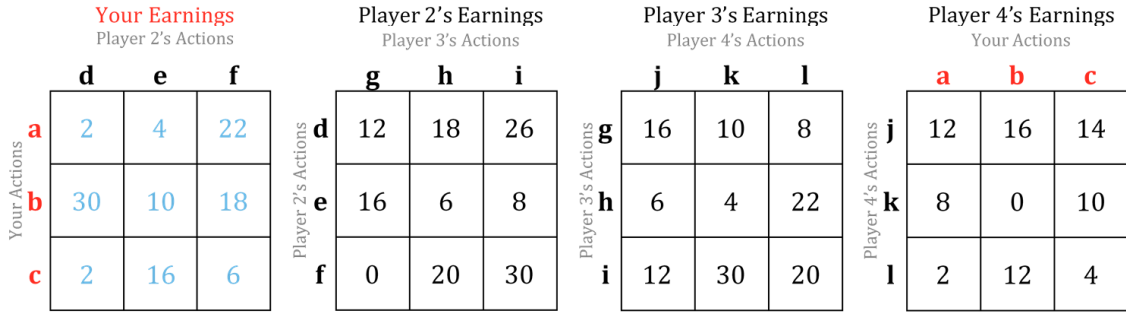


(a) G1

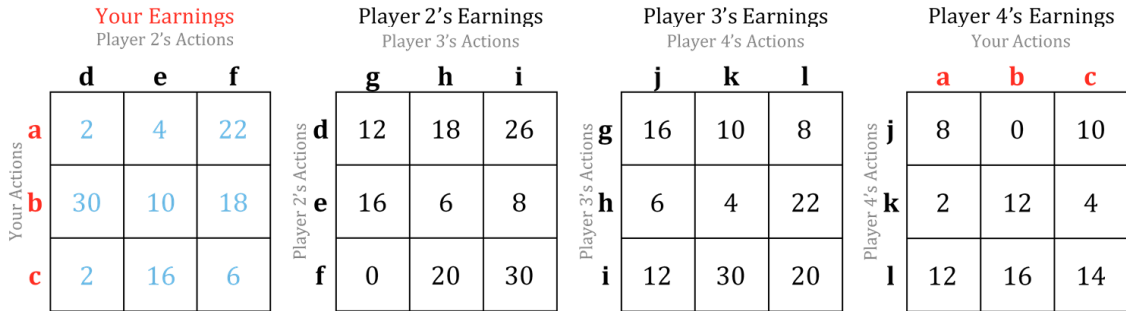


(b) G2

Figure 1: Kneeland's Ring Game



(a) G3



(b) G4

Figure 2: Focal Ring Game

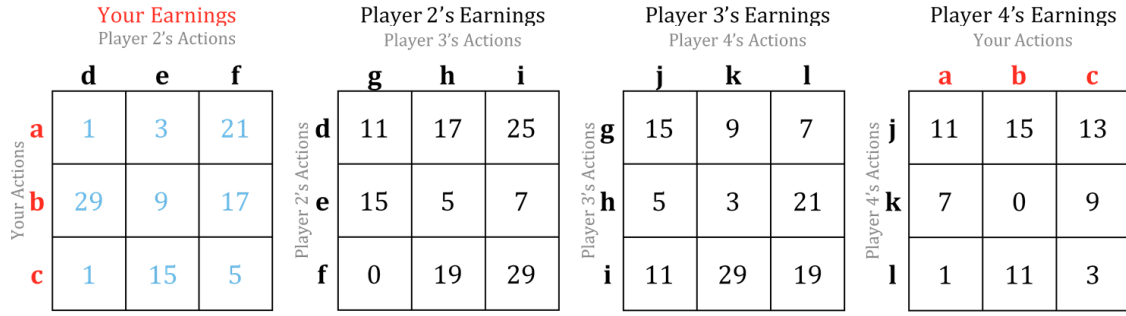


Figure 3: Ring Game against Computer

Table 1: PREDICTED ACTIONS UNDER RATIONALITY AND ASSUMPTIONS ER IN KNEELAND GAMES

Type	Games									
	P1		P2		P3		P4			
	G1	G2	G1	G2	G1	G2	G1	G2		
R1	(a,a)	(b,b)	(c,c)	(a,a)	(b,b)	(c,c)	(a,a)	(b,b)	(c,c)	(a,c)
R2	(a,a)	(b,b)	(c,c)	(a,a)	(b,b)	(c,c)		(a,b)		(a,c)
R3	(a,a)	(b,b)	(c,c)		(b,a)			(a,b)		(a,c)
R4		(a,c)			(b,a)			(a,b)		(a,c)

### 2.2.2 For Altered Ring Game

The altered ring games have similar identification strategy as the original ring game, except that for each lower order rational types (R1-R3) there is a unique action profile that matches the types. To differentiate from the identification that comes from the original ring game, we use L1-L4 to label these types. An L4 subject always plays the rationalizable profiles for games G3 and G4 at any player positions (i.e. (c,a) as player 1, (b,c) as player 2, (a,b) as player 3 and (a,c) as player 4). An L3 subject plays rationalizable action profiles at player 2-4 positions. At player 1 position, since the subject is third-order rational, he limits his attention up until third-order payoff matrix (i.e. player 3's payoff matrix). Since player 3 has a focal strategy (action i), a third-order rational subject will then have action profile (a,a) at player 1's position. For second-rational subjects (L2), he plays rationalizable action profiles as player 3 and player 4. He plays 2nd order rational action as player 2 corresponds to player 3's payoff matrix (i.e. (c,c)), and 2nd order rational action as player 1 corresponds to player 2's payoff matrix (i.e. (b,b)). Lastly, L1 subjects play focal strategy at each player position (i.e. (b,b) as player 1, (a,a) as player 2, (c,c) as player 3 and (a,c) as player 4). The predicted action profiles are listed in 2. Again, we assign each subject to corresponding L-types, allowing 1 error. Subjects are assigned as L0 if their action profiles are not within 1 error range to any of the types.

Table 2: PREDICTED ACTIONS UNDER RATIONALITY AND ASSUMPTIONS ER IN FOCAL GAMES

Type	Games							
	P1		P2		P3		P4	
	G3	G4	G3	G4	G3	G4	G3	G4
L1		(b,b)		(a,a)		(c,c)		(a,c)
L2		(b,b)		(c,c)		(a,b)		(a,c)
L3		(a,a)		(b,c)		(a,b)		(a,c)
L4		(c,a)		(b,c)		(a,b)		(a,c)

## 2.3 Blank Tables and Figures

To test the equality of distribution for Kneeland's results and our results, we will use Kolmogorov-Smirnov test and Kruskal-Wallis test.

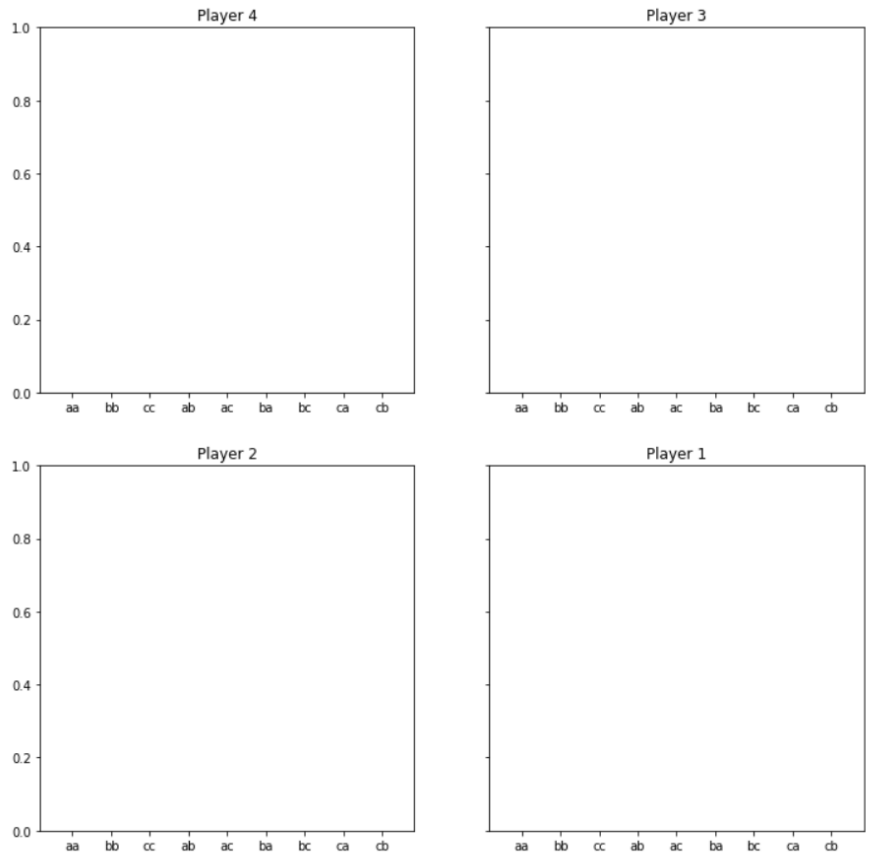


Figure 4: Histogram of subject's action profiles by player position for Kneeland's and Focal ring game

Table 3: Subjects classified by order or rationality, by game

	R0/L0	R1/L1	R2/L2	R3/L3	R4/L4
Kneeland's game					
Focal ring game					
BR ring game					

Table 4: Correlation matrix

	Kneeland's	Focal	BR	Eye gaze test	IQ test	CRT	cognitive score
Kneeland's							
Focal	-						
BR	-	-					

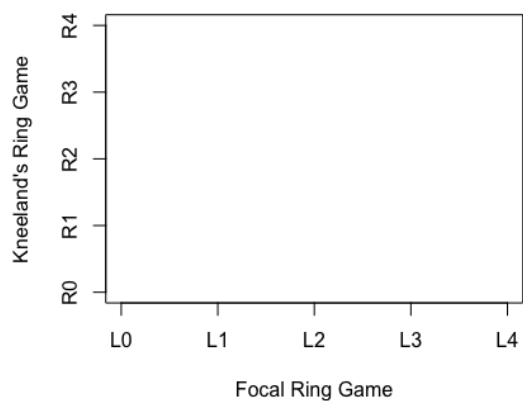


Figure 5: Orders of rationality by Kneeland's game and focal game

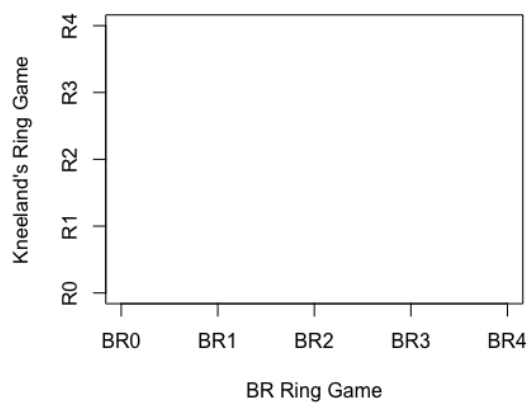


Figure 6: Orders of rationality by Kneeland's game and BR game

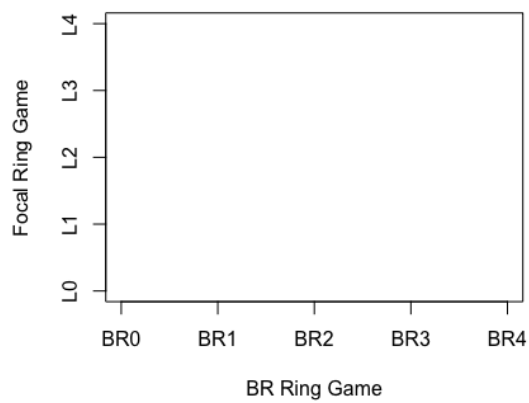


Figure 7: Orders of rationality by focal game and BR game

Table 5: Summary statistics for theory of mind and cognitive tests

	Mean	Median	Max	Min
Eye gaze test				
IQ test				
CRT				

Table 6: Regression results

	Dependent variable: Kneeland's				
	(1)	(2)	(3)	(4)	(5)
Focal		-	-	-	
BR	-		-	-	
Eye gaze test	-	-		-	
cognitive test	-	-	-		
age					
gender					
year in school					
major					