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EXPERIMENTAL "BEAUTY CONTEST" GAME AND SIMULTANEOUS DECISION-MAKING WITHIN VARIOUS GROUPS

Alexander Rymanov[1]

[1]*Department of Corporate Governance and Finance, Novosibirsk State University of Economics and Management, Kamenskaya st., 52/1, 630099, Novosibirsk, Russia*
E-mail: rymanov@yandex.ru

Abstract. The paper examines experimental guessing "p-beauty contest" game. The objective of the study is to conduct an experimental study of simultaneous decision-making by subjects within various groups in the "p-beauty contest" guessing game, and to estimate the influence of various factors. The interaction of factors was evaluated. The contribution to this study extends the analysis of simultaneous decision-making by individuals within various groups to the conditions of the "p-beauty contest" game. The subjects simultaneously took decisions, while being part of a group of three subjects, and as part of a group of six subjects. The results from the experiment showed that the subjects make more rational decisions, being in the larger group. The four-factor (a p-value, a group size, a period, and number of subjects) experimental design shows that the Factors "p-value" and "Number of subjects" main effects were significant. Further, the Factor "p-value" by Factor "Group size," the Factor "Group size" by Factor "Period," the Factor "Group size" by Factor "Number of subjects," and the Factor "Period" by Factor "Number of subjects" interactions were also significant.

Keywords: behaviour, experiment, competition, guessing game, imperfect competition, simultaneous decision-making.

JEL Classification: C91, C72.

1. Introduction

Motivation. Many decisions in the economy are made by participants, formally, or conditionally entering into small groups. It can be competitive firms in the markets with a low level of competition in the industry, participants in competitive procedures (auctions, tenders, competitions) with a small number of participants, as well as employees of one organization.

The competitive character of such relations is correctly described by the model of the game for guessing the "p-beauty contest" guessing game.

"P-beauty contest" game. The "p-beauty contest" game can be described as follows. In each period, the subjects in the game select numbers within the range from 0 to 100. Next, the average value is determined, which is multiplied by the coefficient – "p-value" (in this study, the two values are 0.67 and 0.8). The resulting number is a winning number. A subject whose number is closest to the winning number is the winner. Then the game repeats the required number of periods.

Background literature. The first study from the a game-theoretic model of the "p-beauty contest" game was considered by Moulin (1986).

The first report on a laboratory experiment based on this game was published by Nagel (1995).

A series of field experiments using the "p-beauty contest" game was conducted by A. Bosch-Domenech, R. Nagel, and R. Selten via the readership of the business newspapers Expansion, Financial Times, and the scientific journal Spektrum der Wissenschaft (Bosch-Domenech & Nagel, 1997a, 1997b; Bosch-Domenech, Garcia-Montalvo, Nagel, & Satorra, 2002; Selten & Nagel, 1998). Another field experiment to estimate box-office revenues for movies examined by Court et al. (2018).

Most of the experimental studies of the "Beauty contest game" are devoted to the analysis of the impact of various values of the game parameters: p-value (Nagel, 1995; Camerer, 2003; Ho, Camerer, & Weigelt, 1998), the number of subjects, use the other indicator (median, maximum, minimum) instead of the mean (Duffy & Nagel, 1997).

The problem of measuring steps of iterated reasoning is examined by Stahl and Wilson (1995), Nagel (1995), Stahl (1996, 1998), Camerer and Ho (1999), Gneezy (2005), Rubinstein (2007), Hafner-Burton, Hughes, and Victor

(2013), Camerer, Ho, and Chong (2015), Chen, Micali, and Pass (2015), Cooper, Schneider, and Waldman (2017), Crawford (2017), Gill and Prowse (2016), Volker, Kübler, and Normann (2017), Cartwright, E. (2018), Koch and Penczynski (2018). Li (2017) specified that subjects best-respond to mistaken beliefs about strategies of other subjects. Gorelkina (2018) focused on the expected externality mechanism with a finite number of best-reply iterations.

Moreover, the behavior of individuals and groups is examined by Costa-Gomes and Crawford (2006), Gueth, Kocher, and Sutter (2002), Kocher and Sutter (2005), Sheremeta and Zhang (2010), Kocher, Sutter, and Wakolbinger (2014), Arruñada, Casari, and Pancotto (2015), Hernán and Kujal (2015).

Further, the cognitive hierarchy model is examined by Ho, Noah, and Camerer (2006), Camerer, Ho, and Chong (2004), Prelec (2006), Chen, Du, and Yang (2014), Devetag, Di Guida, and Polonio (2016), Chierchia, Nagel, and Coricelli (2018). Strategic substitutability and strategic complementarity issues examined by Haltiwanger and Waldman (1985, 1989), Russell and Thaler (1985), Cooper et al. (2017).

The contribution in this study extends the above studies on the analysis of simultaneous decision-making by individuals within various groups to the conditions of the "Beauty contest game". Furthermore, the interaction of various factors of the model was evaluated.

Objective of the study. The objective of the study is to conduct an experimental study of simultaneous decision-making by subjects within various groups in the "p-beauty contest" guessing game, and to estimate the influence of various factors.

Method of research. The study was conducted within the framework of behavioral economics. Analysis of variance was used for the analysis of data from the experiment.

2. Experimental design

Subjects of the experiment. Subjects of the experiment were students of a University with the specialization "Management".

Instruction of subjects. At the beginning of the game, the instructor updated the printed instructions with the rules of the experiment. Instructions were read aloud. After that, the subjects asked questions.

The format of the experiment. The laboratory experiment was conducted in a non-computerized form, with the results entered in record sheets.

Groups of subjects and mixing of subjects in groups. The experiment involved two groups of three subjects, and one group of six subjects. Each period groups of three subjects were formed in random. In each period, the compositions of the two groups, consisting of three subjects, changed.

The experiment consisted of two sessions: with different values of the Factor A "p-value" (0.67 and 0.8).

Each session consisted of five periods. In each period, the subjects simultaneously took decisions on the choice of numbers, while being part of a group of three subjects, and as part of a group of six subjects. Economical paired design was used.

Factors. As a result, in the full factorial design, the following factors were used: the Factor A "p-value" (0.67 and 0.8), the Factor B "Group size" (3 and 6 subjects), the Factor C "Period" (1–5), the Factor D "Subjects" (1–6).

Disclosure of information on winning values to the subjects. After each period, the instructor in private informed the subjects of the winning numbers:

a) p-value × the average number for the two groups of the three subjects;

b) p-value × the average number for a group of six subjects.

Therefore, in each period, each subject received information about the winning numbers: the winning number of a group of three subjects (which included the subject) and the winning number of a group of six subjects.

3. Results and discussion

3.1. Average numbers in sessions

Consider average figures selected by subjects (see Table 1).

Table 1. Average figures selected by subjects

		p-value	
		0.67	0.8
Number of subjects in the group	3	22	41
	6	25	34

Consider the session of the experiment in which the value of the Factor A "p-value" is set to 0.67. Subjects selected different numbers from a group of three subjects, and in a group of six subjects. The average for the three-person group was 22. The average for the six-person group was 25. Thus, in groups of three subjects, participants on

average selected smaller numbers than in groups of six subjects.

Consider an experiment session in which a higher value for Factor A is set ("p-value" = 0.8). In this session, on the contrary, in groups of three subjects, participants on average selected higher numbers than in groups of six subjects: 41 and 34, respectively.

3.2. The significance of the main factors and the interaction of factors

The significance of the main factors. Consider the significance of the main factors. The Factor A "p-value" main effect, $F = 37.23$, $p < 0.0001$, was significant.

The Factor B "Group size" main effect, $F = 0.70$, $p = 0.4062$, was nonsignificant.

The Factor C "Period" main effect, $F = 0.30$, $p = 0.8785$, was nonsignificant.

The Factor D "Subjects" main effect, $F = 3.88$, $p = 0.0034$, was significant.

The significance of interaction of factors. Consider the significance of the interaction of factors.

The Factor A "p-value" by Factor B "Group size" interaction, $F = 4.07$, $p = 0.0471$, was significant.

The Factor B "Group size" by Factor C "Period" interaction, $F = 4.14$, $p = 0.0043$, was significant.

The Factor B "Group size" by Factor D "Subjects" interaction, $F = 2.44$, $p = 0.0416$, was significant.

The Factor C "Period" by Factor D "Subjects" interaction, $F = 2.05$, $p = 0.0135$, was significant.

3.3. The main factors

Consider the results of the experiment in more detail.

The Factor A "p-value" main effect. The value of p-value influenced the choice of numbers by the subjects. And in a session with a smaller value of p-value (0.67), subjects selected lower numbers. This was typical for groups of three subjects (see Figure 1), and for groups of six subjects (see Figure 2).

The Factor B "Group size" main effect. In groups with a different number of subjects (3 and six subjects each) at the beginning of the game (the first periods), the differences in numbers were insignificant (see Figure 3).

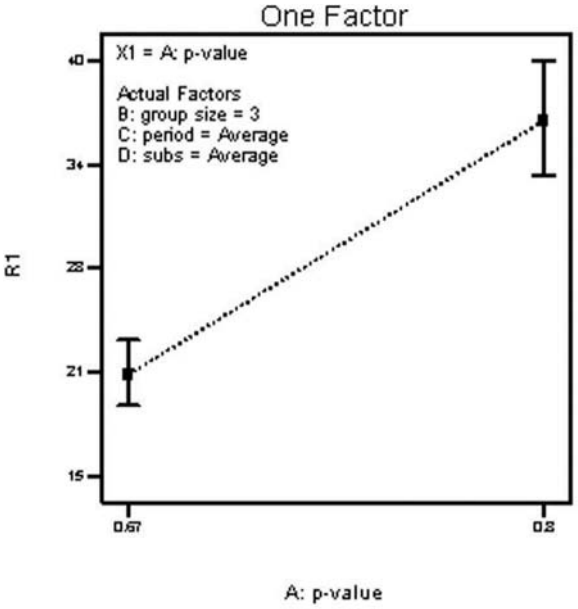

Figure 1. The Factor A "p-value" main effect (a group size = 3)

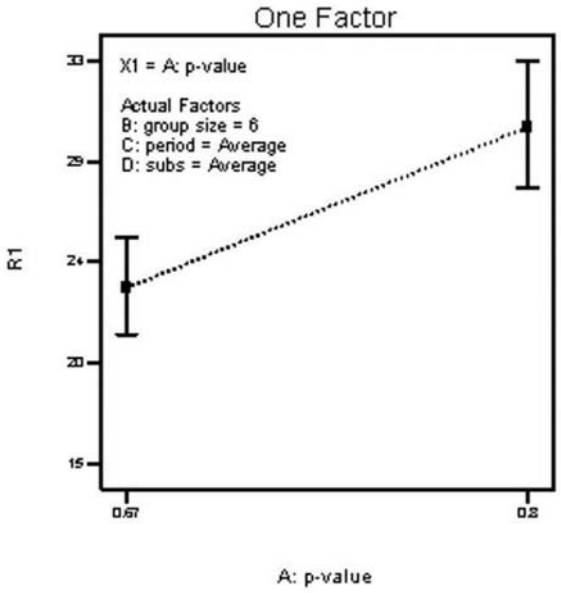

Figure 2. The Factor A "p-value" main effect (a group size = 6)

By the end to the game (5th period), there were significant differences in numbers. Namely, subjects chose lower numbers when they were in the group of six subjects (see Figure 4).

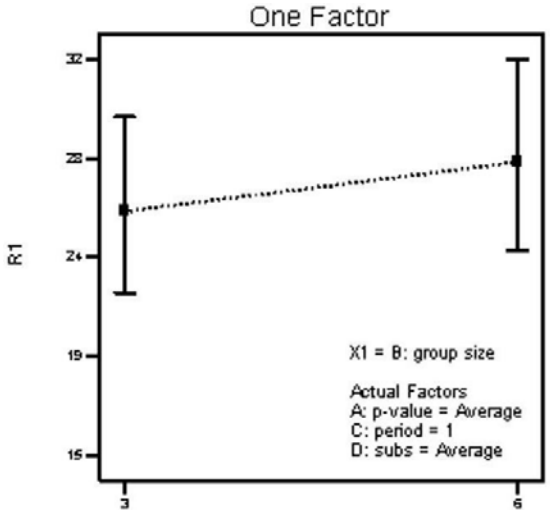

Figure 3. The Factor B "Group size" main effect (the first period)

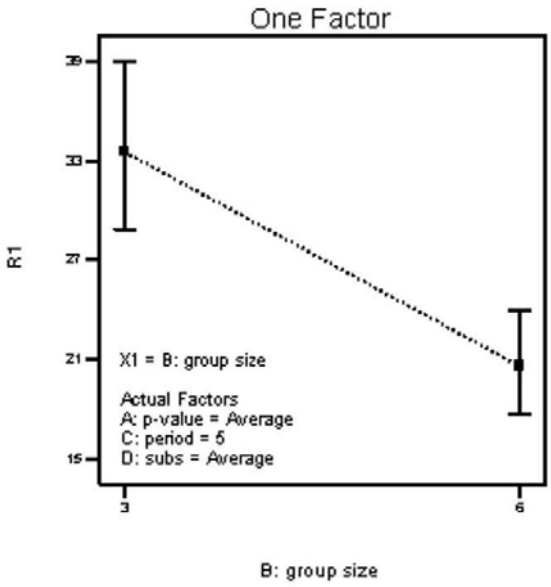

Figure 4. The Factor B "Group size" main effect (the fifth period)

The Factor C "Period" main effect. During each session of the experiment (from the first period to the fifth period), subjects selected higher numbers when they were in a group of three subjects (see Figure 5).

When the subjects were in a group of six subjects, they chose lower numbers from the period to the period (see Figure 6).

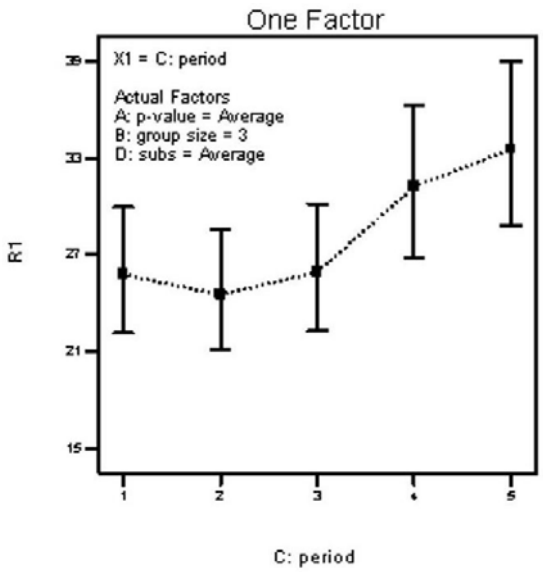

Figure 5. The Factor C "Period" main effect (a group size = 3)

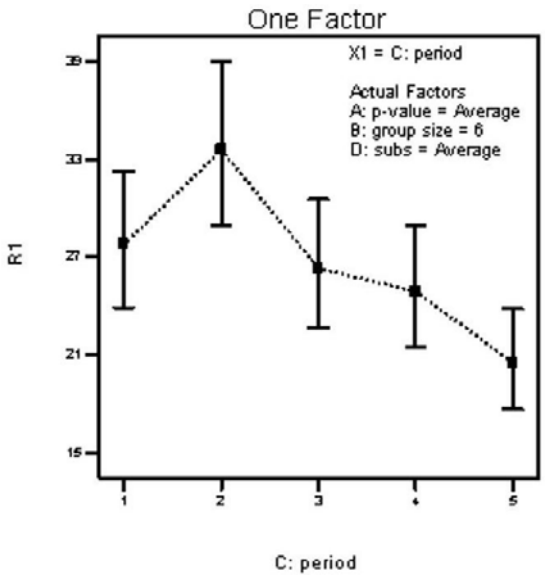

Figure 6. The Factor C "Period" main effect (a group size = 6)

The Factor D "Subjects" main effect. The 4th and 5th subjects chose lower numbers compared to other subjects (see Figure 7).

In addition, although at the beginning of the experiment sessions (the first periods), the selected numbers of subjects varied significantly (see Figure 8), then the selected number of subjects differed slightly by the last periods, and the convergence of the selected numbers of subjects was observed (see Figure 9).

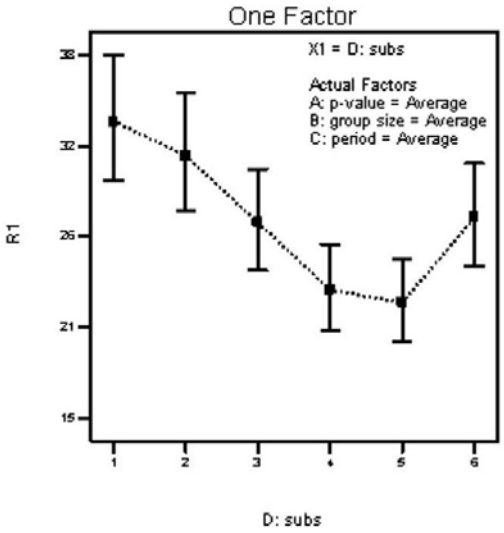

Figure 7. The Factor D "Subjects" main effect

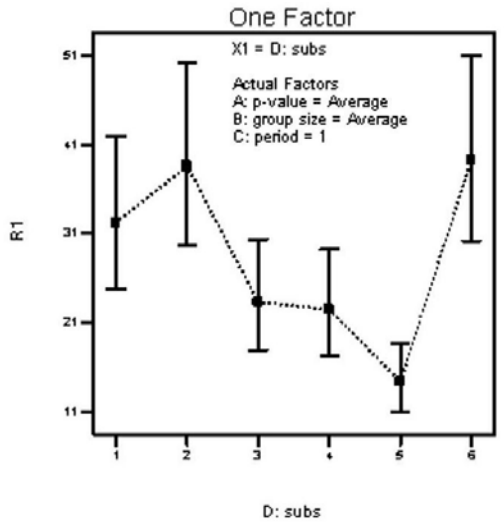

Figure 8. The Factor D "Subjects" main effect (the first period)

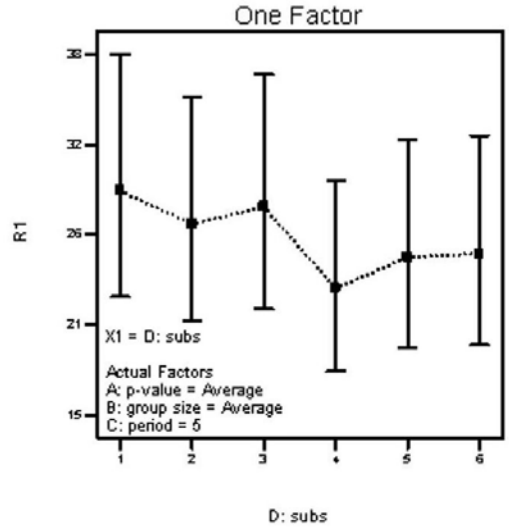

Figure 9. The Factor D "Subjects" main effect (the fifth period)

3.4. Interaction of factors

The Factor A "p-value" by Factor B "Group size" interaction. In groups of three subjects and in groups of six subjects, the difference in the selected numbers for different values of Factor A (p-value – 0.67 and 0.8) is significant (see Figure 10).

A smaller value of p-value (Factor A) influenced the choice of smaller numbers by subjects.

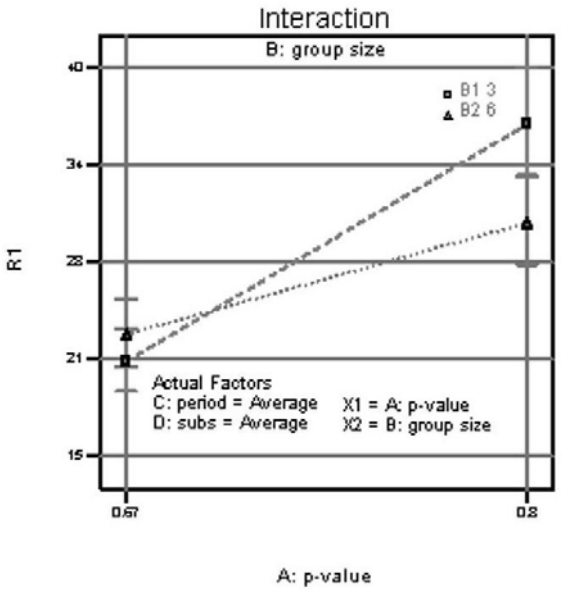

Figure 10. The Factor A "p-value" by Factor B "Group size" interaction

The Factor B "Group size" by Factor C "Period" interaction. During each session of the experiment (from the first period to the fifth period), the results in the group of three subjects increased, for groups of six subjects, declined. For a session with a smaller p-value (0.67), the results were lower (see Figure 11) than for a session with a higher p-value (0.8) (see Figure 12).

Subjects in smaller groups (three subjects), acted less rationally in this case than when they were in larger groups (six subjects).

The Factor B "Group size" by Factor D "Subjects" interaction. Consider the choice of numbers of the subjects in different groups (a group of three subjects and a group of six subjects). In the last periods (4th and 5th periods) of the experiment with a higher value of the "p-value" Factor (0.8), subjects selected lower numbers, being in larger groups of subjects (a group of six subjects) (see Figures 13, 14).

Accordingly, while in a smaller group (groups of three subjects), the same subjects selected higher numbers. At a different value of the "p-value" Factor (0.67), no pattern was revealed.

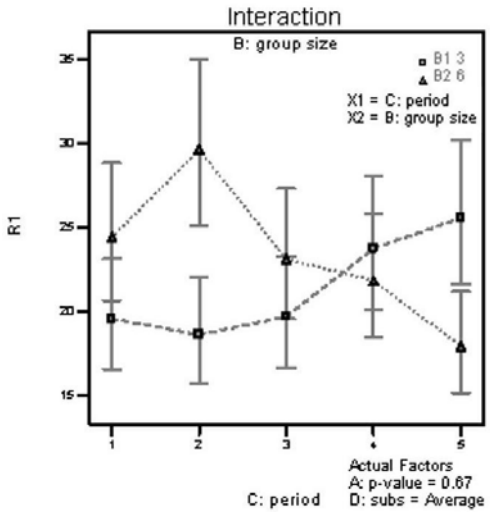

Figure 11. The Factor B "Group size" by Factor C "Period" interaction (p-value = 0.67)

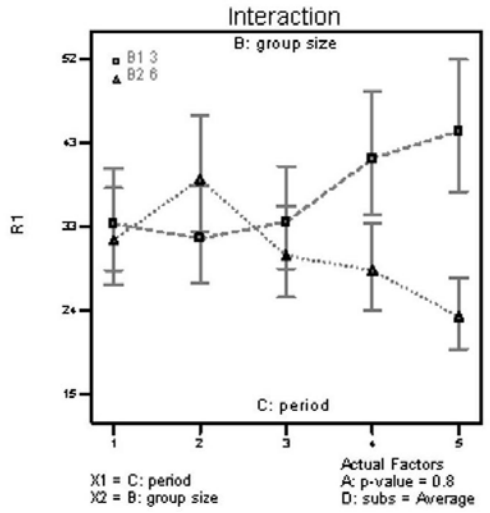

Figure 12. The Factor B "Group size" by Factor C "Period" interaction (p-value = 0.8)

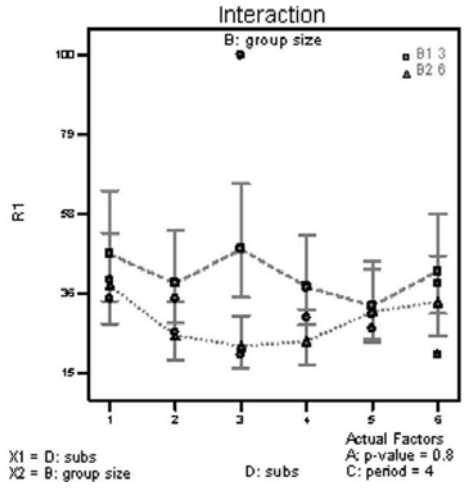

Figure 13. The Factor B "Group size" by Factor D "Subjects" interaction (p-value = 0.8, the fourth period)

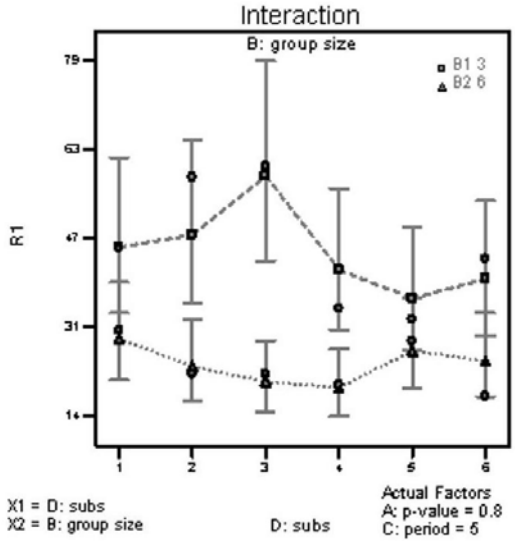

Figure 14. The Factor B "Group size" by Factor D "Subjects" interaction (p-value = 0.8, the fifth period)

The Factor C "Period" by Factor D "Subjects" interaction. At the end of each session (the 4th and 5th periods), the convergence of the numbers was observed (see Figure 15).

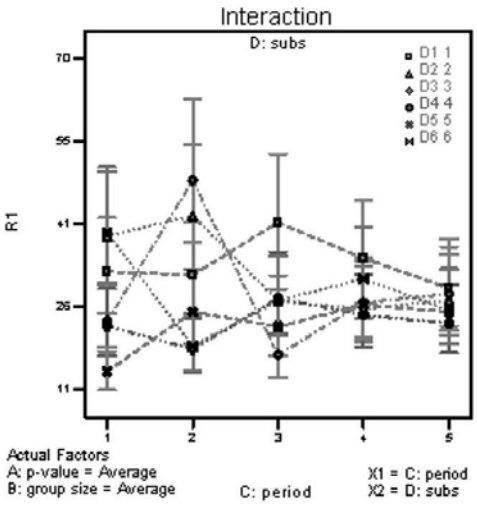

Figure 15. The Factor C "Period" by Factor D "Subjects" interaction

4. Conclusions

The experiment made it possible to assess the behavior of subjects in a difficult situation. This is due to the need for decision-making, being simultaneously in the large group and in the small group. In general, the results of the experiment showed that the subjects make more rational decisions, being in the larger group. The following results were obtained in more detail.

The study estimates various factors of the "p-beauty contest" game. The estimation of the

main effects of factors and the effects of interaction of factors made in the study made it possible to identify significant effects.

In a session with a higher Factor A ("p-value" = 0.8), subjects selected lower numbers when they were in a larger group (six subjects).

Larger groups (six subjects) quickly reached more rational solutions, in comparison with smaller groups (three subjects).

In lesser groups (three subjects) during the sessions (from period to period), irrational behavior of subjects was observed.

The 4th and 5th subjects chose numbers more rationally than other subjects.

The low value of Factor A ("p-value") influenced the choice of subjects by smaller numbers. Subjects intuitively chose smaller values in a session with a lower Factor A value (0.67).

During the experiment, only one of all subjects, being in different groups (3 and six subjects), chose significantly different numbers.

For larger groups (six subjects) at the end of each session of the experiment, there was a descending convergence of the numbers chosen by the subjects. For smaller groups (three subjects), there was an ascending convergence of the chosen numbers.

An additional research may be aimed at studying the behavior of small groups with a different number of subjects.

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Disclosure statement

I have no conflict of interest to declare.

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