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A PLAY AND WIN GAME APPROACH FOR DETERMINATION OF STRATEGIES USED IN GAME THEORY

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Abstract

In the present study, voluntary people of different age groups consisted of children, youngs, adults and olds were asked to play a simple play-and-win game and the results of the games were analyzed to reveal how they behaved in the games to maximize their winning performances. The games were played in two different forms to represent one-shot Prisoner's Dilemma (PD) and iterated Prisoner's Dilemma (IPD). The results showed that age groups in IPD game did not differ from each other in the numbers of games won. On the other hand, gender differences were significant in the children and young groups. Males in children group and females of the youngs group were better in winning a game. In the PD game, the age groups and the genders in these age groups did not differ from each other in the numbers of games won. The evaluation of behaviors of players in general showed that a TIT-FOR-TAT strategy was used by players in combination with pure cooperation to maximize their winnings. We conclude, based on the overall results that cooperation may be the optimal strategy for individual and group success for establishment and maintenance of social dynamics and relationships.

Key Words: Prisoner's Dilemma, Game Theory, Cooperation, Altruism

1. Introduction

Behaviours within the scope of helping are frequently observed in nature and can be pronounced as unilateral helping or altruism where the helpers reduce their direct fitness and as mutual helping or cooperation within species and mutualism between species where partners increase their direct fitness (Bshary, 2010). The cooperative and altruistic behaviors in animals have long been a puzzle for evolutionary biologist (Dugatkin, 2002; Clutton-Brock, 2009). Such behaviours displayed typically by the sterile worker castes in social insects were considered fatal by Darwin (1859) for his theory of natural selection and the central theoretical problem by Wilson (1975) for Sociobiology. The cooperative behaviours between kin (related individuals) can be explained by the kin selection theory but cooperation between unrelated individuals remains a problem and the evolutionary mechanisms that maintain it are still debated. However, reciprocal altruism can be used to understand the logic of the latter case where resource or service exchange among individuals produces a cost but is paid by subsequent benefits by assistance received bilaterally from the partners (Trivers, 1971). Cooperation, in some cases, generates immediate synergistic benefits for the individuals in cooperation and these benefits can exceed the costs of providing assistance as in the 'public goods' games of economists (Bowles and Gintis, 2003; Brown and Vincent, 2008).

Social evolution theory, ecological modeling and evolutionary game theory constitute the three approaches to explain cooperative based behaviours in animals and among them evolutionary game theory provides a good basis for studies on cooperation among unrelated individual (Smith and Price, 1973). Axelrod (1984) used the game theory to explain how cooperation could emerge using the well-known two player games called social dilemmas of which the most widely studied one is the Prisoner's Dilemma (PD). The PD was followed by other game theoretical approaches to explain mechanisms through which cooperation can emerge and be maintained in different settings. The PD is simply based on the assumption that police caughts two people suspected of having committed a joint crime by police and confine them into different rooms, without the possibility to communicate (see Bravetti and Padilla, 2018). Then the police offer each suspect the possibility to confess the crime and defect his partner in exchange for a reduced sentence. In this case, there are 4 different possibilities for the acts of the suspects in response to the offer. If only one suspect defects (not cooperates), the other will get the full sentence but if they defect, both will have the sentence reduced. On the other hand, if they cooperate between themselves and do not confess, then they will immediately given their freedom. The situation can be exemplified in the payoff matrix in Fig. 1.

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		Suspect 1	
		C	D
Suspect 2	C	*R*	*S*
	D	*T*	*P*

Figure 1. The pay-off matrix in a PD game. C: cooperation, D: defection, *R*: reward for cooperation, *S*; the sucker's payoff in cooperation of suspect 1, *T*; temptation to defect and *P*: punishment for defection (*T*>*R*>*P*>*S*).

The matrix above clearly shows that, although the best strategy for each suspect is to defect irrespective of what the other suspect does, *P* is less then *R* points of collaboration. If both suspects choose to cooperate, then *R* will be a higher payoff than mutual defection. However, cooperation is not the safe strategy to choose because a cooperator can be easily exploited by a defector, making each player to behave to maximize their individual payoffs. This scenario is best applied for encounters of two individuals only for once. However, there also exist cases for individuals that have the opportunity to meet again in the future and such cases are termed as Iterated PD (IPD). The IPD allows researchers to understand the basic truths about social behaviour and how cooperation between entities is established and evolves (Mathieu and Delahaya, 2017).

Axelrod and Hamilton (1981) found that if the probability of meeting a given partner in the future was above some critical threshold, although an *always defect* strategy is successful, another strategy called TIT FOR TAT (TFT) which is a conditionally cooperative strategy is a robust solution in IPD. Some other efficient strategies also exist in addition to TFT in IPD cases (Delahaye et al., 2000; O'Riordan, 2000; Li et al., 2011; Press and Dyson, 2012; LI and Kendall, 2013). Cooperation and defection are the two components of all social dilemmas (Dawes, 1980). Experimental evidence showed that players of PD or public good games indeed did not consider the payoffs but placed emphasis on cooperative moves in a bilateral manner, leading a tendency for each individual to be more cooperative in response to increasing rate of cooperative moves of the partner (Fischbacher et al., 2001; Grujić et al., 2010). Former research on PD, social dilemmas and public good games revealed mixed results on gender differences (Balliet et al., 2011; Molina et al., 2013). It is also known that various contextual factors including age, family life, cultural backgroud etc. affect individual choices in social dilemmas. In the present study, we provided empirical evidence on behaviors of individuals of different age groups of both genders by analyzing their behaviors in a simple play-and-win game. The game helped us to **i)** reveal how the players behaved during the game in order to maximize their gains and **ii)** to comparatively analyze how competition, cooperation, selfishness and altruism guided their strategy choices in the game. The game was played by participants in two different types to represent PD and IPD and outcomes of each game were discussed with respect to the game type and characteristics of the player group.

2. Materials and Methods

2.1. The Study Groups

The study groups consisted of individuals (N=160) with friendship, genetic relationship and co-workership interactions (Group 1) and individuals who has no prior relationship of any kind and has no possibility of a second encounter in future (Group II). Each group was further divided into 4 age groups as children (9-15 ages), youngs (16-24 ages), adults (25-50 ages) and olds (51-65 ages). Each age group consisted of 10 female and 10 male voluntary participants.

2.2. The Play-and-Win Game

All participants were asked to play a simple play-and-wind game as pairs of males or females within age groups (see Morgan, 2003). Pairs were given a game card and a coin and were informed about the details of the game (Fig. 2). The game card was obtained by printing 49 circles on a white paper in a 7×7 pattern. The coin was placed on the center circle of the card and the first move was performed by the winner of a toss-up, followed by the first move of the other participant (referred as players in the following text part). The coin could be moved only one circle at a time and only following the lines connecting two circles. This allowed players to move the coin only forward, backward and sidewards. Each player was allowed to perform 10 moves in a single game. The players were asked to reach their goalspots to win a game. The criteria for a single game to finish were to see the coin in a goalspot or to complete all 20 moves of the two players. The game had two possible outcomes as win by one of the players when he/she reached his/her goalspots and to end in a draw if 20 moves were spent without reaching one of the goalspots. Players were not allowed to talk during the game. Players of Group 1 played the game in 10 successive game trials (IPD) and those of Group II played only once (PD).

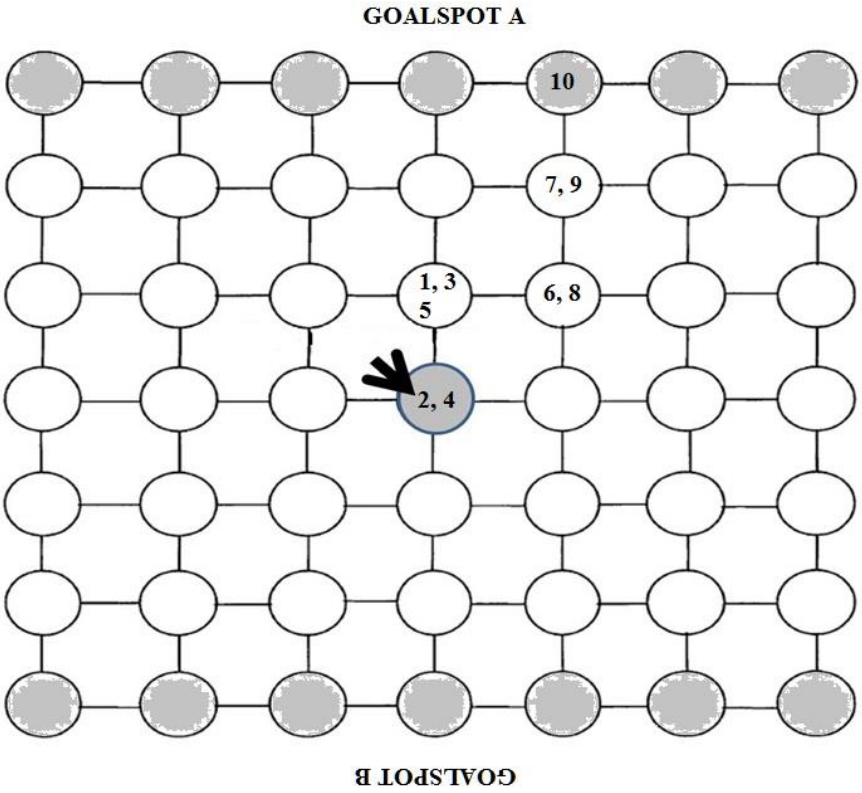

Figure 2. A schematic representation of a game trial. The gray central circle pointed with the black arrow is the starting point of player A. The gray circle lines above and below the card are the two goalspots that the players tried to reach to win a game. The game was won by A in 10 moves. The moves 1-5 and 7-9 correspond to competition, 6 to conflict avoidance and 10 to submitting of player B.

2.3 Data Recording and Analysis

During each game, the forward, backward and sideward moves of each player were counted and recorded. The numbers of total moves in a single game, the number of games ended with a win or a draw were also recorded. Each single game was evaluated based on its outcomes to determine the strategies used by players to win the game. The strategies were categorized as competition, conflict avoidance, submitting and cooperation. Competition might result in a win by one of the players only in cases if the partner cooperates, or it could result in a draw with neither players winning. This latter case was regarded as pure competition and games ended with draws were included in this category. Similarly, cooperation could also be pure which in this case a game could be won by one

player with only 3 moves. Moves performed by one of the players towards the partner's goalspot were considered as submitting. When a player moved the coin, at least in one instance, to the side rather than toward his/her goalspot or toward the partner's goalspot, such moves were recorded as conflict avoidance.

The statistical analysis of the data was performed in GraphPad Prism version 7.00 for Windows. The significance of differences in number of games won by females and males in groups as a whole and in subgroups, of games won by different age groups irrespective of gender, of different strategies recorded during the whole study were statistically tested by t-test and ANOVA test.

3. Results

3.1. IPD

The numbers of different strategies used by players of Group 1 during 10 successive game trials were given in Tab. 1. The mean numbers of different strategies with respect to age groups were given in Fig. 3. There was no significant difference between age groups in the mean numbers of strategies used except the youngs and olds groups comparison for conflict avoidance (ANOVA, $p< 0,05$). The comparison of age groups in terms the number of games won were given in Figs 4-5. The difference between the mean numbers of games won by males (23.5 ± 2.901) and females (22.25 ± 5.573) irrespective of the age groups was not significant (t-test, $t= 0.1989$, $p > 0.05$). The comparison of age groups irrespective of gender also revealed no significant different between the groups (Fig. 4). However, when the differences between males and females in the age groups were compared, the differences were significant in children (t-test, $t= 3.814$, $p < 0.05$) and youngs groups (t-test, $t= 2.51$, $p < 0.05$) but not in adults and olds groups ($p> 0.05$) (Fig. 5).

Table 1. The strategies used by players of Group 1 in IPD.

	Number of different strategies in the initial 5 game trials				Number of different strategies in the last 5 game trials				Total number of strategies			
	Competition	Conflict avoidance	Submitting	Pure cooperation	Competition	Conflict avoidance	Submitting	Pure cooperation	Competition	Conflict avoidance	Submitting	Pure cooperation
Children	532	174	4	10	604	100	5	11	**1136**	**274**	**9**	**21**
Youngs	535	152	6	3	454	135	31	9	**989**	**287**	**37**	**12**
Adults	633	92	10	9	401	56	19	21	**1034**	**148**	**29**	**30**
Olds	713	56	3	8	555	57	6	11	**1268**	**113**	**9**	**19**

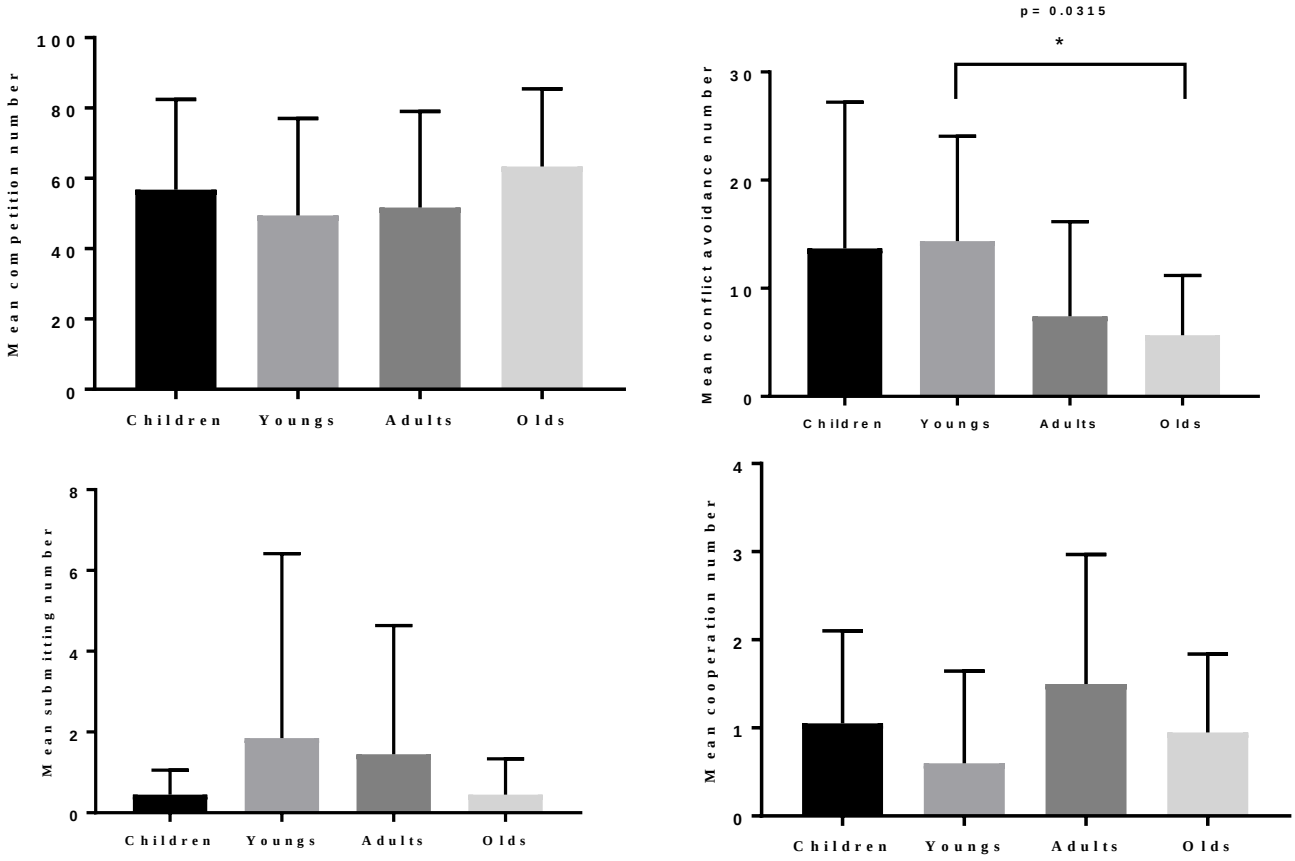

Figure 3. The mean numbers of strategies with respect to ages groups in IPD game. * represents significant differences in mean numbers between the compared groups.

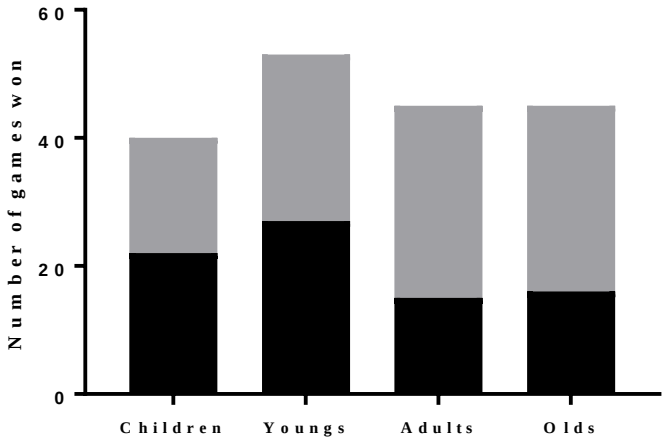

Figure 4. The total number of games won by age groups irrespective of gender. The black parts of the bars represent the initial 5 game trials and the gray bars represent the last 5 game trials. Although the differences between the groups are not significant, adults and olds groups changed their strategies in the last 5 game trials to increase their winning performances.

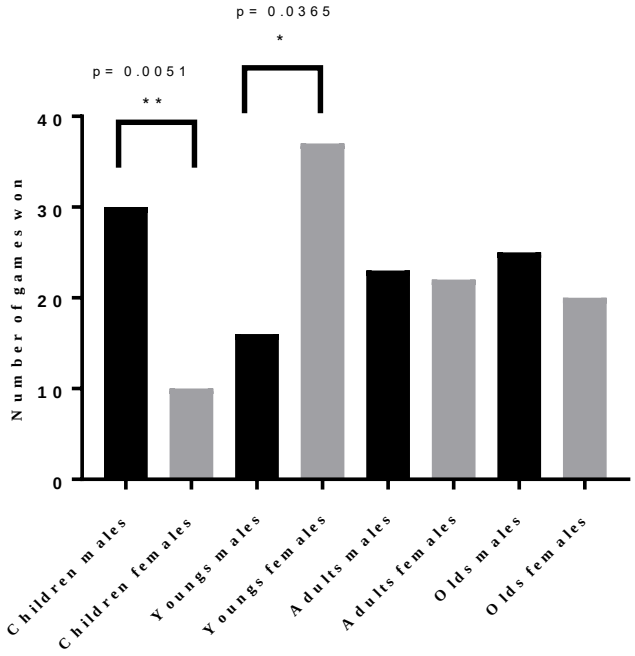

Figure 5. The total numbers of games won by males and females. * represents significant differences in mean numbers between the compared groups.

We further evaluated the overall results of IPD by dividing the 10 game trials in two parts. The first part included the initial 5 and the second part included the last 5 game trials. By doing so, we had the opportunity to see how the type and/or frequencies of the strategies changed and to reveal the increase or decrease tendency in the number of games won during the course of the trials. The comparison of the two parts showed that the strategies employed during the study changed in number either by increasing or decreasing depending on the strategy and the age groups (see Tab. 1). For instance, the frequency of competition strategy decreased in the second part of the game in youngs, adults and olds age groups but increased in children group. Similarly, the frequency of submitting increased in all age groups whereas the frequency of conflict avoidance decreased except olds group where the two parts of the game were almost similar for this strategy. We also included the number of games won by only 3 moves resulting in pure cooperation by the players. Since the number of games won by males and females differed from each other between age groups, we relied on the % frequencies of pure cooperation cases within each group to better compare the groups. The results were given in Fig. 6

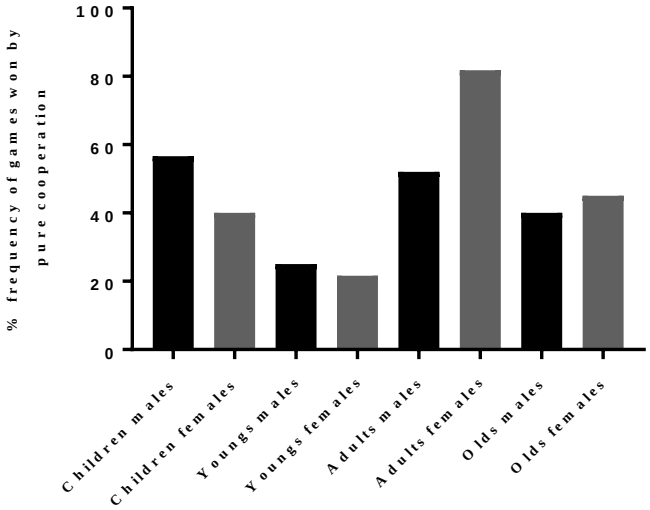

Figure 6. The frequency of pure cooperation cases for males and females in all age groups.

3.2. PD

The results of the games played for once by players of Group II were given in Tab. 2. The comparison of mean numbers of strategies used revealed no significance difference between the groups (ANOVA, $p>0.05$). The differences between the numbers of games won in age groups and by males and females irrespective of the age groups were not significant (ANOVA, $p > 0.05$ for age groups and t-test, $t=0$, $p>0.05$ for males and females).

Table 2. The strategies employed by players of Group II in PD and the number of games won.

	Number of different strategies				Number of games won	
	Competition	Conflict avoidance	Submitting	Pure cooperation	Males	Females
Children	78	12	1	3	3	5
Youngs	125	13	1	0	4	2
Adults	122	20	2	2	1	3
Olds	153	15	2	1	3	1
			TOTAL		**11**	**11**

4. Discussion

The results of PD and IPD games showed that the type of the optimal strategy for individual and group success changed according to the age groups and varied among males and females. Although the age groups did not differ from each other in game winning performances, players of adults and olds groups managed to improve their performances by changing their strategies over the course of the game. For instance, adults won 45 games in total of which 15 were in the initial 5 game trials whereas the resting 30 were in the last 5 trials. This 50% increase in adult performances in winning a game is notable and can be explained easily by the behavioral change occurred after the initial 5 trials. Adults cooperated 9 times for one player to win the game but the cooperative cases increased to 21 during the rest of the game. It is thus reasonable to conclude that cooperation provided a high benefit for adult players. Cooperative cases also increased in other age groups but it is not possible to underline its contribution to overall success of the players. For instance, youngs group increased cooperation by 3 folds in the second part of the games but their winning performances for the two parts were almost the same (27 wins vs 26 wins).

An interesting result was obtained in male-female comparisons. Males in children group were better in winning a game but in youngs group females were more successful (see Fig. 5). In other words, females of the children group and males of the youngs group preferred a competitive strategy. On the other hand, there was no significant different in male and female performances in adults and olds groups. Studies showed that there was no pronounced gender differences in adults in economics based games but males in particular cases were those who were likely to punishe others (Eckel and Grossman, 1996). When the games won by pure cooperation in children group were considered, we saw that 21 cooperative cases occurred. Interesting point in such cases was that females cooperated for 4 times whereas males cooperated for 17 times. The cooperative cases was low for youngs group ($n=12$) but the pattern seen in children group changed for this group. Eight of the 12 games won by one player by pure cooperation belonged to females and 4 belonged to males. The results of a recent study with preschoolers showed that boys were consistently selfish in their contributions throughout the game, whereas girls behaved in a manner consistent with contingent cooperation, specifically generous TFT (Vogelsang et al., 2014). This means that boys interpreted the task as a competition game, while girls interpreted it as a cooperative one.

It is well known in today's social interactions that many people behave conditionally cooperative by cooperating if others also do and maintain cooperation, but lasting cooperation in cheating cases to adopt a punishment strategy by being selfish (Fischbacher et al., 2001). Although such selfish responses do not contribute to individual success, it makes sense because it helps punishment of others. We analyzed some pairs in all age groups and found that when a participant cooperated in a game trial but cheated in the next one, then the following game trial was used to punish the competitor. But if cooperation occurred again by the contribution of the competitor, then the punisher stopped punishment upon the behavioral change of his/her partner. As pointed out by Trivers (1971), cooperative interactions can be regarded as reciprocal exchange of assistance. In our case, assistance is cooperation of players to win the game. Although the highest pay-off can be gained by individuals defecting their cooperative partners, in IPD games, cooperation can persist if assisting behavior occurs reciprocally and partners that are unlikely to reciprocate are avoided (Axelrod, 1984; Nowak, 2006).

Within the order Primates, humans are organisms showing helping behaviors not only to the relatives, those they share a genetic pool with, but also to non-relatives. The cooperative strategy seen in our game players who were non-relatives in most cases can also be regarded as a form of helping behavior since a cooperative move in a game contributes to the others' winning opportunity. Although cooperative behaviors among non-relatives do not fit the classical scheme of natural selection theory of Darwin, there are a couple of ways to explain such cases. Kin selection explains costly acts as benefiting genetic relatives. On the other hand, two theories were suggested to explain cooperation among non-relatives (Tomasello et al., 2012). The first theory originated in the field of evolutionary psychology and is known as "big mistake hypothesis" (Burnham and Johnson, 2005). According to this hypothesis, the altruistic and cooperative behaviors evolved in Pleistocene in small hunter-gatherer groups consisted of mainly individuals with genetic relationships. These behaviors in such groups were selected since they contributed to the fitness of others (mainly relatives), or they might have provided the owner of behaviors to be repaid in future particularly in small groups where all individuals are likely to see each other. In today's modern life, individuals in groups whose members do not know each other or sometimes even do not see others have a tendency to be altruistic and/or cooperative because the mechanisms in the small hunter-gatherer groups are operating in these modern groups. The second hypothesis is known as "cultural selection hypothesis" correspond to a later time period in human evolution and in characterized in bigger social groups (Henrich and Henrich, 2007). The main idea of this theory says that social groups with more altruistic behaviors will override other groups. The difference with the first hypothesis is that the inheritance of behaviors over generations is provided culturally instead of genetical inheritance models. Members of modern groups show a typical behavior by mimiting behaviors of others. If a group is consisted of altruistic individuals, others copy their behaviors and contribute to the group success. In our present case, players of the IPD generally started to compete with each other but switched to cooperation in most cases during the course of the game by which they realized that winning optimization was possible for both players. The cooperation was first employed by one of the players and this costly behavior was copied by the other player and continued until one of the players cheated. When cooperative cases were evaluated, the results showed that the cooperators were both relatives and non-relatives whose behaviors fit the scheme of the above two hypothesis.

Interestingly, players of PD game behaved different than expected because although the best strategy in PD was cheating players in this group won 22 of 40 games of which 6 were won by pure cooperation. Although cooperation is not the optimal strategy in PD cases, there exists empirical evidence showing that individuals cooperate even in their first and only meetings (Henrich et al., 2005; Engel, 2011). As pointed out by Field (2001), cooperation in one-shot PD games is an important experimental finding that needs to be understood to improve insight to the evolution of human behavior. In the absence of a reward, the occurrence of cooperation in one-shot PD cases is thought to be linked to some psychological mechanisms and moral values of the actors. More interestingly, although being selfish was expected to be the best strategy in our PD group, youngs group won the highest number of games even though they had no pure cooperation.

In conclusion, the overall and comparative analysis of our present findings showed that different strategies are used by different age groups and genders to reach a given target but it appears that cooperation may the optimal strategy for individual and group success. The cooperative cases in not only games played with relatives but also by non-relatives show its particular importance for establishment and maintenance of social dynamics and relationships.

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