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Abstract

Theory of mind and individual preferences are important determinants in social decision making. The current study examined in a large sample whether being a cooperative preference type is related with better theory of mind skills. Furthermore, by testing adolescents and adults, we examined the impact of age on this relation. Theory of mind is measured in a Public Goods Game. Results indicate that the cooperative type predicted other players. preference types more accurately in the first round of the Public Goods Game. Regarding age differences, cooperative adults estimated the behavior of players of the same type better than cooperative adolescents. Adolescents show lower cooperation levels and a slower adaption of behavior than adults indicating ongoing development of theory of mind in adolescence.

JEL-Code: C910, D030, D830, H420.

Keywords: theory of mind, social preferences, cooperative behavior, public goods game.

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1 Introduction

Decision-making in social situations often not only depends on a person's own actions but also on the actions of other persons involved. Thus, for making best possible decisions in social environments it is necessary to take the intentions, and emotions of others into account. This enables to predict others' behavior and subsequently adapt one's own behavior. The ability to attribute mental states such as intentions, and emotions to oneself or other persons is referred to as theory of mind (ToM henceforth) (Premack & Woodruff, 1978). Many economic models implicitly presume the application of ToM. Persons are assumed to be able to put themselves into others' shoes to understand their intentions when making a decision (Singer & Fehr, 2005). Another important determinant of decision making in social situations is the heterogeneity of social preferences. Importantly for the purpose of this paper, Fehr & Schmidt (1999) state that persons can be divided into two basic preference types: selfish and other-regarding.[1] The selfish type is only concerned about his monetary outcome. The other-regarding type is also concerned about others' material payoffs (Fehr & Fischbacher, 2002), i.e. she is motivated by various aspects, such as fairness or reciprocity. Fehr & Schmidt (2003) claim that the interaction between both preference types is important to understand behavior in strategic situations. Summing up, outcomes in social situations between two individuals are supposed to depend on individuals' preference types and on their ToM skills. However, surprisingly little is known about how ToM relates to persons' social preferences.

There is a variety of elaborated tasks to assess the development of ToM, i.e. solving social stories (Channon & Crawford, 2000), pictures of the eye regions (Baron-Cohen et al., 2001) or silent video clips of actors expressing mental states (Golan et al., 2006). In the majority of these tasks subjects are rather observers instead of being directly engaged in a social situation. That is, ToM is measured offline (Frith & Singer, 2008). In contrast, strategic games, developed in the field of game theory typically applied in economics, offer the possibility to measure ToM online. In these tasks players are directly involved in social situations where they are required to draw inferences about

[1] Since we apply a Public Goods Game, the other-regarding preference type is named cooperative type henceforth.

the other player's intentions in order to predict her actions (Frith & Singer, 2008). Decision making in strategic and social environments is typically examined with the Prisoner's Dilemma Game (PDG), the Public Goods Game (PGG), or the Ultimatum Game (UG). The PGG is of interest for the present study because the payoffs depend on the group members' choices. The joint payoff in such a situation would be maximized if all players show cooperative behavior by contributing their full endowment to the public good. From an individual point of view, however, the best choice for selfish persons is to contribute nothing to the public good. However, numerous experiments have shown that participants are not as selfish as predicted by the economic standard model. People are rather cooperative and value social factors such as reciprocity or equity and contribute a substantial amount to the public good (for an overview see Ledyard, 1995). Nevertheless, the cooperation is fragile and decreases in repeated play due to the free-riding behavior of selfish participants (Camerer, 2003; Ledyard, 1995).

Hence, in the PGG different behavioral strategies can be observed: those of cooperative and of selfish preference types. According to the literature, the cooperative type is typically willing to cooperate in a prisoner's dilemma game (which induces an equal situation as the PGG) while the selfish type defects (Bogaert et al., 2008). The selfish type can also be induced to cooperate when incentives make cooperation rewarding. Moreover, a cooperative type is willing to cooperate, if she expects that the group member will cooperate as well (Kiyonari et al., 2000). However, the cooperative type is not unconditionally cooperative and stops cooperating when she expects that it will not be reciprocated (Fischbacher & Gächter, 2010). According to the model of Bogaert et al. (2008), cooperation is mediated by signals of group members' trustworthiness. The cooperative type is very sensitive to those signals as it supports the expectation that cooperation will be reciprocated. In this social environment, ToM helps a person to predict how the group member will behave and to signal own cooperative intentions (Ohtsubo & Rapoport, 2006). Hence, to assess trustworthiness and to avoid betrayal the cooperative type tends to have better ToM (Declerck & Bogaert, 2008).

Emonds et al. (2011) investigated differences in social decision making of cooperative and selfish types with fMRI. They found differences in brain

activation for both preference types solving a social dilemma. The selfish type showed more activation in dorsolateral prefrontal cortex, posterior superior temporal sulcus, and precuneus which might indicate that the selfish type is calculative and strategically trying to maximize her payoff. The cooperative type showed more activation in lateral orbitofrontal cortex, anterior superior temporal sulcus, and inferior parietal lobule. This might suggest that the cooperative type is inclined with the perspective of others, and is more norms compliant. Summing up, the cooperation level in the PGG is influenced by the preference type and inferences about group members' likely actions (ToM).

As discussed above, taking others' intentions into account when making a decision is named ToM in psychological research. In economic research the same phenomenon is referred to elicitation of beliefs or expectations. The beliefs about other group members' contributions in PGG are of interest in several studies. As one of the first studies, Offermann et al. (1996) provided independent data on beliefs. They found a weak relation between beliefs and behavior in a step-level PGG. Croson (2007), although not separating for preference types, found a relatively high accuracy of beliefs in a repeated PGG. Fischbacher & Gächter (2010) studied the impact of beliefs and preference heterogeneity on contribution behavior in PGG. They found a positive correlation between beliefs and contributions which is in line with the findings of Neugebauer et al. (2009). Taken economic, psychological, and neuroscience research together, ToM is important in social environments to assess intentions of other involved persons. Particularly, the cooperative type seems to have better ToM to assess signals of trust and to avoid betrayal.

Another important determinant affecting the relation of ToM and social preferences is the development of ToM. In addition to the extensive research in developmental psychology on the emergence of ToM in childhood (Wellmann et al., 2001), recent studies suggest an ongoing refinement of ToM across adolescence until young adulthood (Blakemore, 2008). The period of adolescence is interesting for ToM research since intense cognitive and socio-emotional changes take place. For example, the more complex peer interactions of adolescents require more mature social behavior (Lerner & Steinberg, 2004). The few studies on the topic of ToM development in ado-

lescence found lower scores for adolescents on ToM measures in comparison to adults (Dumontheil et al., 2010; Vetter et al., 2012a; Vetter et al., 2012b). To assess these specific differences sensitive tasks are necessary. Strategic games, like the PGG and the UG,[2] can be applied as a sensitive measure of ToM in social situations. So far, few studies on that topic investigated the relation of ToM or intentions and fairness related behavior by applying the UG. Sutter (2007) investigated the role of ToM by comparing the importance of intentions and outcomes in economic decision making applying the UG. The results showed that children and adolescents paid less attention to intentions of the other player than to outcomes in comparison to adults. Offers were evaluated as unfair even if the proposer only had a limited number of offer possibilities. Thus, intentions of others became more important with age. Also, Güroglu et al. (2009) used the intentionality approach in the UG with a sample in the age range of nine to 18 years. They found that concerns for others' intentions in decision making increased with age. In addition, Sally & Hill (2006) addressed the question whether the development of ToM facilitates cooperation or renders children more selfish. Children played a repeated PDG which induces a similar situation as the PGG. Higher ToM skills led to a higher possibility of cooperation. This implies that the recognition of group member's intention to cooperate is a prerequisite for cooperating in a strategic game. Another study by Fan (2000) revealed that older children showed a higher cooperation level in a PDG than younger children. These results demonstrate the importance of a better developed ToM in strategic games. Summing up, the cooperation level and considering others' intentions in decision making increase with age. These developmental findings suggest that the relationship of ToM and social preferences might be affected by age. However, whether the ongoing development of ToM has an impact on the relationship of ToM and social preferences has not been examined yet.

The major aim of the current paper was to measure differences in ToM, or accuracy of beliefs, between preference types in a PGG. In social decision making, both preference types show different behavioral strategies along with

[2] In this two-person game, the proposer decides how to divide the initial endowment between himself and a second player, the responder. If the responder accepts the proposer's offer, the endowment is divided according to the offer made. If he rejects, both players receive nothing. Especially the behavior of proposers is of interest because they have to take into account the expected behavior and the sense of fairness of responders.

differential neural activation. The cooperative type is typically willing to cooperate in a PDG and is very sensitive to cooperation signals of others. She tends to have a better ToM to assess trustworthiness and avoid betrayal. Hence, we expect that the cooperative type reveals higher estimation accuracy when predicting the other player's behavior in the PGG than the selfish type. The second aim was to measure age difference between adolescents and adults in estimation accuracy and contributions in the PGG. We predicted a better performance for adults than for adolescents.

2 Material and Methods

Participants

The sample consisted of 120 participants: 60 adolescents (23.3% male) between 12 and 15 years (M=13.86, SD=0.92) and 60 young adults (18.3% male) between 18 and 22 years (M=20.23, SD=0.99). All participants spoke German as their first language. The study had been approved by the university ethics committee. Adolescent participants were recruited via flyers or personal advertisement in various German high schools (7th and 8th grade) preparing for university and sports clubs. The adult sample comprised university undergraduate psychology students. Informed consent was obtained before participation from each participant and from either a parent or guardian for participants under 18. Participants of the two age groups did not differ significantly with respect to gender, $\chi^2(1,N=120)=1.2$, $p=.274$, or socioeconomic status (reported household education; mother's education: $\chi^2(1,N=117)=0.185$, $p=.667$; father's education: $\chi^2(1,N=116)=0.327$, $p=.568$).

Public Goods Game

PGG for classification of preference types

We first assessed the preference types of all players. Following the procedure of Fischbacher et al. (2001), we applied the strategy method in a one-shot PGG. Players are told to be randomly assigned to a group of four people. The endowment of 10 tokens could be either invested into a private or a

public good (g_i).The payoff of individual i is given by

$$\Pi_i = 10 - g_i + 0.4\sum_{j=1}^{4} g_j. \tag{1}$$

The economic standard approach would predict complete free riding by all individuals. According to Fischbacher et al. (2001), players make two decisions. First, they make an "unconditional contribution". They are asked how much of their initial endowment they would contribute to the public good independent of the other group members' contributions in a one-shot game. Second, individuals have to fill in a contribution table. This table consists of 11 average contributions the other group members could make in the range of zero up to 10 tokens. Individuals are asked how much they would contribute to the public good given the others' average contribution.

An individual is classified as cooperative if the contribution increases in the average contribution of the group members. For non-monotonic strategies the Spearman rank correlation coefficient between one contribution and the average group contribution has to be both positive and significant at the 1%-level. An individual is also cooperative if the contribution table contains less than four entries of zero and the average contribution is higher than two.

An individual is classified as selfish if being a free rider, i.e., the contribution table contains zero in all entries. Alternatively, at least four entries of the table contain zero and the average contribution is less than two. These individuals were classified as selfish because they could contribute to the public good for strategic reasons. Gächter & Thöni (2005) reveal such strategic cooperation of selfish subjects to be quite common. Hence, individuals who would have been classified as hump-shaped by Fischbacher et al. (2001) could be classified as selfish in this paper. According to Fehr & Schmidt (1999) persons can be basically divided into these two preference types. Since we are interested in the behavior of cooperative and selfish preference types, we follow this approach and separate between these two types only.

Repeated PGG for measuring ToM

After the classification of preference types players played a repeated Public Good Game for four rounds. We chose this number because a pilot study revealed that behavior of preference types does not change significantly after round four. Players were told to play with a human opponent in a partner design who was supposedly sitting in another room. In reality, they played against a computer opponent. The computer strategies were derived from behavior observed in the pilot study. Moreover they were the same for all players in one group. Players were divided into four groups. Group 1 (c-c): a cooperative participant interacted with a cooperative type (homogeneous group). Group 2 (c-s): a cooperative participant interacted with a selfish type (mixed group). Group 3 (s-c): a selfish participant interacted with a cooperative type (mixed group). Group 4 (s-s): a selfish participant interacted with a selfish type (homogeneous group).

Before the game started, as part of the general cover story, individuals received information about the respective group member to draw inferences about the preference type and consequently about his behavior in the PGG. For example, as a cue for the cooperative preference type the following information was given: "Your group member is engaged in social projects for a long time." The endowment of 20 tokens could be either kept in a private account or contributed to a public good. The payoff function is given as:

$$\Pi_i = 20 - g_i + 0.8\,(g_i + g_j)\,. \tag{2}$$

The standard assumption predicts complete free riding by all individuals. Individuals' task was to contribute to the public good and to estimate the opponent's behavior. The second task reveals information about the preference type's estimation accuracy concerning the opponent's behavior. After each round individuals are informed about the average contribution of the group. In addition, individuals had to explain their reasons for contributions and estimations of the opponent's contribution after each round. The experiment was conducted at TU Dresden using the experimental software "z-Tree" (Fischbacher, 2007).

Payment

The classification PGG and the repeated PGG lasted approximately 20 minutes and subjects earned on average EUR 3.00. Participants received their total income as stated in the instructions from both PGG. All participants were paid in cash directly after the experiment. For the psychological ToM measures adolescents received monetary compensation. The adult sample comprised university undergraduate psychology students who participated for course credit.

3 Results

Empirical classification of preference types with PGG

We classified individuals according to the contribution table which indicates the individual's contribution given the average contribution of all group members. In total 48% of all participants were classified as cooperative while 45% were classified as selfish. 7% of the participants could not be classified and are therefore not included in further data analysis. The group composition is reported in Table 1.

	Total		Adolescents		Adults	
	N	%	*N*	%	*N*	%
Cooperative	**58**	**48%**	**27**	**45%**	**31**	**52%**
Group 1 (c-c)	29		14		15	
Group 2 (c-s)	29		13		16	
Selfish	**54**	**45%**	**29**	**48%**	**25**	**42%**
Group 4 (s-s)	27		14		13	
Group 3 (s-c)	27		15		12	
Not classified	**8**	**7%**	**4**	**7%**	**4**	**7%**
	120		**60**		**60**	

Table 1: Empirical classification of preference types.

ToM in repeated PGG

The repeated PGG was applied to measure preference types' ToM during the game online. Before the PGG started, players received information about the other player to support assessing the preference type. According to this information players can decide either to cooperate or to defect. In order to analyze the performance on assessing the group member's type, the estimation accuracy in the first round of the PGG was compared for the cooperative and selfish type in each age group. The estimation accuracy is calculated as 100 (%) minus the difference of player i's estimation of the contribution of player j minus the actual contribution of player j. First, the aim was to compare estimation accuracy of the cooperative and selfish type for the whole sample, not separated into age groups and sub groups. A t-test shows that the cooperative type (M=.81, SD=.15) was initially better able to predict the group member's behavior than the selfish type (M=.73 SD=.17, t[110]=2.37, p<.020, d=.44). After learning the group member's type in round two, there were no significant differences in estimation accuracy between cooperative and selfish types for round two to four.

After analyzing the estimation accuracy for the cooperative and selfish type independent of the age group and the partner's type, we explore the estimation accuracy for each combination of types separately for adolescents and adults. The results can be seen in Table 2.

Preference type	Adolescents			Adults		
	N	*M*	(*SD*)	*N*	*M*	(*SD*)
Cooperative	27	.79	(.15)	31	81	(.14)
Selfish	29	.71	(.19)	25	.76	(.14)

Table 2: Estimation accuracy for age groups.

Estimation accuracy of adolescents

For adolescents a univariate ANOVA revealed significant differences in estimation accuracy between the four sub groups (F[3]=9.46, p<.001, η_p^2 = .90) and is followed by planned comparisons (t-tests). Figure 1 pictures that cooperative individuals in the mixed group showed the highest estimation

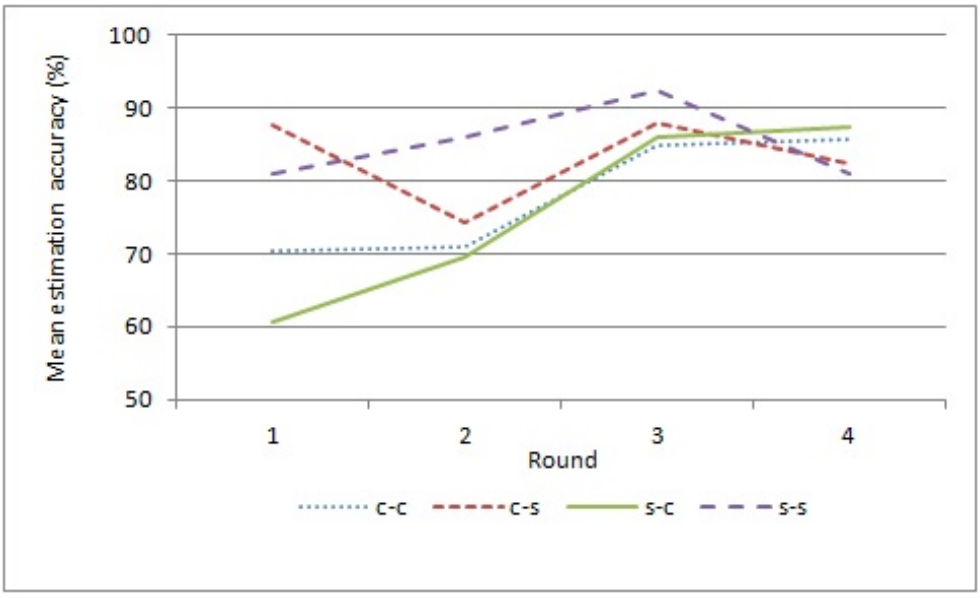

Figure 1: Estimation accuracy for adolescents in the PGG.

accuracy (M=.88; SD=.09) of all groups. The estimation accuracy was significantly higher than the estimation accuracy of cooperative individuals in the homogeneous group (M=.70, SD=.14, p<.001, d=1.53). This suggests that cooperative individuals are better able to recognize the selfish preference type than the own preference type. Comparing the mixed groups, the cooperative type (M=.88, SD=.09) showed a higher estimation accuracy than the selfish type (M=.61, SD=.19, p<.001, d=1.83). This means, that cooperative individuals are better able to predict the behavior of the other type than the selfish type. The selfish type in the homogeneous group (M=.81, SD=.14) estimates the group member's behavior significantly better than the selfish type in the mixed group (p<.003, d=1.20). The selfish type is better able to predict the behavior of the own type than of the cooperative type. There are no significant differences in recognizing the own type between the cooperative and selfish homogeneous groups (p=.053). Taken together, the cooperative type shows the highest estimation accuracy of all groups recognizing the selfish type. Comparing the mixed groups, the cooperative type is better able to anticipate others' type. The selfish type can predict the behavior of a selfish group member more accurate than the behavior of a cooperative group member.

Estimation accuracy of adults

A univariate ANOVA revealed a significant difference in estimation accuracy for adults between the four groups ($F[3]$=3.60, p <.019, η_p^2=.78) and is followed by planned comparisons (t-tests). As can be seen in Figure 2, cooperative individuals in the homogenous (M=.79; SD=.08) and mixed group (M=.83; SD=.18) showed high estimation accuracy. There are no significant differences in estimation accuracy for cooperative adults concerning the group member's type (p=.383). Cooperative adults hence are similarly able to recognize both the own and the selfish type. Comparing the mixed groups, the cooperative type (M=.83, SD=.18) showed a higher estimation accuracy than the selfish type (M=.68, SD=.13, p<.021, d=.96). That is, cooperative adults are better able to predict the behavior of the other type than the selfish type. The selfish type in the homogeneous group (M=.83, SD=.11) estimates the group member's behavior significantly better than the selfish type in the mixed group (p<.007, d=1.25). The selfish type is better able to predict the behavior of the own type than of the cooperative type. There are no significant differences in recognizing the own type between the cooperative and selfish homogeneous groups (p=.272). Taken together, cooperative adults are able to anticipate the behavior of both types equally. In contrast, cooperative adolescents were better able to detect the selfish type. There are no differences in estimation accuracy for the two homogenous groups recognizing the own type.

Comparing estimation accuracy of adolescents and adults

Comparing the estimation accuracy for adolescents and adults, a t-tests shows that cooperative adults in the homogeneous group (M_{adults_round1}=.79, SD_{adults_round1}=.08, M_{adults_round2}=.83, SD_{adults_round2}=.12) estimated the behavior of the group member more accurate in round one and two than adolescents ($M_{adolescents\_round1}$=.70, $SD_{adolescents\_round1}$=.13, $t(27)$=-2.08, p<.047, d=.74, $M_{adolescents\_round2}$=.71, $SD_{adolescents\_round2}$=.17, $t(27)$=-2.22, p<.035, d=.82). However, there were no significant differences in estimation accuracy between adolescents and adults in the other groups and rounds.

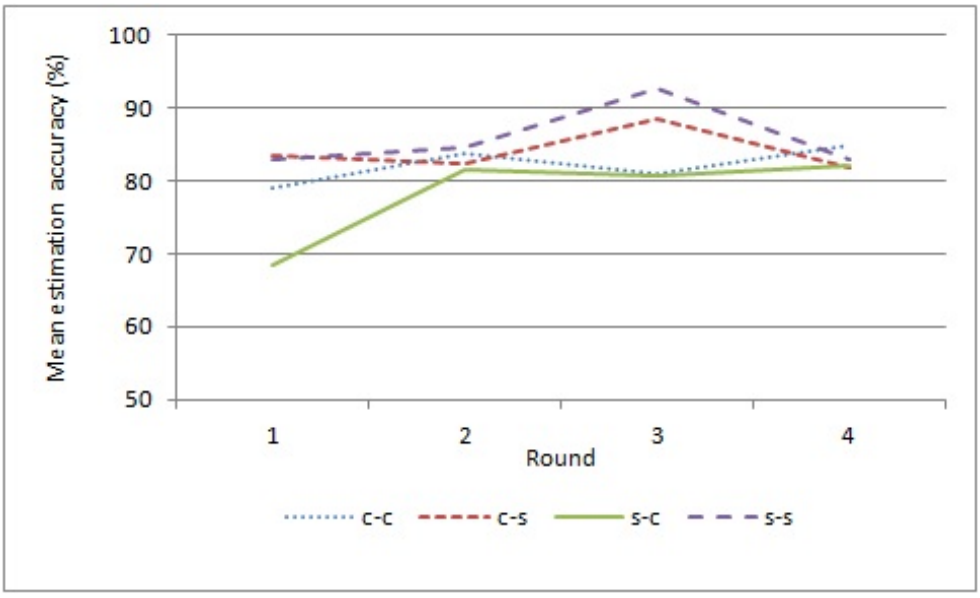

Figure 2: Estimation accuracy for adults in the PGG.

Contributions to the public good

In a next step, we compare the contributions of adolescents and adults to the public good. Figure 3 shows the contributions of the four groups for adolescents and Figure 4 shows the contribution for adults. The cooperation level in the homogeneous cooperative group (c-c) for both age groups was high and stable. Nevertheless, a t-test shows that in the first round cooperative adolescents contributed significantly less to the public good, M=.41, SD=.19 than adults, M=.55, SD=.08, $t(27)$=-2.58, p<.016, d=.95.

A behavioral difference could be observed between cooperative adolescents and cooperative adults in the mixed group (c-s) who played with a selfish type. In contrast to empirical observations, adolescents raised their initial contribution from 39% up to 49% in round two although they played against a selfish type giving a small amount to the public good. Cooperative adults, as expected, reduced their initial contribution of 48% of their endowment to 44% in round two and 29% in round three. This indicates that the majority of individuals are conditionally cooperative. If the group member does not cooperate, individuals adjust their behavior to the selfish type by reducing their contributions. In these groups the last round effect could not be

observed.

The contribution level of selfish participants in the homogeneous group (s-s) is, as expected, low and slightly decreasing. Initially, adolescents contributed 23% of their endowment and adults 26%. Both reduced contributions to 12% in the last round.

A difference in behavior could be observed for selfish adolescents and adults in the mixed group (s-c) playing with a cooperative type. After learning about the group member's preference type selfish adolescents, in contrast to the expectations, reduced their contributions to the public good from 24% to 21% in the second round while adults raised them from 27% up to 44%. A t-test shows that selfish adolescents contributed significantly less, M=.21, SD=.22 in round two than adults, M=.45, SD=.29, $t(25)$=-2.4, p<.024, d=.91. Adolescents raised their contribution in the third round only up to 30%.

Comparing the contributions, adolescents show in general a lower cooperation level and a slower adaption of behavior according to the group member's behavior in all rounds of the PGG than adults.

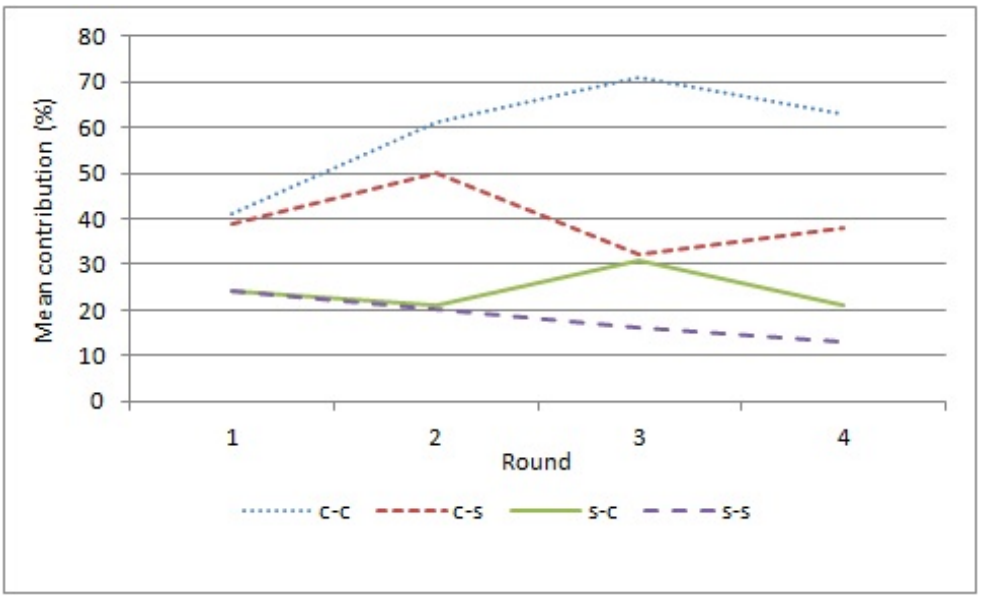

Figure 3: Contribution to the public good for cooperative and selfish preference type for adolescents.

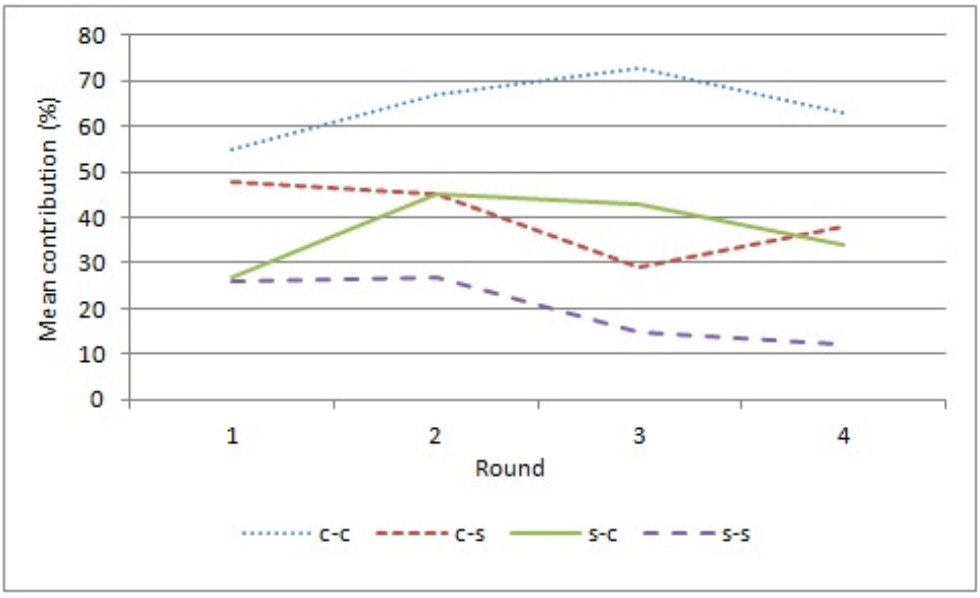

Figure 4: Contribution to the public good for cooperative and selfish preference type for adults.

4 Discussion

The present study examined differences in ToM between preference types in a PGG. Furthermore, age difference between adolescents and adults in estimation accuracy and contributions to the PGG were explored. Overall, as expected, results suggest that the cooperative type has a better ToM than the selfish type. The cooperative type predicted other players' preference types better in the first round of the PGG than the selfish type. Concerning age differences, results indicate that cooperative adults estimated the behavior of players of the same type better than cooperative adolescents.

Estimation accuracy of preference types in repeated PGG

The present paper extends previous studies that found high accuracy of beliefs in a repeated PGG (Croson, 2007) and a positive correlation between beliefs and contributions (Fischbacher & Gächter, 2010). The current study investigated ToM or accuracy of beliefs separated for preference types in a repeated PGG and studied the interaction of both preference types in the PGG regarding ToM. The detailed analysis of preference types' behavior is

important since the collision of preference types in social situations has an impact on the outcomes.

Dividing the sample into a cooperative and selfish type independent of age groups and sub groups, we found that the cooperative type was initially better at predicting the behavior of the group member. This result suggests that initially the cooperative type has an advantage in assessing the preference type and supports the model of Bogaert et al. (2008). They argue that the cooperative type is very sensitive to signals of group members' trustworthiness as it supports the expectation that cooperation will be reciprocated. However, when the preference type is common knowledge as a consequence of the feedback after each round, both preference types are equally able to adjust their behavior.

In the mixed groups, in which a cooperative type estimates the behavior of the selfish type and vice versa, the cooperative type performed better. This result suggests that the cooperative type seems to take the given information about the other player into account to derive the other's type. This nicely dovetails with the model of Bogaert et al. (2008) who found that the cooperative type had a higher sensitivity to signals of group members' trustworthiness. Hence, the cooperative type forms more accurate beliefs about the other's type than the selfish type. This fits to the initially lower contribution level of cooperative players when they play with a selfish type compared to playing with a cooperative type.

Comparing estimation accuracy of adolescents and adults

We found age differences in the cooperative homogeneous group between adults and adolescents in round one and two in the PGG. Adults showed higher estimation accuracy than adolescents. This result implies that adults have more elaborated ToM to interpret cooperative signals than adolescents. The data extends previous results which found age differences in the UG. Sutter (2007) showed in an UG that children and adolescents paid less attention to intentions of the other player in comparison to adults. Also Güroglu et al. (2009) found in an UG that taking the perspective of others into account in decision making increased with age.

Comparing contributions to the public good of adolescents and adults

Preference types show distinct behavioral patterns which is in line with experimental results of Gächter & Thöni (2005). Initial contributions of cooperative players are twice as high as initial contributions of selfish players. Comparing the two cooperative adult groups, players with a selfish group member showed lower initial contributions to the public good than individuals with a cooperative group member. However, there are no differences between the selfish groups. Obviously, the information adults received before the start of the PGG was effective for the cooperative type but not for the selfish type. This fits to the previously described result for estimation accuracy. Possible explanations are: Selfish players do not use given information about the group member for decision making, or they simply do not adjust their behavior to the other player. The latter explanation does not seem to be adequate because selfish players with a cooperative group member raise their contributions to the public good after feedback about the preference type of the other player. However, selfish players do not start to adjust their behavior until they know the other player's type.

Comparing the two cooperative groups for adolescents we could not observe this difference in initial contribution. It seems that the information about the group member does not influence the contribution level of adolescents. This is in line with Sutter (2007) and Güroglu et al. (2009) who found that in the UG that adolescents paid less attention to others intentions than adults. In addition to the existing literature, the current study showed that adolescents obviously did not pay attention to given information about the group member explicitly presented before the game in the instructions.

The initial contribution of adolescents in the homogeneous cooperative group is significantly lower than the initial contribution of adults. Similar results were found for children (Fan, 2000; Sally & Hill, 2006). In both studies younger children showed lower cooperation levels than older children. The present paper tied up to the mentioned studies and extends previous research by showing that different cooperation levels still emerge comparing adolescents and adults. Thus, ToM undergoes further development in adolescence. This is supported by the slower adjustment of adolescents' behavior in mixed

groups of PGG.

5 Conclusions

In social situations the outcome not only depends on own decisions but also on decisions of other persons involved. In such interdependent situations ToM helps to take others' intentions into account for making decisions. Moreover, the outcome depends on individuals' preference type and their innate behavioral strategies. Our results suggest that preference types differ in their ToM skills in the PGG. The cooperative type was initially better at processing the given information about the group member and more accurate in assessing the other's preference type than the selfish type. Further studies could directly address the question how players try to assess the other player's type. This approach could shed light on the question whether players try to infer the type of other players or whether they think others apply similar behavioral strategies. Concerning age difference, cooperative adolescents have lower estimation accuracy in the PGG than adults. Moreover, they show lower cooperation level and a slower adaption of behavior to the group member's behavior in the PGG than adults. Thus, our results indicate that adolescents have not yet reached an adult like ToM.

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