The neurocognitive development of social decision-making

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2. Development of trust and reciprocity in adolescence

We investigate the development of two types of prosocial behavior, trust and reciprocity, as defined using a game-theoretical task that allows investigation of real-time social interaction, among 4 age groups from 9 to 25 years. By manipulating the possible outcome alternatives, we could distinguish among important determinants of trust and reciprocity that are related to the risk and benefit of trusting. The results demonstrate age related changes in sensitivity to outcome for others from late childhood until late adolescence, with different developmental trajectories for trust and reciprocity and differential sensitivity to risk and benefit for self and others.

2.1 Introduction

Adolescence is a developmental period characterized not only by physical and hormonal changes but also by substantial changes in social behavior (Steinberg, 2005). Most notable is change in the nature of social interactions, from competitive to more prosocial behavior (Eisenberg, Carlo, Murphy, & van Court, 1995; Eisenberg, Miller, Shell, McNalley & Shea, 1991; O'Brien & Bierman, 1988; Schaffer, 1996; Van Lange, Otten, de Bruin & Joireman, 1997). Developmental theorists suggest that a prosocial attitude develops during adolescence as a part, or as a consequence of, the development of increased capability for social perspective-taking (Eisenberg et al., 1991, 1995; Kohlberg, 1981; Selman, 1980).

With development, adolescents learn to better understand the perspective of the other and to coordinate between the different perspectives of self, others and society (Martin, Sokol & Elfers, 2008).Perspective-taking is a complex, multi-factor construct; yet there is evidence for at least a weak correlation between perspective-taking and prosocial behavior in adolescence (Underwood & Moore, 1982). Notably, these correlations are stronger for self-report indices than for responses to hypothetical scenarios of prosocial behavior (Eisenberg & Schell, 1986), suggesting that prosocial behavior is best studied using real-life rather than hypothetical social scenarios. Here, we study the development of

prosocial behavior using a two-person interaction game, and we define perspective-taking as the ability to consider outcomes for self in relation to outcomes of others.

Game-theoretical studies can provide an authentic social interaction context in which a 'theory of mind in action' can be investigated experimentally (Gummerum, Hanoch & Keller, 2008). In contrast to studies involving hypothetical scenarios, decisions in games have real consequences. Players allocate real money between themselves and the other player and are paid according to their decisions.Consequently, behavior in games may be more similar to that in real-life contexts. Another strength of using games as a measure of prosocial behavior is that behavior can be operationalized in the same way across age groups (Gummerum et al., 2008). One such game, the Trust Game (Berg, Dickhaut, & McCabe, 1995), is of particular interest for understanding the changes in social cognition that occur during adolescence because it allows us to separately examine two important types of prosocial behavior, trust and reciprocity.

Trust and reciprocity can be considered key elements of prosocial behavior. Proscocial behavior is often characterized by exchanges of favors between non-related individuals (Camerer, 2003). Often these exchanges of favors are separated in time, such that a favor will only be returned on a future occasion. Trust in positive reciprocity at future times is therefore essential to initiate a cooperative interaction. Additionally, reciprocity is necessary to maintain social relationships; if favors are not returned relationships may be short-lived (Lahno, 1995).

In the Trust Game, two anonymous players are involved in dividing an amount of money. The first player, the trustor, has the possibility of dividing a certain amount of money between self and other. However, the trustor can also decide to give all the money to the other who then is able to divide the money; in that case the total amount that is divided between the two players increases. If the second player gets the chance to decide how the money is divided, he or she is confronted with two options—to equally share the money (reciprocate) or to keep most of the money and to give only a small amount to the first player (exploit)[7]. As a consequence, the first player has the possibility of gaining more money if he or she decides to give the money to the second player. However, in doing so the first player also takes the risk that the second player will not reciprocate. Typical findings in the Trust Game are that adults often choose to trust and reciprocate, even when doing so is potentially costly (Berg et al., 1995;

[7] Following Malhotra (2004), we use the terms 'reciprocate' and 'exploit' to describe the two options of player 2. Other common terminology is 'honoring trust' versus 'abuse of trust' (e.g., Buskens, 2003). Note that these labels were not used to explain the paradigm to the participants.

Bolle, 1995; Dufwenberg & Gneezy, 2000; Ortmann, Fitzgerald, & Boeing, 2000; McCabe, Houser, Ryan, Smith, & Trouard, 2001).

In this study, we examine the development of trust and reciprocity in the context of social interaction with anonymous others in the Trust Game. The study is different from studies in which the social interaction examined is with friends, peers or parents (Bernath & Feshbach, 1995; Brett & Willard, 2002; Laursen & Hartup, 2002; Rotenberg et al., 2005; Youniss, 1980). The anonymous method allowed us to examine amore generalized form of trust and reciprocity, underlying all forms social interactions (Rotenberg et al., 2005). The ecological validity of these games has been well assessed in prior work (for a review, see Camerer, 2003). For example, trust behavior in the Trust Game has been shown to be predicted by participants' actual trust behavior in the past (Glaeser et al., 2000) and by their estimation of reliability in real-life situations (Rotenberg et al., 2005).

A prior developmental study using the Trust Game has demonstrated an increase in trust and reciprocity with increasing age among participants of 6 age groups (8, 12, 16, 22, 32, and 68 years; Sutter & Kocher, 2007). With age, participants offered more money and also returned more money; this behavior stabilized between 16 and 22 years of age.

Both trust and reciprocity as defined here are hypothesized to require social perspective-taking abilities, in order to recognize the intentions of the trustor and predict whether the trusted person is likely to reciprocate (Pillutla, Malhotra & Murnighan, 2003; Malhotra, 2004). Based on the theoretical framework that presupposes a relation between development of prosocial behavior and social perspective-taking (Martin et al., 2008), our goals were to investigate the processes related to perspective-taking that may account for changes in trust and reciprocity and to identify the developmental trajectories.

To address these questions, we developed a developmentally appropriate version of the Trust Game (Berg et al., 1995), the Developmental Trust Game (DTG). The DTG is presented in a computerized format and is appropriate for younger participants because the monetary amounts players must divide between themselves are represented with coins instead of numbers and the amounts are relatively small (1–20). The task thus poses a similar level of cognitive difficulty for the youngest children and for late adolescents (for other examples, see Crone & van den Molen, 2004). As in prior studies with adults (Malhotra, 2004), we presented participants with a fixed two-choice paradigm, in which player 1 (the trustor) has the possibility to either trust or not trust the other player. Player 2 (the trustee) also has two choices, to reciprocate and divide money about equally, or to exploit and keep most of the money (see Fig. 2.1).

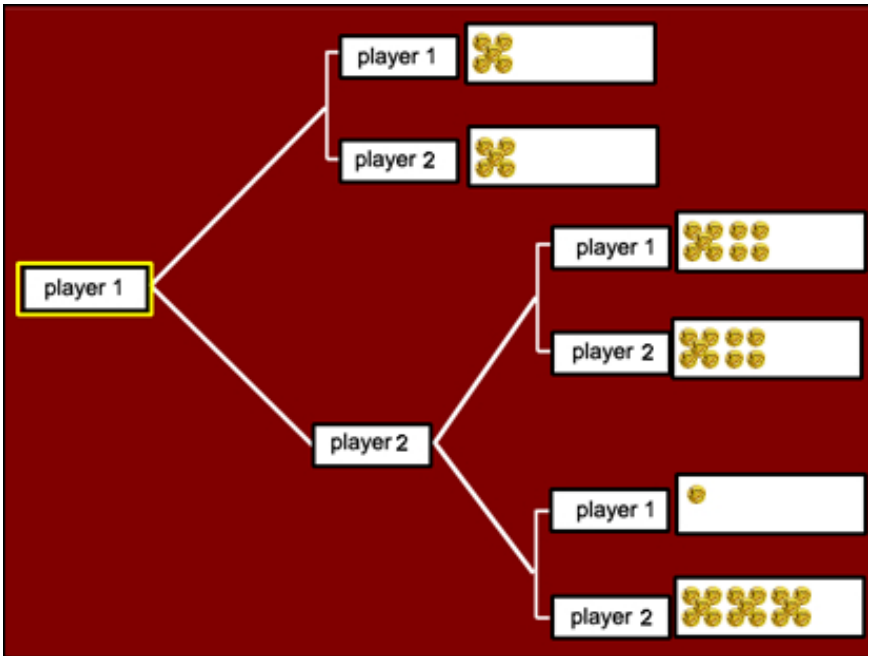

Figure 2.1: The sequence of visual displays that represent the different stages of the Children's Trust Game (DTG). Each round starts with the identification of each player and the designation of player 1 and player 2. Then the game starts and each player is presented with the complete decision tree. At this point player 1 can decide not to trust and the game ends. If player 1 decides to trust, the box with the name of player 2 is highlighted. Subsequently player 2 ends the game by either exploiting or reciprocating. The stakes are represented by a number of 10-cent coins in boxes next to the names of the players. Note that the labels on this figure are for illustrative purposes only and were not visible to the participants.

To examine the role of perspective-taking, defined as the ability to consider the intentions of and consequences for others, we added experimental manipulations to the original Trust Game that may reveal whether participants are taking the intentions of others and consequences for others into account (Pillutla et al., 2003; Malhotra, 2004). We manipulated two factors that may affect trust and reciprocity decisions: the risk of making a decision to trust (risk) and the extent to which a decision to trust is beneficial to the trustee (benefit). Therefore, this design has the potential to reveal more specific developmental changes relative to reports on the average levels of trust and reciprocity among different age groups.

Risk, benefit and perspective-taking: developmental paths in trust and reciprocity.

Trusting always involves a certain amount of risk. When a favor is provided, there is always a chance that it will not be reciprocated. Following Malhotra (2004), we therefore manipulated risk for the trustor by varying the outcome that player 1 can obtain if player 1 decides not to trust player 2 (see Fig. 2.2).

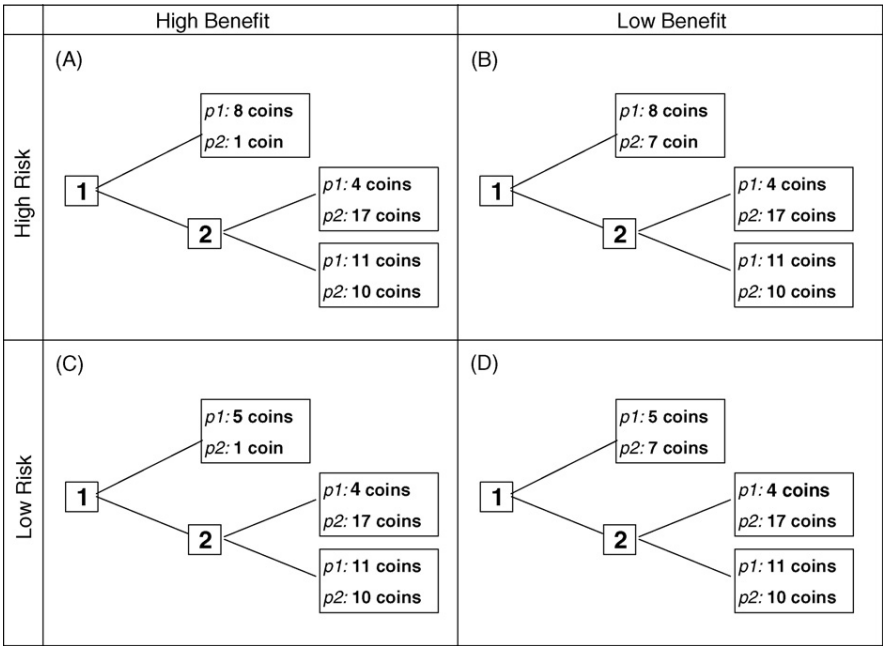

Figure 2.2: Visual representation of the 4 experimental conditions: (A) high risk and high benefit, (B) high risk and low benefit, (C) low risk and high benefit and (D) low risk and low benefit.

In the high-risk conditions, player 1 ensures a high outcome by deciding not to trust player 2. A decision to trust player 2 means that player 1 takes a high risk by forfeiting assurance of this high outcome. In the low risk conditions, player 1 stands to gain only a relatively low outcome. A decision to trust player 2 means that player 1 takes only a low risk by forfeiting assurance of a relatively low outcome (Fig. 2.2).

Consistent with Malhotra (2004), who used a similar manipulation to vary risk, we predicted that player 1's trust decisions would be affected by our risk manipulation. Participants should less often opt to trust player 2 when facing a high-risk decision than when facing a low-risk decision. Because the risk manipulation only affects own outcome for the trustor, and therefore does not

require extensive perspective-taking skills, we expected to see a similar effect of increased risk on player 1's decision to trust at all ages.

With regard to player 2's decisions to reciprocate, we did expect age effects. Increased risk for the trustor may increase the amount of reciprocity by the trustee. In that case the trustee will reciprocate the risk taken by the trustor. Note, however, that it requires the trustee to take the perspective of the other in order to recognize the risk taken by the trustor. Because perspective-taking is thought to develop in adolescence, we expected that that the increase of reciprocity with risk would be larger for adults than for younger participants.

In addition to the risk for the trustor, we also considered the extent to which a decision to trust would benefit the trustee (Malhotra, 2004). Being trusted always involves a certain benefit, which one might or might not reciprocate. Following Malhotra (2004),we therefore also manipulated the benefit for the trustee (player 2) by varying the outcome that player 2 obtains if player 1 decides not to trust player 2. In the low-benefit conditions, player 2 is already assured a high outcome if player 1 decides not to trust player 2. A decision to trust player 2, is therefore only of limited benefit to player 2. In the high-benefit conditions, player 2 receives only a relatively low outcome if player 1 decides not to trust player 2. A decision to trust player 2 is therefore highly beneficial to player 2 (Fig. 2.2).

It is important to distinguish between decisions to trust (player 1 decisions) and decisions to reciprocate (player 2 decisions). With regard to decisions to reciprocate, it seems likely that trustees are more likely to reciprocate when the benefit for being trusted is higher. In other words, we anticipated that participants would value the fact that the trustor takes their benefit into account by subsequently reciprocating. Note, however, that for the trustee to recognize that the trustor took their benefit into account requires perspective-taking. Furthermore, we predict that trustors are more likely to trust when the benefit for the trustee is higher, anticipating the previously proposed increased generosity. Note again that this effect requires the trustor to take the perspective of the trustee; it requires making an inference of the effect of benefit on the state of mind, and subsequent behavior, of the trustee. Thus, in contrast to the risk manipulation, an effect of benefit always requires a certain amount of perspective-taking for both trustor and trustee. Therefore, we expect high benefit to lead to an increase in trust and reciprocity. We expect this benefit effect to be stronger for adults and possibly even absent for the youngest participants.

In addition to the manipulation of benefit and trust we included a control condition to make sure that participants of all ages, especially the youngest, understand the structure of the game. In the control condition it was always best

to trust and to reciprocate, because this would lead to the highest gains for both parties. Therefore, we expect no age differences in trust or reciprocity in the control condition.

We designed the experiment such that participants played multiple games as both trustor and trustee. This design allowed us to examine both trust and reciprocity in the same individual. Importantly, participants were instructed that they were always coupled with a different player.

2.2 Method

2.2.1 Participants

Our sample included 92 participants (49 male) in four age groups: late childhood (M age = 9.43, SD = .59, 12 male, 11 female), early adolescence (M age = 12.35, SD = .56, 17 male, 9 female), middle adolescence (M age = 15.65, SD = .58, 9 male, 14 female) and late adolescence (M age = 22.3, SD = 2.4, 11 male, 9 female). Chi-square analyses indicated that gender distributions did not differ significantly by age. Children and adolescents were recruited from local schools. Adults were university students.

Participants were selected from schools whose populations have common Dutch ethnicity and were mostly Caucasian. Child and adolescent participants were selected with the help of their teachers (children with learning or psychiatric disorders were excluded); informed consent was obtained from a primary caregiver.

2.2.2 Developmental Trust Game

The Developmental Trust Game (DTG, Fig. 2.1) is a version of the Trust Game (Berg et al., 1995; Malhotra, 2004) appropriate for a wide age range. The DTG presents small amounts of money with a number of 10-cent coins in each box of a decision tree.

In each trial, participants were randomly assigned to the role of player 1 (the trustor) or player 2 (the trustee) by a display that was presented for 2500 ms. This screen displayed the first name and picture of both players. After the roles of the participant and the other player were assigned, the trial started. The other player was always matched for age and gender. Participants were told that a different anonymous individual would be paired with them at each trial. However, they actually played against a computer simulation.

Player 1: Trustor. When the participant was assigned the role of player 1 (trustor), the task involved two steps. First, at the beginning of the trial the participant saw the complete decision tree and had to choose between two options: to trust or not to trust. The whole decision tree was represented such

that the player could always see the risk and benefit for each possible choice. If the participant decided not to trust, the coins were divided between the players as represented by the number of coins in each box. If the participant decided to trust, the number of coins in the game was increased and the control of the outcome was in the hands of player 2 (trustee). The choice of the participant (player 1) was presented on the outcome screen by a change in the color of the boxes. The participant then waited for the choice of player 2. The participant was told that the other player made his or her decisions through an internet connection but in reality the choice was made by the computer program after a variable delay of 2–4 s (see Table 2.1 for computerized response pattern). The presentation of this decision was displayed by changing the color of the box representing the choice of the other player. The presentation of the outcome of the trial was displayed for 3 s.

Player 2: Trustee. When the participant was assigned the role of player 2 (trustee), the task also involved two steps. First, the participant awaited the choice of player 1. The participant was told that player 1 would make a decision through an internet connection. In reality, the choice was made by the computer, and the choice was presented within a 3–5 s interval. At this stage, if player 1 chose to trust, the participant was presented with two options: reciprocate or exploit. If player 2 decided to exploit, player 2 would take most of the money and player 1would get fewer coins than in the no-trust option. If player 2 reciprocated the coins were shared equally and both players received more coins, compared to the no-trust option. Risk for the trustor (high versus low) and benefit for the trustee (high versus low) were manipulated, similar to the paradigm used by Malhotra (2004) (see Fig. 2.2). The risk manipulation determined the risk involved in trusting for player 1. If the risk was low, player 1 could potentially lose a small number of coins by trusting player 2 if player 2 chose to exploit the trust (e.g., a loss of 1 coin compared to the no-trust option, see Fig. 2.2 C and D). In contrast, when the risk was high, player 1 could potentially lose a relatively large number of coins by trusting player 2 (e.g., a loss of 4 coins, see Fig. 2.2 A and B). The benefit manipulation determined the benefit for player 2 of being trusted by player 1. In the low-benefit condition, player 2 would get a large number of coins in the no-trust option; therefore the benefit of being trusted was rather small (Fig. 2.2 B and D). The number of coins for player 2 in the no-trust option in the high-benefit condition was small. As a result, there was a large increase of coins (benefit) for player 2 in the case of trust (Fig. 2.2 A and C). The control condition entailed a decision tree in which the option to trust always resulted in a higher pay-off than the no-trust option, regardless of the choice made by player 2.

Table 2.1. Computer simulations of trust and reciprocity for each condition.

	High Risk		Low Risk	
	Trust	Reciprocate	Trust	Reciprocate
High Benefit	47%	73%	60%	67%
Low Benefit	33%	27%	53%	20%

A fixed schedule was used for each of the roles and conditions (Table 2.1), following previous work (Malhotra, 2004). In total, the task consisted of 15 low-benefit–low-risk trials, 15 low-benefit–high risk trials, 15 high-benefit–low-risk trials, 15 high-benefit–high-risk trials, and 10 control trials, for both the trustor role and the trustee role. Consequently, for each participant the task consisted of 140 trials in total. The rounds were presented in random order, and there were breaks after every 20 rounds. The experiment was self-paced and took between 30 and 45 min to complete. At the end of the experiment a screen was presented which displayed the pay-off. The individual pay-off was a variable amount between 3 and 5 Euros. Because previous research with the trust game paradigm has shown that the size of the stakes does not significantly change behavior within different age groups between 8 and 68 years old (Sutter & Kocher, 2007), we were confident to use the same stakes level for all age groups.

2.2.3. Procedure

Child and adolescent participants were individually tested at their school in a quiet room and adult participants were tested in a laboratory, using a standard desktop computer or a laptop. All participants received initial verbal instructions and filled out a questionnaire to assess whether they understood the structure of the game. Subsequently, they played 18 practice rounds to become familiar with the interface. The experimenter personally went over the participant's answers and provided any necessary additional explanation; if necessary an additional set of practice rounds was presented.

Participants were instructed that they were going to play an interactive game with a number of anonymous other players withwhomthey were connected via the internet. It was emphasized that the other participants were unfamiliar to them, coming from other schools or universities participating in the experiment. Only the first name and the first letter of the surname were presented on the screen to identify the other player (e.g. Wouter B.). We used a set of avatars showing silhouettes of real people, instead of real pictures, to prevent their influence on judgments.

Participants were told that at the end of the experiment the computer would randomly select four rounds and the total outcome for the participant in those rounds determined the pay-off. Participants were also reminded that the same rule applied to all the other players they would encounter in the game, to emphasize that their decisions had potential consequences for themselves and others. Participants were paid directly after the experiment. All participants were debriefed at the same time.

Following the DTG, all participants completed the Raven Standard Progressive Matrices (SPM), a non-verbal test of general intellectual ability (Raven et al., 1998). SPM scores were transformed, correcting for age, to IQ estimates. The total duration of the experiment was approximately 65 min.

2.3 Results

2.3.1 Raven SPM

We first examined whether the different age groups differed in general intelligence and the effect of IQ differences on performance. As expected, the number of correct solutions on the Raven SPM task increased with age. Raven scores were z-transformed, using different transformation for different ages, to enable comparisons across age groups. The individuals of all age groups had above average IQs as estimated by transformed Raven SPM scores; 9–10-year olds (M= 118.34, SD = 8.6), 12–23-year olds (M= 123.77, SD = 7.4), 15–16-year olds (M= 122.78, SD = 7.9) and 18–25-year olds (M= 121.30 SD = 10.6). Importantly, the different age groups did not differ in z-transformed IQ scores, $F(3,88) = 2.36$, $p = .075$.

Correlations were computed to determine whether IQ estimates were related to trust and reciprocity patterns. There was no significant correlation between z-transformed Raven SPM scores and the average percentage of trust ($r = .14$, $p = .17$) or reciprocity ($r = .17$, $p = .08$) decisions over all age groups or within each age group (all p's > .08). Nor were there significant relations between raw scores on the Raven SPM and trust or reciprocity (all p's > .1). Therefore these factors were not examined further.

2.3.2. Age differences in trust

Age groups differed in general trust percentage, $F(3,88) = 2.85$, $p < .04$, (see Fig. 2.3). Regression analysis across all participants with age as a covariate revealed a highly significant quadratic trend, $F(2,89) = 7.20$, $p = .006$, $r = .32$, and a mildly significant linear trend, $F(1,90) = 2.02$, $p < .037$, $r = .11$, between age and trust.

To investigate whether there was an effect of risk and benefit on trust decisions, we performed a repeated measures analysis of variance (ANOVA) with risk (high versus low) and benefit (high versus low) as a within-participants factor and age as a between-participants factor. For each participant we calculated the percentage of trust choices in each of the conditions[8]. In our initial analyses we also included gender as a between-participants factor. Because there were no significant effects of gender(all p's > .1) this factor was omitted from further analysis. Similarly we added IQ as a covariate to our ANOVA in order to control for differences in general intelligence. Doing so did not alter our results for the experimental manipulations and it was therefore also excluded in further analyses.

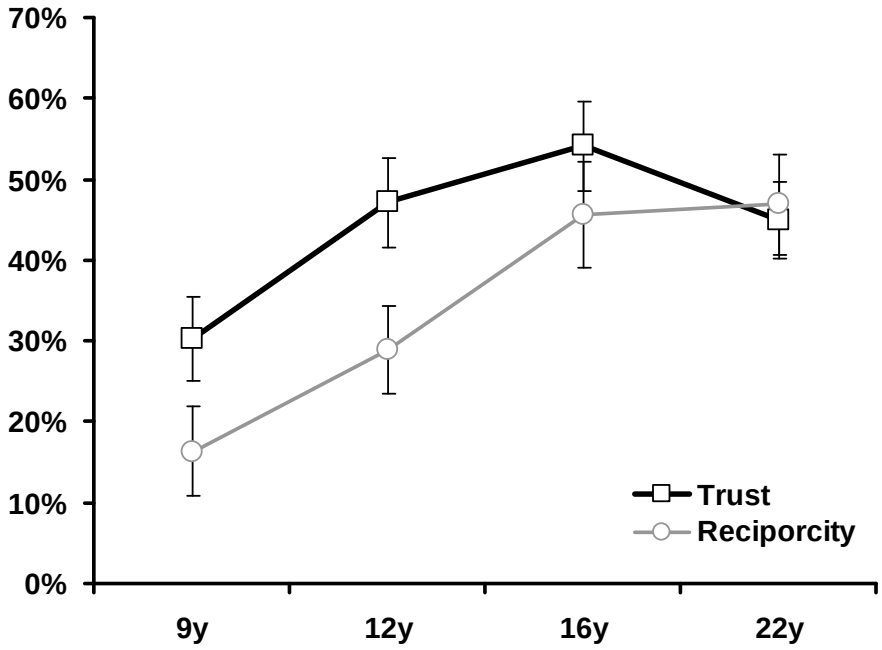

Figure 2.3: The mean percentage of trust and reciprocity decisions over the four experimental conditions for each of the four age groups (error bars represent S.E.).

[8] Because the percentage scores were not always normally distributed (confirmed with Shapiro–Wilk tests, with Lilliefors significance correction), we also analyzed the data using an arcsine transformation. These analyses yielded the same results as the ANOVAs on the untransformed data. To keep the statistics consistent with the behavioral data presented in the graphs, we present the analyses of untransformed data here.

As expected, high-risk trials resulted in fewer trust decisions than low-risk trials, $F(1,88) = 102.68$, $p < .001$. Performance did not differ significantly across age groups, $F(3,88) = 1.66$, $p = .18$. Although we observed no main effect of benefit, $F(3,88) = 2.34$, $p = .129$, we did observe a significant age by benefit interaction effect, $F(3,88) = 5.73$, $p < .001$. To further investigate the nature of the interaction with age we performed separate ANOVAs by age group. As seen in Fig. 2.4, 22-year olds trusted significantly more when the benefit for player 2 was high compared to low, $F(1,19) = 41.43$, $p < .001$, Bonferroni corrected. This difference was not significant for any of the younger age groups (all p's > .1).

In addition, when ANOVAs were performed for each age group separately, an interaction between risk and benefit was found in the youngest group, $F(1,22) = 16.14$, $p < .001$, Bonferroni corrected. Interestingly, 9-year-old children trusted less often when the risk was low and benefit was high, in contrast to all other age groups (Fig. 2.4). Note that no trust in the low-risk–high-benefit condition resulted in more money for player 1 than for player 2 (Fig. 2.2C). It is likely that the youngest age group trusted more often in this condition in order to avoid an outcome in which they got fewer coins than the other.

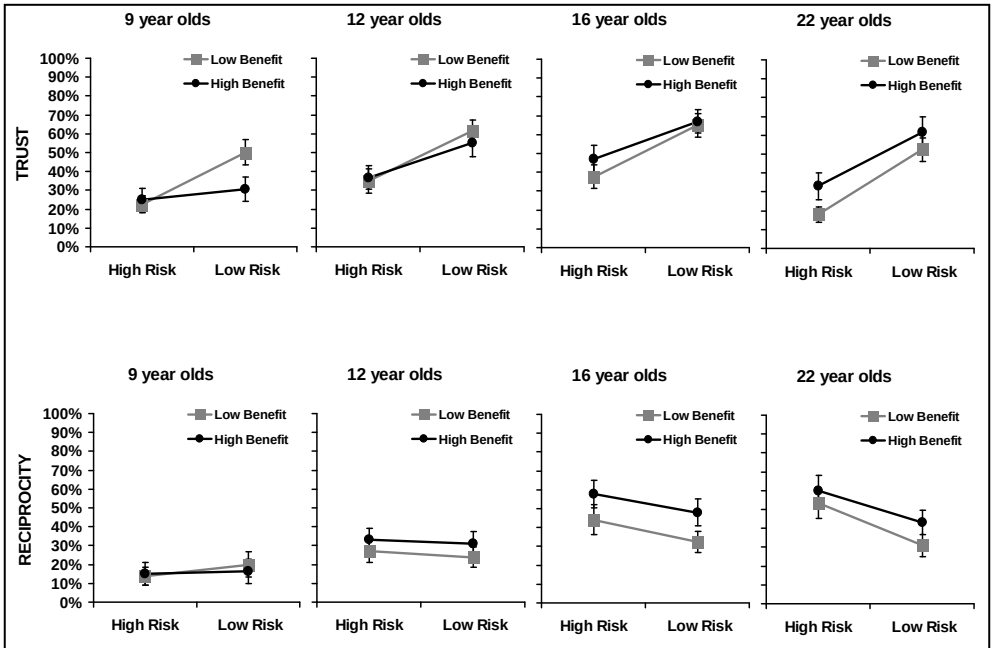

Figure 2.4: The mean percentage of trust and reciprocity decisions in each of the four experimental conditions for each of the four age groups (error bars represent S.E.).

To summarize, in addition to a general increase of trust with age we observed more trust decisions when there was (a) smaller risk for the participant and (b) higher benefit for the other player. The latter effect was only found for 22-year olds, showing that they differentiated more between high and low-benefit settings.

2.3.3. Age differences in reciprocity

Age groups differed in general reciprocity percentage, $F(3,88) = 5.69$, $p < .001$; see Fig. 2.3. Regression analysis across all participants with age as a covariate revealed a quadratic trend, $F(2,89) = 8.55$, $p < .001$, $r = .41$, and a linear trend, $F(1,90) = 16.33$, $p < .001$, $r = .37$, between age and reciprocity.

A repeated measures ANOVA was performed with risk (high versus low) and benefit (high versus low) as within-participants factors and age as between-participants factor for the percentage of reciprocal choices. Again, gender and IQ were dropped from these analyses because our initial analysis revealed no significant effect of gender or IQ on reciprocity (all p's > .1).

As expected, we found an effect of benefit on reciprocity, $F(1,88) = 24.14$, $p < .001$. Participants reciprocated more often when their benefit of being trusted was high rather than low. The effect of benefit on reciprocity differed between age groups: age x benefit $F(3,88) = 4.75$, $p < .005$. Post-hoc ANOVAs revealed that the effect of benefit was found in all age groups (all p's < .001, Bonferroni corrected), except for the 9-year olds who were insensitive to the benefit manipulation, $F(1,22) < 1$, $p = .50$.

In addition, we found a significant main effect of risk on reciprocity, $F(1,88) = 20.77$, $p < .001$. Participants were more willing to reciprocate when the risk taken by the other player was high. The risk effect was qualified by an age × risk interaction, $F(3,88) = 9.24$, $p < .001$. In general, participants reciprocated more often when the risk for the other player was high rather than low, but this difference was only significant for 16- and 22-year olds, $F(1,22) = 10.26$, $p < .005$, and $F(1,19) = 13.23$, $p < .005$, respectively, Bonferroni corrected. There was no risk effect for the two younger age groups (both p's > .1).

To summarize, in addition to a general increase of reciprocity with age we observed that increased benefit for the participant led to increased reciprocity and increased risk for the other player also led to more reciprocity. Increased benefit resulted in increased reciprocity in all age groups except for the 9-year olds, and increased risk resulted in increased reciprocity only for the 16- and 22-year olds.

2.3.4. Control condition

In the control condition we expected high levels of trust as player 1 and high levels of reciprocity as player 2, because these choices resulted in highest gain for both players. The results confirmed our expectations – all groups perform well above chance level – but there were also subtle differences across age groups. A univariate ANOVA with age as fixed factor and percentage of trust choices as dependent variable revealed a group difference, $F(3,88) = 7.95$, $p < .001$, showing that the youngest age group (9–10-year olds) made fewer trust decisions (75%) in their role as player 1 relative to the other age groups, confirmed by post hoc tests (12-, 16-, and 22-year olds; 92%, 95% and 98%, respectively), but they still performed well above chance level. A similar ANOVA for the percentage of reciprocal decisions by player 2 also resulted in significant age differences, $F(3,88) = 3.48$, $p < .02$. Post hoc tests revealed that the 9-year olds (88%) did not differ from the 12-year olds (96%), but the 9-year olds chose to reciprocate significantly less often than the two oldest age groups (16- and 22-year olds, 97% and 98%, respectively).

The lower trust scores by the youngest age group was unexpected, and therefore we reanalyzed the data including only the best performing half of the youngest group, based on a median split of the control scores. A comparison of the high-performing 9-year-old children and the other age groups no longer revealed age differences in the control condition: control trust, $F(3,72) = .72$, $p = .54$, and control reciprocity, $F(3,72) = .65$, $p = .58$. However, the effects on general trust and reciprocity, as well as those on risk and benefit, were not altered when the lower performing 9-year olds were removed from the analyses. This suggests that although there are developmental differences in performance on the control task, these are not related to differences on relevant task behavior.

2.3.5 Pay-off

Because age groups showed differences in types of decisions, they also obtained different amounts of coins during the game. There occurred an increase of total coins with age for the trustor and a decrease for trustee (Table 2.2). This is caused by the fact that trusting yields more coins than not trusting and exploiting yields more coins than reciprocating. Although the patterns of pay-offs differ, there are no significant differences between groups in total earnings, $F(3,88) = 1.67$, $p = .07$. Recall that the players knew that only the pay-off of a small number of rounds would be paid.

2.3.6 Time-on-task effects

Time-on-task effects were examined by dividing the task in three equal blocks. The original ANOVAs were repeated with blocks as an additional within-participants factor of three levels. All reported effects, for trustor as well as trustee, remained significant and did not result in any significant effects for block (all p's > .1). This result shows that participants did not change their patterns of behavior during the task.

Table 2.2 Average pay-off for each role for each age group.

	Player 1	Player 2
9 years	135.3 (7.0)	146.4 (9.3)
12 years	152.4 (7.5)	138.5 (8.5)
16 years	161.0 (8.1)	128.0 (9.0)
22 years	149.8 (8.8)	127.5 (9.8)

2.4 Discussion

This study had two main goals: (a) to develop a new version of the trust game that would allow us to examine the developmental trajectory of trust and reciprocity between late childhood and late adolescence, and (b) to examine the extent to which these processes are sensitive to the risk for the trustor and benefit of being trusted. To this end, the discussion is organized according to these main goals.

2.4.1 Developmental Trust Game

The Developmental Trust Game differs from most previous versions of the Trust Game in three important ways. First, the task was changed into a child-friendly game by making use of small amounts that were visually represented by coins, making sure the task had the same difficulty level for all age groups. Second, the computerized design made it possible to let the participants play multiple games against many different presumed players. This, in turn, made it possible to test each participant in each of the 5 conditions (experimental + control) multiple times, which allowed for robust within participant comparisons. Because we did not find any changes in behavior during the task, we are confident that our results are not due to time-on-task effects, which are possible side-effects of multiple rounds. Third, to our knowledge this is the first study in which participants played the role of trustor as well as trustee in an experiment with multiple trials. The performance of adults resembles the pattern typically seen in past work. That is, participants often chose to trust, suggesting that they expected others to reciprocate, even when decisions were anonymous. Also in line with previous results, adults often reciprocated even when doing so

was costly (Berg et al., 1995; McCabe et al., 2001). We made use of a fixed binary choice paradigm which allowed independent manipulation of risk and benefit in the DTG. As expected, both risk and benefit independently influenced the percentage of trust and reciprocal choices.

In accordance with past work (Malhotra, 2004), we found that adults were sensitive to risk manipulation as trustor and to benefit manipulation as trustee. As expected, participants were more willing to trust when risk was low and more willing to reciprocate when benefit was high. In addition, our study yielded two novel findings.

First, the benefit manipulation also influenced the decisions of the trustor. That is, 22-year olds trusted more often when the benefit for the other player was high rather than low. This increase in trust could be motivated by either altruistic inclination – participants care more about the welfare of the other with age – or by strategic intuition—they expect a higher change on reciprocity and therefore are more willing to trust in service of their own interest. Both explanations rely on more advanced forms of perspective-taking. In both cases the outcome for the other is valued, either intrinsically or instrumentally and integrated in the decision-making process.

Second, in 22-year olds risk manipulation also influenced the decisions of the trustee. In other words, the trustee was more willing to reciprocate when the risk for the trustor was high rather than low. This result suggests that the trustee appreciates the risk taken by the trustor and returns the favor by reciprocating. Playing both roles could have facilitated taking the perspective of the other player, which can be an explanation for the effects of risk and benefit present in the oldest age group but which are absent in a previous study with an adult population (Malhotra, 2004).

Together, the results of this study suggest that for adults trust and reciprocal decisions are not only dependent on their own outcome but also on the consequences for the other. The behavioral pattern of adults provides the framework for understanding developmental changes in trust and reciprocity.

2.4.2 Developmental changes in social decision-making

All age groups scored above chance level on the control task, indicating that the Developmental Trust Game is suitable for developmental research. However, the 9-year-old group scored lower than the adolescent groups. Given that they scored greatly above chance level and given the extensive training and the requirement of correct answers to assessment questions prior to the task, it seems unlikely that 9-year olds did not understand the task. A possible explanation is that 9-year olds did not want to wait for the ‘trust’ outcome and failed to show delay-of-gratification. This is consistent with several studies that show developmental differences on simple delay-of-gratification tasks that last until at least mid-adolescence (Green, Fry & Meyerson, 1994; Green, Myerson & Ostaszewski, 1999). However, future research is needed to investigate this hypothesis in more detail.

Consistent with earlier reports, there was an increase in both trust and reciprocity with age (Sutter & Kocher, 2007). Interestingly, although there were no age differences in overall earnings, children did earn more as the second player by not reciprocating as often as the older age groups. The decrease in earnings with age for the second player could be interpreted as a decrease in 'rational self-interest' behavior and potentially reflects an increase in showing socially desirable behavior. These results are important because they are consistent with prior reports suggesting that there is a general increase of prosocial behavior during adolescence that stabilizes between middle and late adolescence (Eisenberg et al., 1991, 1995; Schaffer, 1996).

In addition to these general developmental changes in trust and reciprocity, we also observed specific changes in trust and reciprocity related to the outcome manipulations as a function of age. First, there were important age related changes in trust decisions. Although all age groups were more willing to trust when the risk was low rather than high, there were age related changes in sensitivity to the benefit of the other player in trust decisions, as was evident for the 22-year olds. The possible motivations to take the consequences of the other player into account require a level of perspective-taking that appears to be present only in the oldest age group (late adolescence). In addition, although all age groups were more willing to trust when the risk was low rather than high, the 9-year-old children showed a slightly different pattern. They were more willing to trust when the risk was low and the benefit was low. This strategy might be explained by the fact that in the low-risk–high-benefit condition, the no-trust option resulted in a relatively higher outcome for player 1 than player 2, a situation which the youngest participants might wish to avoid. As such, this pattern suggests that they were also motivated by competitive motives. This is consistent with previous literature showing that competitive social value orientation – preference for increasing relative gain over others – decreased during adolescence (Van Lange et al., 1997) and another study by Fehr, Bernhard and Rockenbach (2008) showing that children are competitively oriented in social situations.

Second, there were also age related changes in reciprocal decisions. The effect of benefit on reciprocity was present in early adolescence, indicating that in this period basic reciprocity emerges. In contrast, 9-year-old children do not yet show this type of behavior. From middle adolescence onwards, amore elaborate form of reciprocal behavior appeared. At this point participants also chose to reciprocate the risk taken by the other player (trustor).

A comparison of age differences in sensitivity to risk and benefit for trust and reciprocity suggests that, besides a general increase of prosocial behavior, considering the outcomes for the other becomes more important in social decision-making during adolescence. Here this type of perspective-taking was examined in the context of prosocial behavior, but it should be noted that increased perspective-taking ability can also be used for strategic or anti-social purposes, such as lying and cheating (Rotenberg, 1991; Beate & Frith, 1992).

To our knowledge, there are no experimental studies that have investigated both the development of on-line prosocial behavior and development of perspective-taking during adolescence. Prior studies have suggested that there are subtle developmental changes on experimental measures of perspective-taking during adolescence (Choudhury, Blakemore, & Charman, 2006; Duhmontheil, Apperly & Balkemore, 2009), but these studies did not examine perspective-taking in a social context. Our data also suggest that later in adolescence there is no general increase in prosocial behavior but rather a sophistication of prosocial behavior. Although trust and reciprocal behavior were at a stable level at mid-adolescence, there were still changes in the effect of the outcome manipulations until late adolescence. Thus, with age, prosocial behavior becomes more context dependent, leading to more prosocial behavior in one context (e.g. a high-risk and high-benefit situation) but less in another (a low-risk and low-benefit situation).

Finally, our current results do not speak to the issue of a presumed relation between behavioral measures of taking into account the intentions of and consequences for the other and other direct measures of perspective-taking. It would therefore be interesting for future studies to include additional measures of perspective-taking. One way to shed more light on this research question would be to ask participants to think aloud while performing these tasks. Furthermore, it would be interesting to extend the present research involving a generalized other by studying interaction with specific others such as peers or parents.