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The development of adolescent trust behavior

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ABSTRACT

Interpersonal trust shows developmental changes during adolescence. The current study used a longitudinal design to examine the development of trust behavior, the presence of gender differences in these developmental trajectories, and the association between individual differences in these developmental trajectories and perspective-taking abilities. The participants played a trust game with a hypothetical trustworthy partner and a trust game with a hypothetical untrustworthy partner in 3 consecutive years (M_{age} = 12.55 years, M_{age} = 13.54 years, and M_{age} = 14.54 years). Concerning the development of trust behavior, the results showed an age-related increase in initial trust behavior and indicated increasingly adaptive trust behavior with age during untrustworthy interactions, whereas no evidence was found for age-related changes in the adaptation of trust during trustworthy interactions. Gender differences were found for the development of initial trust behavior (with boys showing a stronger increase with age than girls), whereas no support was found for the presence of gender differences in the developmental trajectories of adaptive trust behavior during trustworthy and untrustworthy interactions. Furthermore, no evidence was found for perspective-taking abilities to explain individual differences in the development of initial trust behavior or in the development of adaptive trust behavior during trustworthy and untrustworthy interactions. The results provide evidence that, during adolescence initial trust behavior increased with age, more for boys than for girls, and that both boys and girls showed a stronger adaptive response to the untrustworthy partner but not to the trustworthy partner.

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Introduction

Trust plays an important role during social interactions and social relationships (Lewicki & Wiethoff, 2000). Trust development starts at an early age and forms a crucial component of adaptive psychosocial functioning during childhood (Erikson, 1963). Trust remains essential during adolescence, a time when peer relationships are being established and become more important and grow more complex (Brown & Larson, 2009; Erdley & Day, 2017). There are several cross-sectional studies showing that trust behavior continues to develop throughout adolescence (Lee et al., 2016; Sutter & Kocher, 2007; Van den Bos et al., 2012). However, age-related changes in trust behavior have not been examined using longitudinal designs, which have the advantage of studying within-person change. In the current study, using a longitudinal design, we examined the development of adolescent trust behavior, whether these trajectories differ for boys and girls, and whether developmental trajectories of trust behavior are related to perspective-taking abilities.

Adolescence is an important developmental phase for the sociocognitive processes that underlie trust behavior. These include social learning processes, the ability to take the perspective of others into account, and inferring the intentions, goals, and desires of others (Blakemore, 2012; Burnett et al., 2011; Kilford et al., 2016). These skills facilitate smooth social interactions that enable adolescents to build strong relationships with their peers. It has been suggested that age-related changes in trust behavior during adolescence are related to these sociocognitive processes, for example, to social learning and perspective taking (Fett et al., 2014; Van den Bos et al., 2010). Age-related changes in trust behavior may also be related to motivational processes such as social preferences and expectations. The social preference for equity (e.g., the tendency to avoid getting less than others) influences the degree of trust toward others, and this preference changes throughout adolescence (McAuliffe et al., 2017; Meuwese et al., 2015; Westhoff et al., 2020). In addition, expectations about how the other person might behave (i.e., the predictions about the other person's behavior based on norms) affect the decision to trust, and these expectations change throughout adolescence (Ma et al., 2020; Westhoff et al., 2020).

Whereas trust behavior can be affected by expectations that exist prior to the social interaction, trust can also develop dynamically within the social interaction. Therefore, trust can best be assessed using so-called second-person paradigms in which the participant is actually engaged in an interaction with a partner (Schilbach et al., 2013). An example of such a paradigm is the trust game (Berg et al., 1995). In a one-round trust game, the trustor allocates an amount of money between themselves (the trustor) and the trustee (i.e., the interaction partner). The amount of money that is shared with the partner is called the investment, which is indicative of trust behavior and is tripled before the partner receives it. Subsequently, the partner returns an amount to the trustor, which is indicative of reciprocal behavior (i.e., trustworthiness), and keeps the remainder for themselves (the partner). Using a one-round trust game, levels of baseline trust toward (unknown) others can be investigated (operationalized by the trustor's investment). The game can be expanded to multiple rounds (i.e., a multi-round trust game), simulating a back-and-forth social interaction (Camerer & Weigelt, 1988). The investment during the first round of the multi-round trust game is often considered the level of initial trust behavior because, in contrast to baseline trust behavior, this decision might be affected by strategic considerations such as safeguarding one's social reputation. Another type of trust behavior that can be examined using the multi-round trust game is the adaptation of trust behavior throughout the game, which can be quantified as the change in investments in response to the trustworthiness of the partner. A change (increase or decrease) in the trustor's investments throughout the interaction can indicate the trustor's understanding of the partner's intentions and whether the partner's feedback behavior is integrated in the trustor's investment decisions. The partner's behavior is often mod-

eled using a preprogrammed algorithm. In this way, adaptive trust behavior of the trustor can be examined in response to specific partner behavior (e.g., trustworthy vs untrustworthy).

Cross-sectional studies have found mixed evidence for the development of baseline trust behavior (i.e., in studies that used a one-round trust game) and initial trust behavior (i.e., in studies that used a multi-round trust game) throughout adolescence. In a one-round trust game study, baseline trust behavior increased from ages 8 to 22 years, after which it stayed more or less stable until age 68 (Sutter & Kocher, 2007). An increase in initial trust behavior during adolescence was confirmed in a study by Van den Bos et al. (2012) (ages 11–21). However, other studies reported a decrease in baseline trust behavior (Derks et al., 2014 [ages 14–16]) or no evidence for a change in initial and baseline trust with age (Fett et al., 2014 [ages 13–18]; Güroğlu et al., 2014 [ages 9–18]; Lemmers-Jansen et al., 2017 [ages 16–27]; Lemmers-Jansen et al., 2019 [ages 13–19]; Van de Groep et al., 2018 [ages 12–18]). Despite these previous studies being well-powered, the studies present mixed evidence in that some, but not all, studies found age-related increases in baseline and initial trust behavior during adolescence.

Other studies have focused on age-related changes in the adaptation of trust behavior by using multi-round trust games. The results of a cross-sectional study by Lee et al. (2016) showed that, compared with a group of young adolescents (ages 12–13 years), mid-adolescents (ages 14–15) and late adolescents (ages 16–18) were better able to adjust their trust behavior in response to the behavior of the partner. The results of another cross-sectional study showed improved adaptation of trust behavior in trustworthy interactions throughout childhood and adolescence, whereas the adaptation of trust behavior toward an untrustworthy partner remained constant (Westhoff et al., 2020 [ages 8–23]). In another study, it was found that, with age, adolescents are increasingly able to adapt trust behavior in both trustworthy and untrustworthy interactions (Van den Bos et al., 2012 [ages 10–23]). The development of trust behavior might continue into late adolescence when social interactions may become more complex, as shown by a study from Van den Bos et al. (2010) in which more cognitively demanding trust games that require explicit consideration of the perspective of the partner (ages 9–25) were used. However, in two studies, no evidence for an association between age and the adaptation of trust during adolescence was found (Fett et al., 2014 [ages 13–18]; Lemmers-Jansen et al., 2017 [ages 16–27]). In conclusion, most of these cross-sectional studies suggest that adolescence is an important developmental phase for learning to adjust trust behavior in response to the trustworthiness of the interaction partner.

Individual differences in the development of trust behavior may be related to underlying sociocognitive processes such as perspective taking. Social interactions based on trust require the participant to consider the interaction partner's point of view. During these interactions, one must not only understand how one's own trusting behavior is perceived by the interaction partner but also understand the intentions that drive the partner's behavior to predict the way the partner may respond. The results of a cross-sectional study by Fett et al. (2014) showed that, compared with adolescents with lower perspective-taking abilities, adolescents with higher perspective-taking abilities showed higher levels of initial trust behavior, higher levels of trust toward a trustworthy partner, and a stronger decline in their trust toward untrustworthy partners. This may suggest that individual differences in the development of trust behavior throughout adolescence are related to differences in perspective-taking abilities.

Another factor that may influence developmental trajectories in social behavior and social cognition is gender (Van der Graaff et al., 2014, 2018). A meta-analysis of studies in adults indicated that men show more baseline trust than women (Van den Akker et al., 2020). In (late) adolescent samples, some studies found that boys showed more initial trust than girls (Derks et al., 2014 [ages 14–16 years]; Lemmers-Jansen et al., 2017 [ages 16–27]; Van de Groep et al., 2018 [ages 12–18]), whereas other studies were unable to confirm this finding (Fett et al., 2014 [ages 13–18]; Lemmers-Jansen et al., 2019 [ages 13–19]). Gender differences in the adaptation of trust behavior have been examined less often. Two studies in adolescents showed no support for gender differences during interactions with a trustworthy partner, but the results tentatively suggested a stronger adaptation of trust behavior in boys compared with girls during untrustworthy interactions (Lemmers-Jansen et al., 2017 [ages 16–27]; Lemmers-Jansen et al., 2019 [ages 13–19]). In addition, in a student sample, men showed lower levels of trust behavior toward a partner who violated their trust and were less likely to restore trust when the partner tried to rebuild the trust relationship compared with women (Haselhuhn et al., 2015). Altogether, there is a paucity of studies that examine gender differences in (the development of) adolescent trust behavior, but overall

studies seem to suggest that men show higher levels of initial trust behavior and a stronger adaptation of trust behavior during untrustworthy interactions than women.

In the current study, we used a longitudinal design to examine three research aims, namely, the development of trust behavior, the presence of gender differences in the developmental trajectories of trust, and whether individual differences in the development of trust behavior were related to perspective-taking abilities. Previous studies have used cross-sectional designs to examine between-person differences in the development of trust behavior, whereas longitudinal designs can shed light on the individual development of trust behavior over time (i.e., the between-person differences in within-person change that may exist) (Robinson et al., 2005). Three waves of data collection were conducted during which each participant played two conditions of a multi-round trust game (i.e., the trustworthy condition with a trustworthy partner and the untrustworthy condition with an untrustworthy partner). The participants were informed that they would play two games with computer counterparts (displayed as cartoon animations). In both conditions, a preprogrammed algorithm was used to model the partner's trustworthiness. Perspective-taking abilities were measured through the administration of the Interpersonal Reactivity Index (IRI), which was collected during Wave 1.

Three outcome measures of trust behavior were used. Related to the first research aim (i.e., the development of trust behavior), we hypothesized an age-related increase in initial trust behavior (i.e., the investment during the first round of the first game increased with age) and an age-related change in the adaptation of trust behavior. Specifically, in the trustworthy condition we expected the increase in investments during the game to become stronger with age, and in the untrustworthy condition we expected the decrease in investments to become stronger with age. Related to the second research aim (i.e., gender differences in the development of trust), we hypothesized that the increase in initial trust behavior with age was stronger for boys compared with girls. This was based on preliminary evidence provided by a meta-analysis in adults (Van den Akker et al., 2020) and by several studies in adolescents (Derks et al., 2014; Lemmers-Jansen et al., 2017; Van de Groep et al., 2018) where the results indicated increased levels of initial and baseline trust in men (boys) compared with women (girls). Furthermore, we hypothesized that the developmental effects related to the adaptation of trust in the untrustworthy condition were stronger for boys than for girls (i.e., the hypothesized age-related decrease in investments during the game was stronger for boys than for girls). This was based on several studies in adolescents and young adults (Haselhuhn et al., 2015; Lemmers-Jansen et al., 2017, 2019) showing that boys adapted trust behavior more strongly compared with girls during untrustworthy interactions. The results of the limited number of previous studies indicated no evidence for gender differences during trustworthy interactions (Lemmers-Jansen et al., 2017, 2019); hence, the investigation for gender differences in the adaptation of trust behavior during trustworthy interactions was on an exploratory basis. Related to the third research aim (i.e., the relationship between perspective-taking abilities and the development of trust behavior), we hypothesized that the development of initial trust behavior was stronger for adolescents with higher perspective-taking abilities compared with adolescents with lower perspective-taking abilities given that these abilities enable one to understand how one's initial trust decisions are perceived by others; thus, that high initial trust may pay off in the future (Fett et al., 2014). Furthermore, we hypothesized greater developmental changes in the adaptation of trust behavior for adolescents with higher perspective-taking abilities compared with adolescents with lower perspective-taking abilities (i.e., a stronger age-related increase in investments during the trustworthy condition and a stronger age-related decrease during the untrustworthy condition) given that these abilities allow faster and/or more accurate predictions about the partner's trustworthiness level and therefore can support adaptive behavior in response to the partner's behavior (Fett et al., 2014).

Method

Participants

The current study is part of the longitudinal #SOCONNeCT project that involved six waves of data collection (September 2017 through June 2020) at eight secondary schools in the Netherlands. The

participants were recruited at the beginning of their first year of secondary school. All the participants were enrolled in the senior general secondary educational track or the pre-university educational track, which form the two higher levels of education within the Dutch education system (during the data collection period, these two higher levels constituted the top 40 % of pupils based on academic achievement). Schools received €7.50 per participating pupil per wave and were encouraged to use the financial compensation for class activities. An additional payout could be earned based on a participant's average earnings per trial in the trust game (see "Trust game" section). Per class, the average of these payouts in both conditions was added to the financial compensation for the class.

The trust game that was analyzed in the current study was collected during Wave 1, Wave 3, and Wave 5 of the #SOCONNeCT project (the trust game was not included in the data collection during the other waves of the #SOCONNeCT project). The waves were conducted at approximately 12-month intervals. Wave 1 was conducted during the first year of secondary school, Wave 3 was conducted during the second year of secondary school, and Wave 5 was conducted during the third year of secondary school. The participants were included in the current study if they completed the trust game during at least one of the three waves and if they completed the IRI during Wave 1. Some participants dropped out of the study between the waves (e.g., due to a lack of motivation to participate in the next wave or because they moved to a different class or school).

A total of 647 adolescents provided written informed consent before the start of Wave 1 of the #SOCONNeCT project. Of these 647 participants, 2 did not participate in any of the waves analyzed in the current study and therefore were excluded from the analyses. Of the remaining 645 participants, 30 were absent during the data collection for the trust game during Wave 1, meaning that 615 participants completed the Wave 1 trust game. Of these 615 participants, 28 were excluded from statistical analyses (due to issues arising during the administration of the trust game such as a lack of time or motivation to finish the game). Of these 587 participants, a further 13 were excluded from statistical analyses because they did not have enough time or motivation to finish the IRI, meaning that 574 participants were included in the analyses of Wave 1 (M_{age} = 12.55 years, SD = 0.39, range = 11.11–13.98; 267 boys). During the Wave 3 administration of the trust game, 534 participants completed the game, of which 20 participants were excluded (due to issues arising during the administration of the trust game such as a lack of time or motivation to finish the game). Of these 514 participants, 40 did not complete the IRI during Wave 1, meaning that 474 participants were included in the analyses of Wave 3 (M_{age} = 13.54 years, SD = 0.39, range = 12.07–14.97; 221 boys). During the Wave 5 administration of the trust game, 434 participants completed the trust game, of which 8 participants were excluded (due to issues arising during the administration of the trust game such as a lack of time or motivation to finish the game). Of these 426 participants, 38 did not complete the IRI during Wave 1, meaning that 388 participants were included in the analyses of Wave 5 (M_{age} = 14.54 years, SD = 0.40, range = 13.33–15.98; 178 boys). See Fig. 1 for a flow chart visualizing the inclusion process of the participants in the current study. In total, 337 participants completed the trust game during all three waves, 164 participants completed the trust game during two waves, and 97 participants completed the trust game during one of the waves. Of the participants included in the final analyses, 99 % were born in West European countries, whereas few of the participants were born in other countries such as Asian countries or North or South American countries.

Comparisons between those participants who dropped out during the study and those who did not showed no significant differences in the distribution of boys and girls, in perspective-taking abilities (with one exception; see below), and on measures of trust behavior. More specifically, no significant differences were found in the number of boys and girls, the IRI score, and the Wave 1 measures of initial trust behavior and mean trust behavior in both conditions when comparing those adolescents who participated in Wave 1 and Wave 3 and those adolescents who participated only in Wave 1 but not in Wave 3. Furthermore, no significant differences were found in the number of boys and girls and on the Wave 3 measures of initial trust behavior and mean trust behavior displayed in both conditions when comparing those adolescents who participated in Wave 3 and Wave 5 and those adolescents who participated only in Wave 3 but not in Wave 5. The adolescents who participated in Wave 3 and Wave 5 did score higher on the IRI during Wave 1 compared with those who participated only in Wave 3 but not in Wave 5, $t(472) = -2.79$, p =.006.

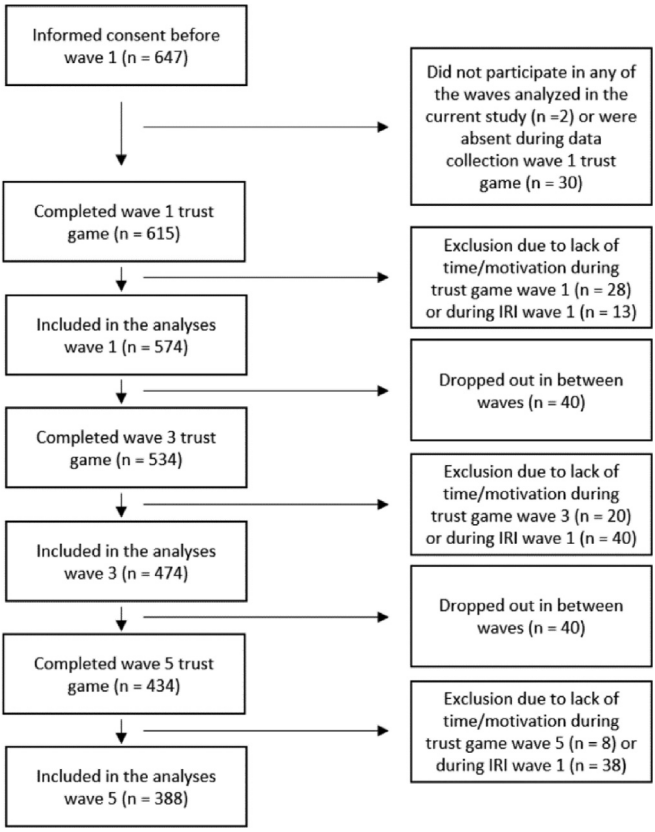

Fig. 1. Flow chart of the inclusion process of the participants in the current study.

Procedure

The participants and parents/caregivers were informed about the aims and the procedures around participation in the #SOCONNeCT project through an information letter distributed via the schools. In addition, the researchers provided information evenings at the participating schools. Both the participants and parents/caregivers provided active written informed consent prior to the start of data collection. Data collection was done at school in the participants' classrooms under supervision of the researchers and trained research assistants and lasted about 90 min, including classroom explanations and the administration of tasks and questionnaires not analyzed in the current study. The questionnaires and tasks were validated prior to data collection in several focus groups with adolescents, and explanations were adjusted according to the feedback received during these sessions. The data collection started with an explanation of the procedures and the participants' rights. During the data collection, the tasks and questionnaires were completed individually at individual desks. The administration of the trust game started with a joint extensive explanation in class on how the game works. Then, on a laptop (provided by the researchers), all participants needed to answer three questions about the game correctly to show that they understood the procedure of the game before they were able to start the game. The #SOCONNeCT project was approved by the scientific and ethical review board of the Faculty of Behavioural and Movement Sciences of Vrije Universiteit Amsterdam.

Materials

Demographics

Information on demographics, such as the date of birth and gender (boy, girl, or other), were collected during each wave of the #SOCONNeCT project (however, none of the participants responded with "other" in the demographics questionnaire). Age was used as a continuous variable in the analyses.

Trust game

The multi-round trust game was used to measure trust behavior (Berg et al., 1995). During each wave, each participant completed two conditions of the game (the trustworthy condition and the untrustworthy condition). The conditions were administered in counterbalanced order. Both conditions consisted of 15 trials. Before the game started, a joint extensive explanation of how the game works was given in the classroom and a comprehension check was done individually (see "Procedure" section). During each wave, the participants were informed that they would play two games with computer counterparts (displayed as cartoon animations).

A trust game trial started with a screen that displayed the numbers 0 to 10, and the participants were asked to make an investment by using the arrow keys to select the amount they wished to invest (see Screen 1 in Fig. 2). The investment was multiplied by 3 and received by the partner. Next, a screen was presented that displayed a cartoon animation accompanied by the text "the partner is thinking" (see Screen 2 in Fig. 2). This was followed by a screen that revealed the partner's return (see Screen 3 in Fig. 2). Then, a screen with the total earnings for both players for that trial was displayed (see Screen 4 in Fig. 2). The trust game was administered three times (during Wave 1, Wave 3, and Wave 5 of the #SOCONNeCT project). The same trust game was used during each wave, but the appearances of the cartoon animations used as interaction partners were changed and given different names to prevent learning effects.

The interaction partner in the trust game was a cartoon animation, as opposed to a human partner, because it was unfeasible and undesirable to use deception in a longitudinal design (i.e., falsely informing the participants that they were playing with a human counterpart) where debriefing would not have been possible until the final wave. The behavior of both partners was modeled using a preprogrammed algorithm. The specific return of the partner in each trial was determined by the

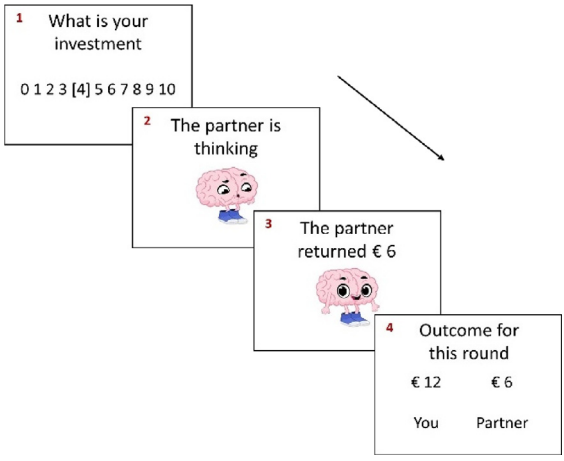

Fig. 2. This is an example of a trial in the trustworthy condition. The investment is €4, which is multiplied by 3. This means that the partner received €12, and the participant kept €6. The partner's return is €6. Thus, the outcome of this trial is €12 for the participant and €6 for the partner. In this example, the factor that determined the partner's return was 1.5.

participant's investment multiplied by a factor. The algorithm for both partners was programmed in such a way that the partner's behavior was equally trustworthy for the first five trials. This was done to establish an identical baseline of trustworthiness for both partners. In both conditions, the partner's behavior changed after the first five trials. From the sixth trial onward, the algorithm modeled adaptive trustworthy partner behavior in the trustworthy condition and adaptive untrustworthy partner behavior in the untrustworthy condition.

In both conditions, the factor for the first trial was randomly selected from the values 1.2, 1.3, and 1.4. Then, in both conditions, the value of the factor for the second trial through the fifth trial increased by 0.1 when the participant's investment increased compared with the investment during the previous trial (in steps of 0.1 with a minimum factor of 1.2 and a maximum factor of 1.4). The value of the factor stayed the same when the investment decreased or when the investment did not change compared with the previous trial. From the sixth trial onward, the algorithm determining the partner's return was different for both conditions.

In the trustworthy condition, the trustworthiness of the partner then increased compared with the first five trials. The factor for the sixth trial was randomly chosen between 1.5 and 2.0 (in steps of 0.1). For the seventh trial through the fifteenth trial, the factor increased by 0.1 when the participant's investment increased compared with the investment during the previous trial (with a minimum factor of 1.5 and a maximum factor of 2.0). The factor did not change when the participant's investment decreased or stayed the same compared with the previous investment. In the trustworthy condition, the partner's return was always more than the participant's investment (because the minimum factor is 1.5). The partner increased the return (i.e., showed reciprocal trustworthy behavior) when the participant increased the investment (i.e., showed trust behavior).

In the untrustworthy condition, in contrast, the partner's trustworthiness decreased compared with the first five trials. The factor for the sixth trial was randomly chosen between 0.7 and 1.2 (in steps of 0.1). The factor for the seventh trial through the fifteenth trial decreased by 0.1 when the participant's investment increased compared with the previous investment (with a minimum factor of 0.7 and a maximum factor of 1.2). The factor stayed the same when the participant's investment decreased or when it did not change compared with the previous trial. In sum, both algorithms were adaptive to increases in the participants' investments, but in the trustworthy condition the relative returns increased in response to increased investments, whereas in the untrustworthy condition the relative returns decreased.

In the current study, we used three outcome measures of trust behavior. The first outcome measure was initial trust behavior, the second outcome measure was the adaptation of trust behavior during trustworthy interactions, and the third outcome measure was the adaptation of trust behavior during untrustworthy interactions. Initial trust behavior was operationalized by the investment during the first trial of the first game that was played. The adaptation of trust behavior in the trustworthy condition was operationalized by the change in investments during the sixth trial through the fifteenth trial in the trustworthy condition (i.e., excluding the first five trials during which the algorithms of both conditions were programmed to model equally trustworthy behavior). Similarly, the adaptation of trust behavior during untrustworthy interactions was operationalized by the change in investments during the sixth trial through the fifteenth trial in the untrustworthy condition (i.e., excluding the first five trials during which the algorithms of both conditions were programmed to model equally trustworthy behavior).

Interpersonal Reactivity Index

Perspective-taking abilities were assessed using the IRI, which is a self-report questionnaire (Davis, 1983). The subscale perspective taking was used, which consists of seven items. The sum score of the perspective-taking scale was calculated and used as a measure of perspective-taking abilities in the analyses of the current study (Items 1 and 4 require reverse scoring). Higher sum scores indicate higher levels of perspective-taking abilities (range of sum scores = 0–28). Answers are given on a 5-point scale from 0 = *does not describe me at all* to 4 = *describes me very well.* The questions are as follows: (1) "I sometimes find it difficult to see things from the 'other guy's' point of view"; (2) "I try to look at everybody's side of a disagreement before I make a decision"; (3) "I sometimes try to understand my friends better by imagining how things look from their perspective"; (4) "If I'm sure I'm right

about something, I don't waste much time listening to other people's arguments"; (5) "I believe that there are two sides to every question and try to look at them both"; (6) "When I'm upset at someone, I usually try to 'put myself in his shoes' for a while"; (7) "Before criticizing somebody, I try to imagine how I would feel if I were in their place." A Dutch version of the IRI was used, which was validated in Dutch (adolescent) samples and shown to have good psychometric properties (De Corte et al., 2007; Hawk et al., 2013). The IRI was completed on an iPad provided by the researchers.

Statistical analyses

Multilevel analyses were used to examine the research aims of the current study. The analyses were performed in R Version 4.1.1 using the *lme4* and *lmerTest* packages (Bates et al., 2015; Kuznetsova et al., 2017; R Core Team, 2020). Using multilevel analyses, fixed effects and random effects can be modeled. As such, the mean starting point in investments can be captured by a fixed intercept, whereas individual differences in starting points are modeled by a random intercept. Similarly, the mean trajectory of the change in investments is captured by a fixed slope, whereas a random slope accounts for individual differences in the change in investments.

A manipulation check was performed before the main analyses were conducted to examine whether the algorithm that modeled the partner's behavior had the expected effect within each condition (averaged over all ages). This was done using a multilevel model with the random intercept for age and for participant and the two-way interaction between trial and condition as a fixed effect (including the main effects of trial and condition). We expected follow-up analyses to reveal a positive effect of trial (i.e., an increase in investments) in the trustworthy condition and a negative effect of trial (i.e., a decrease in investments) in the untrustworthy condition.

For the main analyses, three outcome measures of trust behavior were used (these were initial trust behavior, the adaptation of trust behavior during trustworthy interactions, and the adaptation of trust behavior during untrustworthy interactions). For each outcome measure, the first research aim was to examine the development of trust behavior, the second research aim was to examine the presence of gender differences in the development of trust behavior, and the third research aim was to examine whether individual differences in the developmental trajectories of trust were related to perspective-taking abilities. For each outcome measure, one model building procedure was used to test the three research aims, and maximum likelihood estimation method was used to fit the models. The model building procedures consisted of different steps. Fixed effects or random effects were added in each step of the model building procedures that are explained below. In each step of the model building procedure, the fit of the model was compared with the fit of the previous best fitting model. Only when the model fit improved as a result of adding fixed or random effects was the effect kept in the consecutive model. Model comparisons were performed using the likelihood ratio test. Models were regarded significantly better if the p value of the likelihood ratio test was lower than .05 (p <.05). The Akaike information criterion (AIC) values and Bayesian information criterion (BIC) values were provided for completeness. Lower AIC and BIC values indicate a better model fit.

For each outcome measure of trust, analyses were started by fitting a model with the levels participant and class to calculate the intraclass correlation (ICC) values for both levels. In this step, we examined how much variability in the investment during the first trial (used for initial trust behavior) or in the investments in all trials (used for the adaptation of trust behavior) is due to between-person differences and how much variability is due to differences between classes. Based on the ICC for the level class, we decided whether to add the level class in the remaining steps of the model building procedure. The remaining modeling steps for the procedures are explained below.

Initial trust behavior

The first model building procedure addressed initial trust behavior. Age was entered into the analyses as a centered predictor where zero corresponded to the youngest age in the dataset. The repeated measure of initial trust over the 3 consecutive years served as an outcome variable. First, a null model with the random intercept for participant was fitted (without fixed effects). The first level of this model was age (within-person variability), and the second level was participant (between-person

variability). In Step 1, the linear main effect of age was added as a fixed effect. If the fit of the model including the linear main effect of age was better than the fit of the null model, we kept the effect in the model (and otherwise omitted the effect). In Step 2, the two-way interaction between the linear effect of age and gender was added as a fixed effect (and also the lower order terms, i.e., the main effect of age and gender). In Step 3, the three-way interaction among the linear effect of age, gender, and perspective-taking abilities was added (and also the lower order terms, i.e., the main effects of age, gender, perspective-taking abilities and the related two-way interactions). In Step 4, the random slope of age on the level of participant was added.

The adaptation of trust behavior

The second and third model building procedures addressed the adaptation of trust behavior in the trustworthy condition and the untrustworthy condition, respectively. Both procedures consisted of similar steps, and for both conditions the data were repeated measures of the same participant over trials and over 3 consecutive years. In both model building procedures, trial was entered into the analyses as a centered predictor where zero corresponded to the first trial. Age was entered into the analyses as a centered predictor where zero corresponded to the youngest age in the dataset. The investments per trial served as an outcome variable. The steps of both procedures were as follows. First, a null model with the random intercept for age and for participant was fitted (without fixed effects). The first level of this model was the level of trial, the second level was the level of age, and the third level was the level of participant. In Step 1, the two-way interaction between trial and the linear effect of age was added as a fixed effect (and also the lower order terms, i.e., the main effect of trial and the main effect of age). If the fit of the model was better than the fit of the null model, we kept the effect that was just added (and otherwise omitted the effect). In Step 2, the three-way interaction among trial, the linear effect of age, and gender was added as a fixed effect (and also the lower order terms, i.e., the main effect of trial, age, and gender and the related two-way interactions). In Step 3, the four-way interaction among trial, the linear effect of age, gender, and perspective-taking abilities was added (and also the lower order terms, i.e., the related main effects, the related two-way interactions, and the related three-way interactions). In Step 4, the random slope of trial on the level of age was added. In Step 5, the random slope of trial on the level of participant was added.

Results

Manipulation checks

As a manipulation check, we examined whether the algorithms had the expected effects within each condition (averaged over all ages). A multilevel model including the random intercept for age and for participant, two-way interaction between trial and condition, and the main effects of trial and condition was fitted. The results showed that the two-way interaction between trial and condition was significant, $t(27284) = 31.07$, $p < .001$. This indicated that the effect of trial was different for the trustworthy and untrustworthy conditions. Follow-up analyses showed a significant positive linear effect of trial in the trustworthy condition, $t(12924) = 15.93$, $p < .001$, and a significant negative linear effect of trial in the untrustworthy condition, $t(12924) = -30.63$, $p < .001$. These results indicate that the algorithms had the expected effects within each condition. The descriptive statistics about the trust behavior in the two conditions per wave are reported in Table 1.

Initial trust behavior

Before starting with the model building procedure for initial trust, a model with the random intercept for participant and for class was fitted (without fixed effects). The results of this model showed that 32 % of the total observed variability in the initial investment scores was due to between-person differences. Furthermore, the results indicated that 6 % of the total observed variability in the initial investment scores was due to differences between classes. In other words, the initial investment scores are correlated approximately .06 for pupils nested in the same class. This is a low correlation

Table 1
The descriptive statistics per wave.

Type of behavior	Wave 1 Mean (*SD*)	Wave 3 Mean (*SD*)	Wave 5 Mean (*SD*)
Initial trust behavior			
Boys	3.48 (2.15)	4.03 (2.43)	4.83 (2.83)
Girls	2.97 (1.51)	3.15 (1.75)	3.52 (2.05)
Total	3.21 (1.85)	3.56 (2.14)	4.12 (2.52)
Mean trust behavior (trustworthy condition)			
Boys	6.23 (2.19)	6.67 (2.08)	7.33 (2.21)
Girls	5.43 (1.91)	5.78 (2.16)	6.15 (2.15)
Total	5.80 (2.08)	6.20 (2.17)	6.70 (2.25)
Mean trust behavior (untrustworthy condition)			
Boys	4.49 (1.53)	4.55 (1.77)	4.71 (1.91)
Girls	3.94 (1.42)	3.89 (1.36)	3.82 (1.42)
Total	4.20 (1.50)	4.20 (1.60)	4.23 (1.71)

given that in educational research ICC values between .10 and .25 are common at the class level (Hedges & Hedberg, 2007; Snijders & Bosker, 2011). Based on the low correlation and to keep the model as parsimonious as possible, we decided to not include the level class in the model building procedure for initial trust behavior.

The model building procedure showed that the final model included the two-way interaction between the linear effect of age and gender as a fixed effect (and the main effects of age and gender), the random intercept, and the random slope of age but not the three-way interaction among the linear effect of age, gender, and perspective-taking abilities [the results of the likelihood ratio test when the model in the final step, which was Step 4, was compared with the previous best fitting model, which was the one in Step 2, were $\chi^2(2) = 26.18$, $p < .001$]. The explained variance of the final model is .45, meaning that the overall model (including both the fixed and random effects parts) explains 45 % of the variance in the initial investments. The results of the full model building procedure are presented in Table 2, and a full description of the final model is presented in Table 3.

The first research aim was to examine the development of initial trust behavior. The results of the final model showed a significant positive linear main effect of age, indicating that initial trust behavior increased with age (see Fig. 3). The second research aim was to examine gender differences in the development of initial trust behavior. The results of the final model showed a significant two-way interaction between the linear effect of age and gender. This indicates that the effect of age was different for boys and girls. Follow-up analyses showed a significant positive linear effect of age in boys, $t(225) = 5.95$, $p < .001$, and a significant positive linear effect of age in girls, $t(225) = 3.28$, $p < .001$ (see Fig. 3). Furthermore, the main effect of gender was not significant. Together, these results indicate no support for gender differences in initial trust behavior at 11 years of age but do indicate that both boys and girls showed a significant linear increase in initial trust behavior over the years, with boys showing a stronger increase compared with girls. The third research aim was to examine whether individual differences in the developmental trajectories of trust were related to perspective-taking abilities. The model in Step 3, which included the three-way interaction among the linear effect of age, gender, and perspective-taking abilities (and the related main effects and two-way interations), did not fit significantly better than the previous best fitting model in Step 2 [the results of the likelihood ratio test when the model in Step 3 was compared with the previous best fitting model in Step 2 were $\chi^2(4) = 5.48$, $p = .24$]. The results of the model fit in Step 3 showed that the two-way interaction between the linear effect of age and perspective-taking abilities was not significant, which indicated that there is no evidence for individual differences in the developmental trajectories of trust behavior to be predicted by perspective-taking abilities. The fixed effect that was added in the model in Step 3 (i.e., the three-way interaction among the linear effect of age, gender, and perspective-taking abilities) therefore was omitted during the continuation of the model building procedure and not included in the final model.

Table 2
The Akaike information criterion and Bayesian information criterion values of the three model building procedures.

Type of behavior	Null model		Model in Step 1		Model in Step 2		Model in Step 3		Model in Step 4		Model in Step 5	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
Initial trust behavior	6185	6201	6139	6160	6096	6127	6098	6151	**6073**	**6116**	Not applicable	
Adaptation of trust behavior (trustworthy condition)	65,634	65,564	65,241	65,294	65,201	65,284	65,199	65,343	64,856	65,023	**64,790**	**64,964**
Adaptation of trust behavior (untrustworthy condition)	69,217	69,247	68,288	68,341	68,242	68,325	68,246	68,930	68,040	68,146	**67,993**	**68,107**

Note. AIC, Akaike information criterion; BIC, Bayesian information criterion. The final models are printed in bold.

Table 3
Initial trust behavior: The results of the final model.

	Beta coefficient	Standard deviation/ Standard error	*t* value (*p* value)	95 % CI[a]	
				Lower	Upper
Random effects					
Intercept participant		1.16		0.35	1.67
Slope age		0.54		0.27	0.73
Residual		1.62		1.52	1.72
Fixed effects					
Intercept	2.65	0.20	13.24 (<.001)	2.29	3.08
Age linear	0.60	0.09	6.94 (<.001)	0.42	0.76
Gender	0.04	0.27	0.14 (.89)	−0.57	0.55
Age × Gender	−0.38	0.12	−3.23 (<.001)	−0.59	−0.14

Note. The results of the fit of the final model reporting beta coefficients, standard deviations of the random effects, standard errors of the fixed effects, *t* values, *p* values, and the 95% confidence intervals (CIs) are shown. Boys are coded as 0, and girls are coded as 1.

[a] The 95% CI of the random effect is on the standard deviation of the effect because the *lmerTest* package does not report beta coefficients and *p* values for random effects. The 95% CI of the fixed effect is on the beta coefficient.

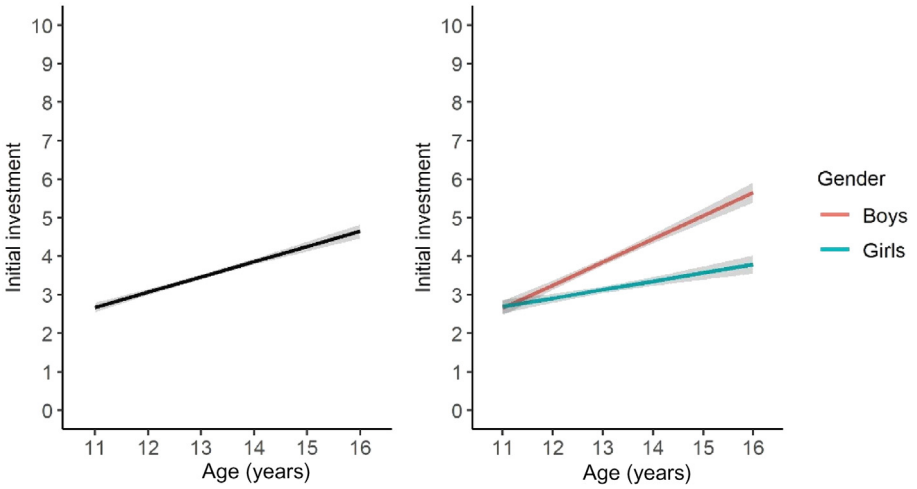

Fig. 3. The increase of initial trust behavior with age averaged over the sample (left panel), with boys showing a stronger age-related increase than girls (right panel). For both figures, age is displayed on the × axis. The initial investment is displayed on the *y* axis. The lines in the figure represent the model-implied age-related linear increase in initial investment for the entire sample (left panel) and split according to gender, that is, boys and girls (right panel).

The adaptation of trust behavior in the trustworthy condition

Before starting with the model building procedure for the adaptation of trust behavior in the trustworthy condition, a model with the random intercept for participant and for class was fitted (without fixed effects). The results of this model showed that 29 % of the total observed variability in the investment scores was due to between-person differences. Furthermore, the results indicated that 6 % of the total observed variability in the investment scores was due to differences between classes. In other words, the investment scores are correlated approximately .06 for pupils nested in the same class. Based on the low correlation and to keep the model as parsimonious as possible, we decided to not include the level class in the model building procedure for the adaptation of trust behavior in the trustworthy condition.

The model building procedure showed that the final model included the four-way interaction among trial, the linear effect of age, gender, and perspective-taking abilities as a fixed effect (and the related main effects, two-way interactions, and three-way interactions), the random intercepts, the random slope of trial at the level of age, and the random slope at the level of participant [the results of the likelihood ratio test when the model in the final step, which was Step 5, was compared with the previous best fitting model, which was the one in Step 4, were $\chi^2(1) = 68.37$, $p < .001$]. The explained variance of the final model is .55, meaning that the overall model (including both the fixed and random effects parts) explains 55 % of the variance in the investments. The results of the full model building procedure are presented in Table 2, and a full description of the final model is presented in Table 4.

The first research aim was to examine the development of the adaptation of trust behavior during trustworthy interactions. The results of the final model showed no significant two-way interaction between trial and the linear effect of age, meaning that there is no evidence for a stronger increase in the investments during trustworthy interactions as adolescents become older. The second research aim was to examine gender differences in the development of the adaptation of trust behavior during trustworthy interactions. The results indicated that the three-way interaction among trial, the linear effect of age, and gender was not significant. This means that there is no evidence for gender differences in the change of investments over the years. However, the results of the final model did indicate a significant positive linear main effect of age and a significant two-way interaction between the linear main effect of age and gender. The results of the post hoc analyses showed a significant positive linear effect of age in boys, $t(226) = 4.24$, $p < .001$, and a significant positive linear effect of age in girls, $t(270) = 3.78$, $p < .001$. These results indicate that the participants showed a significant linear increase in mean trust behavior during trustworthy interactions over the years and that this increase was stronger for boys compared with girls (see Fig. 4). The third research aim was to examine whether

Table 4
The adaptation of trust behavior in the trustworthy condition: The results of the final model.

	Beta coefficient	Standard deviation/ Standard error	*t* value (*p* value)	95 % CI[a]	
				Lower	Upper
Random effects					
Intercept participant		1.02		0.81	1.19
Slope trial at level participant		0.03		−0.16	1.00
Intercept age		1.88		1.75	1.98
Slope trial at level age		0.22		−0.55	−0.40
Residual		1.98		1.95	2.00
Fixed effects					
Intercept	3.84	0.89	4.30 (<.001)	1.86	5.63
Trial	0.13	0.12	1.09 (.27)	−0.12	0.38
Age	0.80	0.36	2.20 (.03)	0.10	1.54
Gender	2.59	1.24	2.09 (.04)	0.04	5.24
Perspective taking	0.09	0.06	1.46 (.15)	−0.04	0.21
Trial × Age	−0.02	0.05	−0.37 (.71)	−0.12	0.09
Trial × Gender	−0.28	0.16	−1.67 (.09)	−0.62	0.08
Age × Gender	−1.38	0.50	−2.78 (.005)	−2.41	−0.38
Trial × Perspective Taking	−0.002	0.008	−0.20 (.84)	−0.02	0.02
Age × Perspective Taking	−0.02	0.02	−0.89 (.38)	−0.07	0.03
Gender × Perspective Taking	−0.21	0.08	−2.56 (.01)	−0.38	−0.04
Trial × Age × Gender	0.10	0.07	1.51 (.13)	−0.04	0.23
Trial × Age × Perspective Taking	0.0009	0.003	0.28 (.78)	−0.007	0.007
Trial × Gender × Perspective Taking	0.02	0.01	1.53 (.13)	−0.006	0.04
Age × Gender × Perspective Taking	0.08	0.03	2.46 (.01)	0.008	0.14
Trial × Age × Gender × Perspective Taking	−0.006	0.004	−1.36 (.18)	−0.01	0.004

Note. The results of the fit of the final model reporting beta coefficients, standard deviations of the random effects, standard errors of the fixed effects, *t* values, *p* values, and the 95% confidence intervals (CIs) are shown. Boys are coded as 0, and girls are coded as 1.

[a] The 95% CI of the random effect is on the standard deviation of the effect because the *lmerTest* package does not report beta

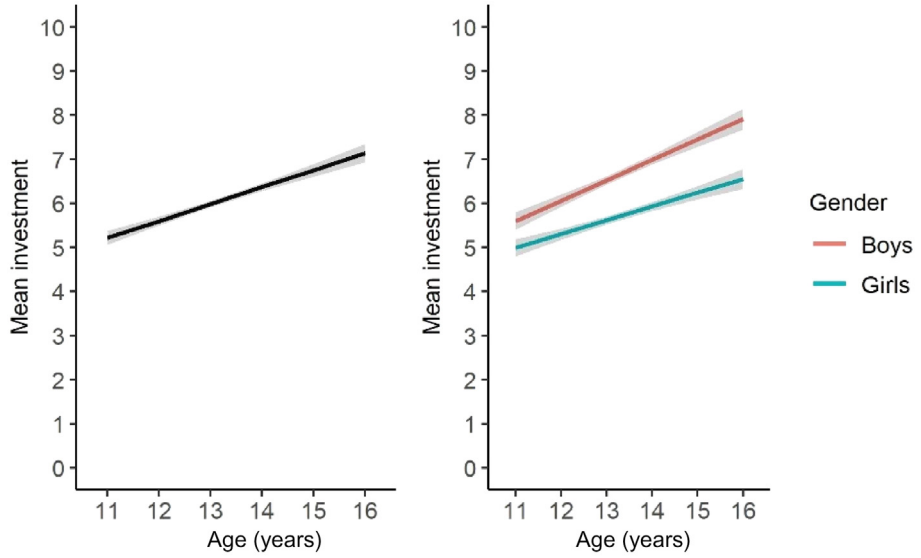

Fig. 4. The increase of the mean level of trust behavior with age averaged over the sample (left panel), with boys showing a stronger age-related increase than girls (right panel) (trustworthy condition). For both figures, age is displayed on the × axis. The mean investment is displayed on the *y* axis. The lines in the figure represent the model-implied age-related linear increase in mean investment during the game for the entire sample (left panel) and split according to gender, that is, boys and girls (right panel).

individual differences in the developmental trajectories of trust were related to perspective-taking abilities. The results of the final model did not indicate a significant interaction among trial, the linear effect of age, and perspective-taking abilities. This means that there is no evidence that perspective-taking abilities are related to individual differences in age-related changes in the adaptation of trust behavior during trustworthy interactions. The results of the final model did indicate a significant three-way interaction among the linear effect of age, gender, and perspective-taking abilities (see Fig. 5). The results of the post hoc analyses indicated no significant main effect of perspective-taking abilities, $t(639) = 1.55$, $p = .12$, and no significant two-way interaction between the linear effect of age and perspective-taking abilities in boys, $t(554) = -0.84$, $p = .40$, whereas the two-way interaction between the linear main effect of age and perspective-taking abilities was significant for girls, $t(554) = 1.98$, $p = .048$. This indicates that the higher the perspective-taking abilities, the stronger the increase in the mean investment over the years in girls (see Fig. 5).

The adaptation of trust behavior in the untrustworthy condition

Before starting with the model building procedure for the adaptation of trust behavior in the untrustworthy condition, a model with the random intercept for participant and for class was fitted (without fixed effects). The results of this model showed that 15 % of the total observed variability in the investment scores was due to between-person differences. Furthermore, the results indicated that 2 % of the total observed variability in the investment scores was due to differences between classes. In other words, the investment scores are correlated approximately .02 for pupils nested in the same class. Based on the low correlation and to keep the model as parsimonious as possible, we decided to not include the level class in the model building procedure for the adaptation of trust behavior in the untrustworthy condition.

The model building procedure showed that the final model included the three-way interaction among trial, the linear effect of age, and gender as a fixed effect (and the related main effects and

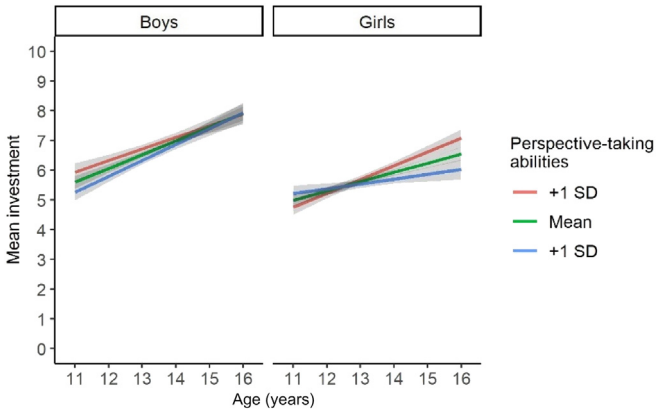

Fig. 5. The significant interaction between age and perspective-taking abilities for girls (right panel) on the mean investment (trustworthy condition). For both figures, age is displayed on the × axis. The mean investment is displayed on the *y* axis. The lines in the figure represent the model-implied age-related linear increase in mean investment over the years for boys (left panel) and for girls (right panel) for different values of perspective-taking abilities scores. Perspective-taking abilities was analyzed as a continuous variable, but for visual purposes only the values + 1 standard deviation above the mean, the mean, and − 1 standard deviation below the mean are displayed in the figure.

two-way interactions), the random intercepts, the random slope of trial at the level of age, the random slope at the level of participant, but not the four-way interaction among trial, the linear effect of age, gender, and perspective-taking abilities [the results of the likelihood ratio test when the model in the final step, which was Step 5, was compared with the previous best fitting model, which was the one in Step 4, were $\chi^2(1) = 49$, $p < .001$]. The explained variance of the final model is .34, meaning that the overall model (including both the fixed and random effects parts) explains 34 % of the variance in the investments. The results of the model building procedure are presented in Table 2, and a full description of the final model is presented in Table 5.

The first research aim was to examine the development of the adaptation of trust behavior during untrustworthy interactions. The results of the final model showed a significant, negative two-way interaction between trial and the linear effect of age, meaning that the decrease in investments during the untrustworthy condition became stronger as adolescents became older (see Fig. 6). The second research aim was to examine gender differences in the development of the adaptation of trust behavior during untrustworthy interactions. The results of the final model indicated no significant three-way interaction among trial, the linear effect of age, and gender. This means that there is no evidence for the developmental pattern related to the decrease in the investments during the game to be different for boys and girls. The third research aim was to examine whether individual differences in the developmental trajectories of trust were related to perspective-taking abilities. The model in Step 3, which included the four-way interaction among trial, the linear effect of age, gender, and perspective-taking abilities (and the related main effects, two-way interactions, and three-way interactions), did not fit significantly better than the previous best fitting model in Step 2 [the results of the likelihood ratio test when the model in Step 3 was compared with the model in Step 2 were $\chi^2(8) = 12.08$, $p = .15$]. The results of the model fit in Step 3 showed that the three-way interaction among trial, the linear effect of age, and perspective-taking abilities was not significant, which indicated that there is no evidence that perspective-taking abilities are related to individual differences in age-related changes in the adaptation of trust behavior during untrustworthy interactions. The fixed effect that was added in the model in Step 3 (i.e., the four-way interaction among trial, the linear effect of age, gender, and perspective-taking abilities) therefore was omitted during the continuation of the model building procedure and not included in the final model.

Table 5
The adaptation of trust behavior in the untrustworthy condition: The results of the final model.

	Beta coefficient	Standard deviation/ Standard error	*t* value (*p* value)	95 % CI[a]	
				Lower	Upper
Random effects					
Intercept participant		1.10		0.95	1.27
Slope trial at level participant		0.11		0.08	0.15
Intercept age		1.28		1.15	1.41
Slope trial at level age		0.19		0.17	0.22
Residual		2.34		2.31	2.37
Fixed effects					
Intercept	4.91	0.22	22.23 (<.001)	4.43	5.34
Trial	−0.11	0.04	−3.08 (.002)	−0.18	−0.04
Age	0.32	0.09	3.65 (<.001)	0.15	0.50
Gender	−0.39	0.30	−1.29 (.20)	−1.06	0.18
Trial × Age	−0.06	0.01	−3.87 (<.001)	−0.09	−0.03
Trial × Gender	−0.005	0.05	−0.11 (.91)	−0.10	0.10
Age × Gender	−0.20	0.12	−1.7 (.09)	−0.43	0.05
Trial × Age × Gender	0.02	0.02	1.08 (.28)	−0.02	0.06

Note. The results of the fit of the final model reporting beta coefficients, standard deviations of the random effects, standard errors of the fixed effects, *t* values, *p* values, and the 95% confidence intervals (CIs) are shown. Boys are coded as 0, and girls are coded as 1.

[a] The 95% CI of the random effect is on the standard deviation of the effect because the *lmerTest* package does not report beta coefficients and *p* values for random effects. The 95% CI of the fixed effect is on the beta coefficient.

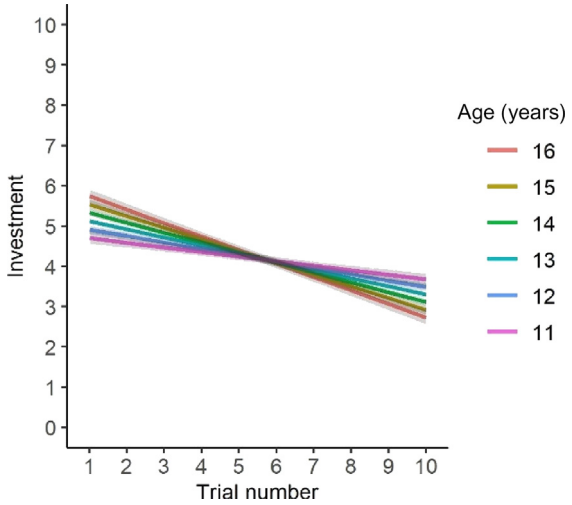

Fig. 6. The decrease in trust behavior (i.e., the adaptation of trust behavior) becomes stronger with age (untrustworthy condition). Trial number is displayed on the × axis. The investments are displayed on the *y* axis. Age was analyzed as a continuous variable, but for visual purposes only the ages 11 through 16 years are displayed in this figure. The lines in the figure represent the model-implied age-related linear decrease in investments during the game.

Discussion

In the current study, we examined the development of adolescent trust behavior, the presence of gender differences in the development of adolescent trust behavior, and the association between individual differences in the developmental trajectories of trust and perspective-taking abilities. The

results indicated an increase of initial trust behavior with age, with boys showing a stronger age-related increase compared with girls. No evidence was found for individual differences in the development of initial trust behavior being related to perspective-taking abilities. During trustworthy interactions, no evidence was found for age-related changes in the adaptation of trust behavior, neither for gender differences nor for an association between the developmental trajectory of adaptive trust behavior and perspective-taking abilities. In the trustworthy condition, results did indicate an age-related increase in the overall level of trust behavior that was shown toward the partner (with boys showing a stronger age-related increase than girls; for girls, this age-related increase was stronger for adolescents with higher perspective-taking abilities compared with adolescents with lower perspective-taking abilities). In the untrustworthy condition, the results showed a stronger decrease in trust behavior with age, but no support was found for different developmental patterns for boys or girls or for an association with perspective-taking abilities.

In the current study, we used a longitudinal sample to study the development of trust behavior, which has the advantage of enabling the examination of between-person differences in within-person change (Singer & Willett, 2003). As hypothesized, the results of the current study showed an increase in initial trust behavior during adolescence. However, the results provided no evidence that this age-related increase in initial trust behavior was related to perspective-taking abilities. In the literature, other processes that could underlie this developmental increase in initial trust behavior are suggested such as changing expectations about the partner's trustworthiness. A previous study showed that, with age, adolescents expect the partner in a social interaction to be more trustworthy, and these expectations may influence the extent of initial trust behavior that adolescents themselves show (Ma et al., 2020). This means that, in the current study, the higher stakes (i.e., higher initial investments) that the adolescents showed with increasing age may have been guided by stronger expectations about the partner's reciprocal behavior. Another process that might have played a role is the changing preferences regarding equity. In a recent study, the preference to avoid the outcome that one would get less than the partner was less strong for older adolescents compared with younger adolescents (this preference is called "disadvantageous inequality aversion"), and these lower levels of disadvantageous inequality aversion explained the higher levels of trust behavior that the group of older adolescents showed (Westhoff et al., 2020). Having lower levels of disadvantageous inequality aversion when adolescents are older might have played a role in the current study as well, which would mean that, with age, adolescents become less opposed to noncooperative behavior of the partner, and this may have led to higher levels of initial trust behavior.

Furthermore, in line with the hypotheses, the results showed that the increase of initial trust behavior with age was stronger for boys compared with girls. No evidence for gender differences was found at 11 years of age, but the differences increased during adolescence, possibly suggesting that the differences in initial trust that have previously been found in adults (Van den Akker et al., 2020) start to emerge during adolescence. The results indicated that there was no evidence that these gender differences in developmental changes were related to gender differences in perspective-taking abilities. Another suggestion that has been put forward in the literature is that gender differences in initial trust behavior may be related to gender differences in risk-taking behavior. The decision to trust is made under uncertainty because by trusting an unknown other, one makes oneself vulnerable and accepts the chance that this may result in a negative outcome (Van den Akker et al., 2020). Research has shown that the amount that the trustor shares with the partner (i.e., the investment) is positively related to the risk attitude (Chetty et al., 2021; Lönnqvist et al., 2015). In addition, people who are more averse to uncertain and ambiguous situations show less trusting behavior (Li et al., 2019; Vives & FeldmanHall, 2018). Gender differences in risk-taking differences may give rise to the gender differences in initial trust behavior, with some studies indicating that women are more risk averse than men (Borghans et al., 2009; Dohmen et al., 2011), and these gender differences in risk preferences seem to emerge during early adolescence (Andreoni et al., 2020). However, we should note that a number of studies using experimental tasks were unable to find gender differences in risk-taking behavior in adolescents (Filippin & Crosetto, 2016; MacPherson et al., 2010; White et al., 2008), suggesting that future research could examine whether gender differences in adolescent initial trust behavior actually result from differences in levels of risk-taking behavior or are due to other behavioral processes. Furthermore, as previously discussed, the expectations that people have about others'

reciprocal behavior play an important role in trust behavior. Therefore, another explanation for the gender differences in initial trust behavior could be that, compared with women, men expect other people to show higher levels of reciprocal behavior, which can lead to higher levels of cooperative and trust behavior among men (Buchan et al., 2008; Dorrough & Glöckner, 2019; Romano et al., 2017).

In contrast to our hypothesis, the results of the current study did not provide evidence for age-related changes in the adaptation of trust behavior during trustworthy interactions. In addition, in the trustworthy condition, no evidence was found for gender differences in age-related changes in the adaptation of trust behavior or for an association between age-related changes in the adaptation of trust and perspective-taking abilities. Perhaps the absence of the relationship between the adaptation of trust behavior and age during trustworthy interactions could be explained by the fact that the partner in our study responded in a less trustworthy manner than the interaction partner in previous work. For example, in the study by Van den Bos et al. (2012), the partner reciprocated on 80 % of trials during a binary choice trust game, and their results did show a developmental increase in trust behavior during interactions with a trustworthy partner. Although there was no evidence supporting developmental effects related to the way behavior changed throughout the interaction (i.e., the adaptation of trust behavior that gives insights into the back-and-forth interaction between individuals), the results of the current study did indicate that the overall level of displayed trust behavior increased with age and that this increase was stronger for boys than for girls. In girls, this age-related increase in the overall level of trust was stronger for adolescents with higher perspective-taking abilities compared with adolescents with lower perspective-taking abilities. This indicates that stronger tendencies to consider another person's perspective were related to higher age-related increases in the level of overall trust behavior in response to a partner showing signs of trustworthiness, meaning that the participants with higher perspective-taking abilities became more trusting when getting older.

In line with the hypotheses, the results of the current study further indicated that the decrease in trust behavior during untrustworthy interactions was stronger as adolescents became older. In the untrustworthy condition, the participant was better off not increasing the investment (i.e., either lowering the investment or not changing the investment compared with the previous trial) to lose relatively less money. The current results indicate more adjustment behavior in response to the untrustworthiness of the partner with age. Adequate adjustment behavior in response to untrustworthy behavior might become especially relevant during adolescence. This is a period when social contacts increase, when social hierarchies play a big role, and when one is particularly sensitive to peer acceptance and rejection (Erdley & Day, 2017; Koski et al., 2015). These factors make social interactions during adolescence more complex, and as adolescents meet more new people, the detection of untrustworthiness might start to play a bigger role (Crone & Dahl, 2012; Hillebrandt et al., 2011). In contrast to the hypotheses, the results did not provide evidence that these developmental trajectories during the untrustworthy condition were different for boys and girls or that they were related to perspective-taking abilities. Together with the results found for initial trust behavior, the findings suggest that as adolescents get older they show increasing levels of initial trust behavior toward unknown others. However, if this trust is not reciprocated within a repeated interaction and they are exploited by untrustworthy interaction partners, this results in a stronger age-related decrease in trust behavior.

Although support was found for gender differences in the development of initial trust behavior, the results did not indicate evidence for gender differences in age-related changes in the adaptation of trust behavior. This suggests that showing initial trust behavior toward others (without having prior expectations about the interaction partner's trustworthiness) and the ability to adapt one's own trust behavior when getting to know the partner better are different processes, which means that different mechanisms may underlie these two types of trust behavior. As suggested earlier, gender differences in expectations about the partner's trustworthiness may play a role in initial trust behavior (e.g., that men have higher expectations of the partner's reciprocal behavior than women), whereas these expectations may be less relevant during continued interactions when the partner reveals increasingly more information about themselves. Future research may further investigate the processes that underlie these gender differences, for example, by administering questionnaires that explore the motivation for the decisions that are made or by including measures of risk-taking behavior (e.g., a risk preference task). In addition, future research can further examine whether and how perspective taking relates to trust behavior. Frequently, the suggestion is made that perspective taking is one of the underlying

processes of trust behavior; however, this has not been examined often. Previous cross-sectional work found associations between the two processes (Fett et al., 2014). However, in contrast, no significant association between perspective-taking abilities and trust behavior were found in a study by Van de Groep et al. (2018) or in the results of the current study. This may have to do with the type of trust behavior that was examined, the type of trust game that was used, or the measurement that was used for perspective-taking abilities. Another important direction for future studies is to examine the validity of the trust game by relating trust game behavior to aspects of trust behavior in social interactions in daily life because the latter are obviously more complex than the controlled experimental setting of the trust game.

Several considerations should be kept in mind when interpreting the current results. First, it is important to consider the specific design of the trust game that was used. An important difference of the current trust game design, as compared with previous studies, is that the participants were informed that they would play games with computer counterparts (displayed as cartoon animations). The cartoon animation was required in the current longitudinal study because it was unfeasible and undesirable to use deception of falsely informing the participants that they were playing with human counterparts. However, the use of cartoon animations may have affected the way in which the social interaction was perceived by the participants. Nonetheless, playing games with computer counterparts elicits similar (though weaker) responses compared with playing with human counterparts, and this is especially the case when the computer's behavior was adaptive to the participant's decisions (as in the current study) (Decety et al., 2004; Kircher et al., 2009; Rilling et al., 2004; Van't Wout et al., 2006). Furthermore, the choice of a cartoon animation as interaction partner was considered appropriate because the cartoon animation resembled characters in video games, which adolescents are highly familiar with (Adachi & Willoughby, 2013; Ream et al., 2013). A notable strength of informing the participants about the use of a cartoon animation as interaction partner is that it reduces the effects of potential bias resulting from the participants' beliefs regarding the (real or fictitious) character of the other player. Second, longitudinal designs come with limitations. One of the biggest concerns is a selection bias given that the sample consists of a selection of participants who are willing to participate for the entire duration of the study (the dropout of participants is a concern here). Fortunately, multilevel analysis allows the inclusion of participants who participated in only part of the waves. However, the sample of the current study is still prone to a selection bias given that many participants in our sample are Western and from schools comprising students who perform at a relatively high academic level, which limits the generalizability of the results. Third, the trust game in the current study involved the exchange of money of which the value may have changed as the adolescents grew older. Consequently, the value of the investments, returns, and total earnings in the game may have been perceived differently when the adolescents were older compared with when they were younger. Previous work in adolescents showed no support for differences in the motivation for monetary rewards across age (Rodman et al., 2021). Although these results tentatively suggest that the motivational value of money is similar across age during adolescence into young adulthood, this previous study did not use the trust game. Therefore, we cannot completely discount the possibility that an age-related change in the subjective value of money may have played a role in the current trust decisions.

To conclude, the development of trust behavior throughout adolescence was examined in the current study by using a longitudinal sample. An increase of initial trust behavior at the start of the social interaction was present between ages 11 and 16 years as well as stronger age-related adaptive trust behavior throughout the interaction when the partner behaved untrustworthy. The development of initial trust behavior was stronger for boys compared with girls, whereas no evidence for gender differences in adaptive trust behavior was found. No support was found for significant associations between individual differences in the development of trust behavior (for both initial trust behavior and the adaptation of trust behavior) and perspective-taking abilities. Altogether, these results suggest that adolescents show ongoing developments in the way they approach a social interaction and in the way they tailor their social behavior to the demands of complex, potentially harmful surroundings. Well-developed adaptive social skills are relevant for the social challenges inherent to adolescence and are related to positive social outcomes (Crone et al., 2020; Crone & Dahl, 2012). This shows the importance of understanding how adolescents deal with social interactions, especially during the

period of life when social interactions and relationships increase and the social world becomes more complex.

Data availability

Data will be made available on request.

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Ethics statement

This study was approved by the scientific and ethical review board of the Faculty of Behavioral and Movement Sciences of Vrije Universiteit Amsterdam. All participants and parents/caregivers signed informed consent. Data were collected in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

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