Trust learning in the repeated Trust Game: a meta-analytic study

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Abstract

Trust involves making oneself vulnerable by relying on the expectation that others will reciprocate and act in a trustworthy manner, leading to mutual benefit. In behavioral economics and psychology, the Trust Game is a widely used paradigm to measure trust. The repeated Trust Game is a modified version of the Trust Game in which participants encounter the same partner(s) multiple times, allowing for reputation and trust learning. The aim of the present meta analysis was to identify features of the repeated Trust Game, participant characteristics, and manipulations of partner trustworthiness that affect trust learning. This is the first meta-analytic study to specifically assess trust learning in the repeated Trust Game and included 404 effect sizes from over 8,000 participants from 68 studies. Our findings indicate that the partners' behavioral trustworthiness, in the form of their reciprocation rate, is by far the most influential factor in participant trust learning ($\beta = 3.0$). Furthermore, the results reveal that manipulating prior information about partners can have an effect on the amount of learning, but only for manipulations of trustworthiness/morality. Notably, in ingroup-outgroup studies, participants learn from their partners' trustworthiness and it is *not* affected by their partners' group membership.

Keywords

Repeated Trust Game, Meta-Analysis, Trust Learning

Data availability

Preregistration, Collected Data and Supplementary Material
The preregistration, summary of collected data (publications and corresponding effect sizes), the code for analysis, and supplementary material, can all be found on OSF: https://osf.io/nemq3/.

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Declaration of Conflicting Interests

The authors declare no conflict of interest.

Author Contributions

All authors contributed to conceptualization, CD and LS collected and analyzed the data, and all authors wrote the manuscript and approved the final version.

Introduction

Trust & the Trust Game

Drawing from psychology and economics, in behavioral economics, trust can be defined as relying on the expectation that others will reciprocate and act in a trustworthy manner, leading to mutual benefits (Berg et al., 1995). Indeed, trust involves three components: the self, the partner, and the specific goal or expectations in a current situation, i.e.: "I trust you to do X" (Simpson, 2007). As such, trust can be defined as a willingness to take risks and engage in cooperative behavior with others in situations characterized by uncertainty and/or risk. Trust therefore involves a certain vulnerability on the part of the one bestowing trust, the trustor, and who is acting in the faith that the recipient of that trust will respond in kind.

Trust can be defined along several axes. First, general trust, or initial trust, is effectively the amount of trust someone demonstrates toward someone they have no information about (McKnight et al., 1998; Yamagishi, 2011; Yamagishi et al., 2015). More specifically, general trust is at play when someone does not have information about how trustworthy another individual is, and they must interact. However, once someone has information about the trustworthiness of an individual, the trust then becomes evidence-based; their general trust is now replaced by that individual's specific reputation (Yamagishi, 2011; Yamagishi et al., 2015).

The Trust Game (TG) has emerged as one of the most widely used paradigms in the social sciences to study trust and cooperation (Berg et al., 1995) and can be used to measure general and evidence-based trust. The game involves two players: the trustor and the trustee, or investor and investee, respectively. The trustor is given a sum of money and can choose to send a portion of it to the trustee. The amount sent is multiplied by a factor (often greater than one) and the trustee receives the multiplied investment. The trustee can then decide how much, if any, of the multiplied amount to return to the trustor. The amount and/or frequency the trustor/investor invests on a given trial reflects the extent to which the trustor trusts the trustee. The trustee's decision to reciprocate by returning a portion of the multiplied amount reflects their level of trustworthiness and fairness.

In its simplest form, the Trust Game consists of this single interaction, also referred to as the single-shot Trust Game. However, it can also incorporate multiple rounds with the same partners, allowing for the examination of trust and reciprocity dynamics over time (King-Casas et al., 2005), also referred to as the repeated Trust Game. Repeated interactions enable participants to learn from each other's behaviour and adjust their strategies accordingly. This longitudinal aspect of the game contributes to understanding the evolution of trust (Cox & Deck, 2005), reflecting how trust is established through repeated interactions (Anderhub et al., 2002; Camerer & Weigelt, 1988). Although many studies have used the repeated Trust Game, there exists no meta-analysis or systematic review on how participants learn from their partners as a function of their trustworthiness and other contextual factors surrounding the repeated Trust Game.

Trust Game Learning: Evidence and Priors

Most studies using the repeated TG show that participants change their trust/investment behaviour to adapt to their partners' trustworthiness, but do not shed their pre-existing biases completely (Chang et al., 2010; Fareri et al., 2012, 2015; Telga et al., 2018; Vermue et al., 2018). Studies which used reinforcement learning models to assess how participants update their trust toward their partners in the repeated TG differ in their results, indicating that features of the game may have an effect on learning (Chang et al., 2010; Fareri et al., 2012, 2015).

Reinforcement learning is the process or situation where an agent (a person or an algorithm) interacts with an environment, learns from its experiences, and adapts its behaviour to achieve its goals by maximising the accumulated rewards (Sutton & Barto, 2018). The learning process of that agent can be modelled, and aspects of the agent's learning assessed, including the extent to which the agent exploits or explores choices in their learning environment. As such, reinforcement learning models are one approach with which participants' learning in the repeated Trust Game can be assessed: participants experience gains and losses in a sequence of moves/bids for trust with the ostensible objective of maximising gains (Chang et al., 2010).

Chang et al. (2010) used reinforcement learning models to investigate how participants' trust was updated throughout the TG; in particular how initial trustworthiness beliefs and the behavioural evidence of trustworthiness interacted. They found that both the initial trustworthiness judgement as well as subsequent experience interact synergistically in participants' decision to trust throughout the game. Other studies with reinforcement learning models have shown evidence for confirmation and positivity biases in learning in the repeated TG (Fareri et al., 2012, 2015), fitting with findings from forced choice tasks[1] outside of the TG literature (Biele et al., 2009, 2011; Lefebvre et al., 2017; Palminteri et al., 2017), indicating participants may learn differently from positive outcomes vs. negative outcomes.

Another crucial point is that studies that contrasted fair/good and unfair/bad partners in the form of high and low reciprocation rates, respectively, have shown a stronger result in reducing prior biases (Chang et al., 2010; Delgado et al., 2005; Telga et al., 2018), compared to those that included the maximally uncertain reciprocation rate of 50% (Fareri et al., 2012, 2015). Consequently, the extent to which participants learn from their partners may be affected by

[1] Forced-choice tasks are tasks in which a participant is forced to make a choice between alternatives presented, usually 2 to 4. The task is typically designed in a way that there is a correct choice and participants' accuracy in their ability to discriminate between beneficial and non-beneficial choice(s) is measured. One example is the Iowa Gambling Task, IGT (Bechara et al., 1994) in which participants try to obtain high rewards by choosing the best of four choice options.

certain features of the individual or game, with the reciprocation rate being particularly important.

Aims & hypotheses

Although the repeated Trust Game is widely used, and has been included in some meta-analyses, typically what is examined and reported is either the participants' initial trust on the first trial (Johnson & Mislin, 2011; Stanley et al., 2011) or participants' average investment/trust behaviour with their respective partners during the game (Cañadas et al., 2015; Telga et al., 2018). Currently, however, there exists no meta-analysis or systematic review on how and to what extent participants *learn* or change their trust behaviour over time during the trust game, and the factors that may influence this learning process, such as demographics (interindividual) or game features.

Many studies have shown that participants learn about their partners' trustworthiness through repeated interaction in a repeated Trust Game paradigm by adjusting their investment behaviour to their partners' behavioural trustworthiness throughout the course of the game (Cañadas et al., 2015; Delgado et al., 2005; Tortosa et al., 2013; Vermue et al., 2018). This indicates that overall participants do learn to trust their partners (and also learn to trust them less if they are untrustworthy). However, studies have also shown that prior biases can impair or affect trust learning (Fareri et al., 2015; Fouragnan et al., 2013; Tortosa et al., 2013; Vermue et al., 2018). As such, the question remains if and to what extent trust learning is modified by other factors.

Previous findings point to a variety of factors that could have an effect. In both the single-shot (Johnson & Mislin, 2011) and in the repeated TG (Vermue et al., 2018), it has been shown that participants from different countries invest differently. In terms of the trust game design, evidence suggests that the investor's endowment and the amount by which the investor's investment is multiplied influence participants' investment behaviour (Alós-Ferrer & Farolfi, 2019; Johnson & Mislin, 2011). Some studies include controlled reciprocation rates with fictitious partners, e.g. pre-programmed responses (Phan et al., 2010), whereas other studies let two participants interact "live" with a real person (Cochard et al., 2004). In "live" interactions, participants often adapt a tit-for-tat investment strategy, focused on a trial-by-trial response to the *behavior* of their interaction partner (Engle-Warnick & Slonim, 2004), which may differ from when participants play with pre-programmed responses.

We therefore hypothesized that participants do learn and change their trust behaviour as a result of their partners' trustworthiness, as measured by the reciprocation rate, given the strong evidence for it, and this will play a larger role in learning compared to participant demographics and game features. The demographics and game features could still have an influence and require testing.

Our second area of investigation analyzed how negative and positive priors affect trust learning. These often include the following manipulations: the partners' morality or pre-existing trustworthiness, social closeness/similarity of the partner to the participants, and social group (ingroup-outgroup) membership.

Several studies have included a manipulation of partners' morality or pre-existing trustworthiness prior to the Trust Game (Delgado et al., 2005; Fareri et al., 2012; Maurer et al., 2018; Zarolia et al., 2017). Such manipulations have been shown to significantly impair participants' ability to learn their partners' true (behavioural) trustworthiness (Zarolia et al., 2017). However, the extent to which the priors affect participants' investment behaviour seems to depend on the strength of the partners' behavioural trustworthiness (Delgado et al., 2005).

Group membership can similarly affect participants' trust learning: one study showed that participants learn less from outgroup members of a different nationality compared to ingroup members of the same nationality with high reciprocity but learn equally from outgroup and ingroup members with low reciprocity (Vermue et al., 2018). Another study (Duncan et al., 2023) has shown that participants changed their trustworthiness judgments according to their partners' behaviour but that the greatest change in investment and in trustworthiness perception was for ethnic ingroup members who behaved unfairly (with low reciprocity). Social closeness may bias participants learning even more: in one social closeness TG design, participants had a strong bias to trust their friend more than a computer or other social control, even when all were pre-programmed to have the same reciprocation rate (Fareri et al., 2015).

Given that the literature has shown differing results in terms of how priors interact with partner trustworthiness to influence trust learning, we conducted subgroup analyses on studies that used the following manipulations: social closeness, group membership, prior trustworthiness/morality, and an exploratory analysis of priors across all manipulations.

Methods

Preregistration, Collected Data and Supplementary Material

The preregistration, summary of collected data (publications and corresponding effect sizes), the code for analysis, and supplementary material, can all be found on OSF: https://osf.io/nemq3/.

Systematic Search

As the Trust Game paradigm is used in psychology, neuroscience, and behavioral economics, we searched the following databases: *Scopus*, *PubMed*, *PsycInfo*, *PsycArticles*, and *EconBiz*. Search terms were applied to "all fields" in each database, including title, abstract, and keywords to be as inclusive as possible.

The search terms were pre-registered and as follows: "trust game" OR "multi-round trust game" OR "repeated trust game" OR "investment game" OR "multi-round investment game" OR "repeated investment game" OR "multi-round reciprocity" OR "repeated reciprocity". The following filters were also included: article language - English, Article type - journal article or conference paper, and year of publication starting in 1988, the first year the Trust Game was published (Camerer & Weigelt, 1988; later formalized as the investment game by Berg et al., 1995). The search term “reciprocity” was always accompanied by “multi-round” or “repeated” because in a preliminary, investigative search without “multi-round” or “repeated” yielded thousands of additional, non relevant results. Note that most of the search results were publications with the single-shot Trust Game/Investment Game. Figure 1 shows the number of ineligible studies that were removed.

The search was completed on July 14th, 2020. Due to delays in data coding and collection, a second round was conducted on Nov 28th, 2021 to add more contemporary articles to the meta-analysis. Both searches were identical, except for a minimum publication year of 2020 in the second round to avoid duplicates.

After excluding duplicates and meta-analyses (Figure 1), the searches yielded **1639** unique articles as potentially eligible for analysis.

Inclusion Criteria

Following the systematic searches, papers were then evaluated by 2 independent reviewers (pre-registered as 3 reviewers but one had to leave the project partway) who read the papers and evaluated their eligibility for analysis in 2 phases of criteria. Phase I assessed minimal criteria for inclusion based on the study’s design; Phase II assessed what data (if any) was missing, requested it from the authors, and included articles for which we received the necessary data.

Phase I - Minimal Criteria for Inclusion

1. Must be the Trust Game. Other cooperation games, such as the Ultimatum Game, were not considered.
2. Must be the repeated TG, meaning repeated interactions with the same partner(s).
3. Studies published in 1988 or later.
4. Participants must have played the role of the **investor.** If participants played both roles, the data in which they were in the investor/trustor role was analyzed.
5. Partners are represented as human or human-like - participants need to be investing in another person, as opposed to an asset or stock.
6. The repeated interaction needs to be measured on the same day. Studies that have participants play with partners in a single-shot game on day 1, and then play with the same partners again on day 7 were not accepted.

From the list of 1639 articles, 148 met the meta-analysis inclusion criteria. The inter-rater reliability - a raw proportion of the sum of ratings in agreement divided by the total number of ratings - was 90%. Any reviewer discrepancies related to article eligibility were thoroughly debated before a final decision on inclusion or exclusion was made.

In phase II of our eligibility assessment, we requested the necessary information from authors to calculate a trust learning effect size. For nearly all articles, information needed to be requested or analyzed if already available on an open-source platform. If the information for pre-post investment behavior or the Pearson's correlation[2] between those values was neither reported nor made available to us when requested (nor was the raw data shared), then the study was excluded. Authors were also asked for missing demographic data, such as the proportion of female participants or mean age, however if not provided, we did not exclude the article. Authors were sent one reminder after 4-6 weeks and a second reminder 3 weeks thereafter.

Data Availability & Response Rate

Of the 148 articles meeting inclusion criteria I, effect sizes were obtained for 83 or 56% of those articles. In several cases, the same data was included in multiple publications, which were then subsequently counted as one study, yielding unique 69 studies. Note that one study was eliminated due to having extreme effect sizes (+3SD; see code on OSF for further details), leading to a final total of 68 studies.

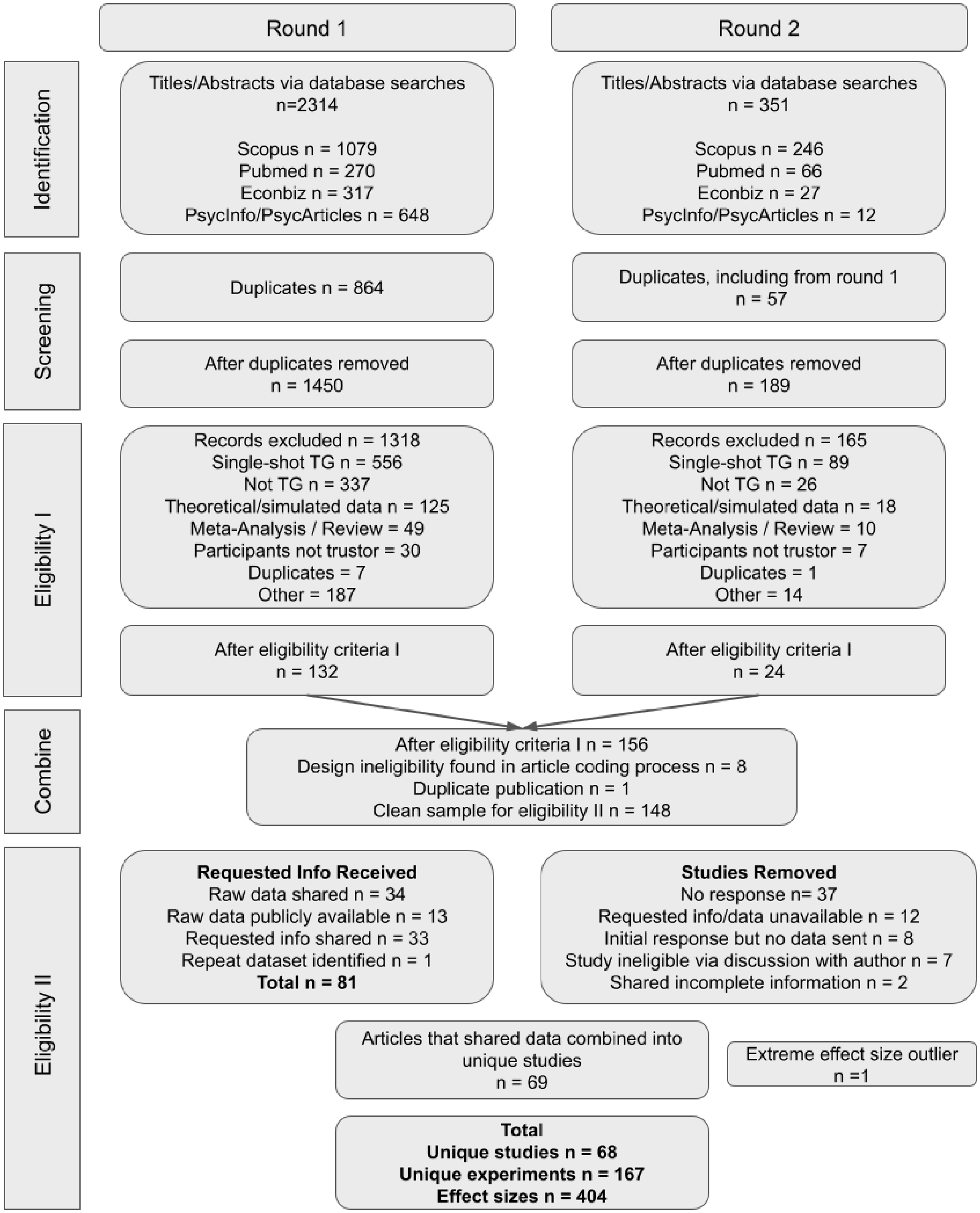
Regarding data availability, 13 studies had the raw data publicly available; for 24 studies the authors shared their raw data with us, and for 30 articles, the authors shared the metrics we requested (see Figure 1 for more details).

Our final sample included 68 studies or 167 experiments[3] with 164 unique participant groups, 404 effect sizes, and a total $N = 8{,}285$ unique participants.

[2] The correlation value is necessary for calculating an unbiased Hedges' g effect size (Lakens 2013).
[3] Studies or experiments that were included in multiple publications were only counted once.

Figure 1

Diagram of study collection, evaluation, and removal



Coding Effect Sizes

Coding effect sizes and missing data

Correlations between pre and post measures were rarely reported, a value necessary to calculate an unbiased Hedges' g effect size (Lakens, 2013). In the preregistration we stated we would impute missing correlation values with the average correlation value obtained from other studies. However, as the standard deviation of correlation values was high, and this value impacts the effect size substantially, instead of imputing the average value, we simply excluded studies for which we could not calculate unbiased effect sizes.

Calculating Effect Sizes: Hedge's *g*

As pre-registered, Hedges' *g* effect sizes were calculated first by calculating the correct Cohen's *d* and then applying Hedges' correction bias. Specifically, Cohen's *d* for repeated measures (Cohen's d_{rm}) was used, as it removes additional bias from the effect size by taking into account the correlated nature of the data for repeated measures (Lakens, 2013) as follows:

$$d_{rm} = \frac{M_{diff}}{SD^2_{pre} + SD^2_{post} - 2 \times r \times SD_{pre} \times SD_{post}} \times \sqrt{2(1 - r)}$$

However, when sample averages are used to estimate the population effect, it results in an overestimation of the population effect (Hedges, 1981). To address this bias, Hedges' *g* is used, as it is the equivalent of Cohen's *d* but with bias correction (Cumming, 2013; Hedges & Olkin, 1985; Lakens, 2013), as follows:

$$g \approx d \times (1 - \frac{3}{4(N) - 9})$$

Coding Study Characteristics

The trust game design features and participant characteristics that were included in our main models and their justification are described in detail below. See the Code Book and dataset on the OSF repository for a complete overview of these variables for each study.

Reciprocation Rate - pre-registered

The reciprocation rate quantifies the amount or frequency of the partner's reciprocation. The reciprocation rate has been defined differently across studies. For example, some authors define it as the proportion reciprocated of the multiplied investment (Buskens et al., 2016), others define it as the proportion reciprocated of the original investment, before it is ostensibly multiplied (Acar-Burkay et al., 2014), and yet others define it as a frequency of a binary reciprocation (Fareri et al., 2015; Phan et al., 2010). In order to compare the reciprocation rate across the various studies, we defined and analyzed the reciprocation rate as the average proportion of the multiplied investment that was reciprocated.

Type of Reciprocation Rate - pre-registered

Three categories of reciprocation rates were identified: "Fixed" refers to the reciprocation being fixed across the experiment, e.g. the partner reciprocates 50% of the investment on 75% of the trials (van den Bos et al., 2012). "Variable" denotes that the reciprocation rate changes, which would include the "live" games with other participants as the reciprocation is by definition not fixed (Johnsen & Kvaløy, 2016) as well as algorithm-based reciprocation study that have a defined variability, for example, reciprocating 45-75% of the multiplied investment or 0-25% of the multiplied investment (Vermue et al., 2018). "Adaptive" is when the reciprocation rate increases the more the participant invests, or decreases the less the participant invests (Gromann et al., 2013), likely facilitating the learning process more than the other types of reciprocation rates.

Counterfactual reciprocation rate - exploratory

One way to facilitate reputation learning is to provide information about the partners' reciprocating behavior on trials for which the participant doesn't make an investment, henceforth referred to as counterfactual reciprocation. Palminteri et al. (2017) showed that people take into account factual and counterfactual learning similarly. In a repeated TG that included counterfactual outcomes, Phan et al. (2010) showed that activation in brain areas crucial for reward processing was similar for avoiding a loss (learning from counterfactual information) and receiving reciprocation. Given these results, we hypothesized that including counterfactual outcomes in the repeated TG could facilitate participants' learning.

Investment: binary or continuous - pre-registered

In some studies, participants have a binary option to invest or not invest with a fixed amount (D. Fareri et al., 2012, 2015; Phan et al., 2010). In others, participants can select any amount from their endowment (Rosenberger et al., 2019, 2020; Vermue et al., 2018), which could affect participants' investment behavior and learning given they have a wider range of options to indicate their trust.

Multiplication Factor - exploratory

The trustor's investment is multiplied by a factor such that the partner receives more than what the participant invested (therefore creating an expectation of reciprocation). Johnson & Mislin (2011) found that it did not play a role in trust (investment from the trustor), but *did* play a role in trustworthiness (reciprocation from the trustee), whereas Lenton & Mosley (2011) found that increasing the multiplier increases the proportion of the endowment sent by the trustor. A higher multiplication factor could lead to higher investment and more learning.

Partner Endowment - pre-registered

Johnson & Mislin (2011) found that if the trustee received an initial endowment, trustors invested less with them, whereas Rodrigo-González et al. (2021) found that trustors invested more with trustees who have higher endowment. There is a conflict between different motives underlying decision making in the trust game, including expectations of reciprocity (fairness) and inequality aversion (Brülhart & Usunier, 2012; Rodriguez-Lara, 2018). Given the mixed evidence and motivations for participants displaying an endowment effect, it was included as a moderator.

Initial Endowment: Fixed, variable, first trial only - exploratory

Given that endowment has previously been previously shown to affect investment (Johnson & Mislin, 2011), the type of endowment that the participant has - only available on the first trial, fixed every trial, or varying across trials - could also have an effect and was included as a moderator.

Live game vs. algorithm - pre-registered

In live games both players are free to decide how much to invest and reciprocate on each trial or adopt a tit-for-tat approach in which they mirror the behavior of their partner. Subsequently, the learning curves are different than when users play with an algorithm with a fixed strategy and endgame effects, in which trustors trust less on the last trials, are often present (Cochard et al., 2004; Johnsen & Kvaløy, 2016; Kanagaretnam et al., 2010; van Miltenburg et al., 2012), suggesting more learning with algorithms.

Finite vs. Infinite Game - pre-registered

There is a distinction between studies which inform participants about the number of trials beforehand (Fareri et al., 2012, 2015) and those that do not (Buskens et al., 2016; Fett et al., 2012), henceforth referred to as finite and infinite paradigms, respectively. It has been shown that when participants do know the number of rounds (“definite”), they tend to invest less on the last trials because reputation building is over (Engle-Warnick & Slonim, 2004).

Trust Game Reward - exploratory

Johnson & Mislin (2011) showed that if the subjects’ payment was random, instead of systematic and based on their performance, it had a statistically significant, negative effect on the subjects’ investment in the single-shot TG. Therefore, if participants are given that they are more willing to engage in risk/investment with their partners, this could affect their learning.

Number of Trials - pre-registered

None of the studies in our meta-analysis explicitly tested the effect of the number of trials on learning. However, in nearly all of the studies, a general learning curve can be observed: when participants play with consistent partners (e.g. fair or unfair) their investment changes accordingly; in the early trials they quickly invest more/more frequently, reaching a peak, then tapering off and the inverse is observed for unfair partners (Chang et al., 2010; Collins & Juvina, 2021; Fouragnan et al., 2013; Phan et al., 2010; Telga et al., 2018; Vermue et al., 2018). Therefore, we hypothesized the number of trials would facilitate learning.

Participant Student Population - pre-registered

Johnson & Mislin (2011) hypothesized that students would invest less than non-students in the trust game due to previous research (Bellemare & Kröger, 2003; Fehr & List, 2004), no statistically significant effect at the meta-analytic level was found. Another study found that students behaved more selfishly than non-students (Belot et al., 2015). However, these studies did not use repeated games with the same partner, and therefore *learning* may or may not be different in student populations.

Participant Clinical Populations - pre-registered

There is evidence that non-neurotypical participants with psychological and neurological diagnoses, invested differently, on average, than nonclinical controls, suggesting that the learning rate between clinical and nonclinical groups could be different (Gromann et al., 2013; Maurer et al., 2018; Sutherland et al., 2020) with clinical diagnoses or traits including schizophrenia (Gromann et al., 2013) and autism (Maurer et al., 2018).

Country/Region - pre-registered as exploratory

There is evidence that people from some cultures are more trusting than others in the TG (Johnson & Mislin, 2011; Kiyonari et al., 2006). It has also been shown that preferences for risk-taking, positive and negative reciprocity, and trust, vary by country within the collectivist/independent categories (Falk et al., 2018). Therefore, we grouped the countries by continent as was done by Johnson & Mislin (2011). We did not include country-level effects because the sample sizes for each country were quite small and can produce unreliable estimates.

Participant Gender - pre-registered as exploratory

It has been shown that there are differences between men and women's trust behaviour. Falk & Hermle (2018) found that women show a higher preference for trust and a lower preference for risk than men do. In the repeated TG, it was found that men showed more basic trust than women and that when playing with fair and unfair partners, males decreased their trust more over time than females did (Lemmers-Jansen et al., 2017). Together, the results of these studies indicate that gender could be a moderating effect in trust learning in the repeated TG.

Participant Age - pre-registered as exploratory

Several studies have shown that trust increases with age (Fett et al., 2014; Poulin & Haase, 2015; Sutter & Kocher, 2007; van den Bos et al., 2012), and that willingness to trust increases linearly with age in a single-shot trust game paradigm (Sutter & Kocher, 2007). It has been shown that compared to teenagers, older adults invested more with a trustworthy partner, and showed a stronger decline in trust (less investment) with an unfair partner (Fett et al., 2014). However, (Lemmers-Jansen et al., 2017) did not find any behavioral differences in TG based on participant age (ranging from 16 to 27), and as such, this effect may not be consistent across each TG setup.

Analytical Strategy

Mixed-effects models were used for all meta-analytic estimates, which is recommended when studies are drawn from different populations (Quintana, 2015) and work better than fixed-effects only models with highly nested meta-analytic data (Fernández-Castilla et al., 2020). Specifically, different conditions were treated as nested within each experiment, and each experiment was nested in the overall study/publication. This was done following the protocol by Harrer et al. (2021), and using the Metafor package in R (Viechtbauer, 2010).

Main Analyses

The main analytical model included the aforementioned preregistered and exploratory features of the trust game and demographics that were identified as having potential effects on trust behavior. We hypothesized that the partner's reciprocation rate (the average proportion of the multiplied investment returned by the partner to the participant) would be the most important factor in participants' learning.

Subgroup analyses

Group Membership - pre-registered

The effect of the group membership and its interaction with the reciprocation rate was analyzed, as it has been shown that participants learn less from outgroup members compared to ingroup members with high reciprocity (Vermue et al., 2018), yet single-shot TG studies have shown a tendency for participants to trust/invest with their ingroup more (Stanley et al., 2011). We hypothesized that there could be an interaction effect in that participants would learn more from the group members doing the unexpected/astereotypical behavior (ingroup member behaving unfairly; outgroup member behaving fairly).

Social closeness - pre-registered

The effect of the social closeness between participants and their partners on trust learning and its potential interaction with the reciprocation rate (behavioral evidence) was analyzed. For example, Fareri et al. (2015) found that participants had strong prior beliefs about a personal friend being more trustworthy compared to a stranger, and playing the repeated TG did not significantly change their trust behavior toward their friend, despite the friend and the stranger both reciprocating at 50%. As such, we hypothesized that overall participants learn through repeated interaction, but the extent of this trust learning depends on the strength of participants' initial bias and the partner's reciprocation rate. Without a strong behavioral manipulation to counteract the initial bias, we expect that the amount of learning will be reduced compared to other experiments which present the partners' behavioral evidence in one strong direction.

Trustworthiness/Morality - pre-registered

Many studies include a manipulation of the partners' morality or trustworthiness apart from their reciprocity prior to the multi-round Trust Game, to assess how this affects investment behavior and learning (Delgado et al., 2005; Fareri et al., 2012; Maurer et al., 2018; Zarolia et al., 2017). In some cases, manipulations have been shown to impair participants' ability to learn their partners' true (behavioral) trustworthiness (Delgado et al., 2005; Fouragnan et al., 2013; Tortosa et al., 2013; Zarolia et al., 2017). As such, the goal of this analysis was to examine the interaction of behavioral trustworthiness (the reciprocation rate) with prior or accompanying expectation of the partners' trustworthiness, including using trustworthy vs. untrustworthy faces, vignettes and/or information about a partner's prior trustworthiness or morality, among others.

Clinical groups - pre-registered

As pre-registered, we analyzed learning in clinical groups vs. non-clinical groups on the condition that we collected at least 3 studies that worked with that clinical group. The minimum *n* was reached for 2 clinical groups: schizophrenia and psychosis, the results of which are in the supplementary materials.

Priors across all studies - exploratory

The subgroup analyses included in the pre-registration provide some indication of how these works based on specific *types* of negative/positive prior that was presented - social closeness, ingroup-outgroup, or trustworthiness/morality manipulations.

To extend these findings, we conducted an exploratory analysis that examined the role of a prior - negative, positive or neutral/none - and its interaction with reciprocation rate across all studies. Note that the neutral category includes both studies that explicitly created a "neutral" prior (usually as a basis of comparison to negative or positive) and studies with no prior, together forming the category "neutral/none".

Results

Descriptive summaries of the studies, participant characteristics, and trust game features are in the supplementary information (SI Table 1), as well as a forest plot of the pooled effect sizes from each study (SI Figure 1).

Full features model

The full features model included the reciprocation rate and all moderators listed in the analytical strategy. The model showed a positive, statistically significant effect of the reciprocation rate, with the largest effect size of $\beta = 3.0$, confirming the hypothesis that the reciprocation rate has the largest effect on learning. The only other statistically significant effect was a negative effect for live vs. programmed games, e.g. that participants in live games invest *less* over time compared to programmed games. This is likely due to end-game effects: participants tend to invest less on the last few rounds and especially on the last round to maximize their gains (Camerer & Weigelt, 1988; Engle-Warnick & Slonim, 2004).

Table 1

Full features meta-analytic model

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept	-1.535	0.474	-2.467	-0.604	0.001
RR	2.954	0.200	2.560	3.348	0.000
RR adaptive	-0.152	0.304	-0.749	0.445	0.616
RR variable	0.201	0.240	-0.271	0.673	0.403
RR counterfactual	-0.054	0.217	-0.480	0.372	0.803
Investment Continuous v. Binary	-0.032	0.207	-0.438	0.375	0.878
Multiplication Factor	0.246	0.131	-0.011	0.504	0.061
Endowment first trial only	-0.873	0.714	-2.277	0.531	0.222
Endowment variable	-0.302	0.550	-1.385	0.780	0.583
Partner endowment	-0.210	0.228	-0.659	0.240	0.359
Live game	-0.615	0.307	-1.219	-0.012	0.046
Infinite game	-0.468	0.353	-1.163	0.227	0.186
Trust game reward	-0.260	0.214	-0.681	0.161	0.225
N trials	-0.001	0.003	-0.006	0.004	0.572

Continent: Africa	0.096	0.661	-1.204	1.397	0.884
Continent: Asia	0.313	0.313	-0.303	0.929	0.319
Continent: Australia	-0.031	0.260	-0.544	0.481	0.904
Continent: Europe	-0.162	0.217	-0.588	0.264	0.456
Continent: South America	1.223	0.759	-0.270	2.716	0.108
Mean Age	-0.007	0.005	-0.018	0.003	0.187
Proportion female participants	0.064	0.229	-0.386	0.514	0.780
Students	0.382	0.207	-0.026	0.790	0.066
Clinical population	0.117	0.148	-0.175	0.408	0.432
Random Effects					
	Estimate	N levels			
Publications (level 1)	0.197	58			
Experiment/Participant group (level 2)	0.000	143			
Effect size condition (level 3)	0.129	359			

Note. AIC = 721.1, BIC = 820.4. There was significant moderation of the moderator effects, F(df1=22, df2=336) = 10.9, p < .001 and a significant effect of heterogeneity, QE(df=336) = 668.8, p < .001. RR = reciprocation rate; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

It is important to note that 45 effect sizes were dropped from the analysis due to having missing values for the participant mean age and proportion of participants who were female. The values from 11 studies were dropped: Acar-Burkay et al., 2014; Attanasi et al., 2019; Cochard et al., 2004; Fiedler & Haruvy, 2017; Johnsen & Kvaløy, 2016; Kanagaretnam et al., 2010, 2012, 2014; Lamba et al., 2020; Lunawat et al., 2021; Meidinger & Terracol, 2012; Schniter & Sheremeta, 2014; Tomlinson, 2012. Note that the Kanagaretnam publications used the same data so it is counted as 1 dataset.

Full Features Model Publication Bias

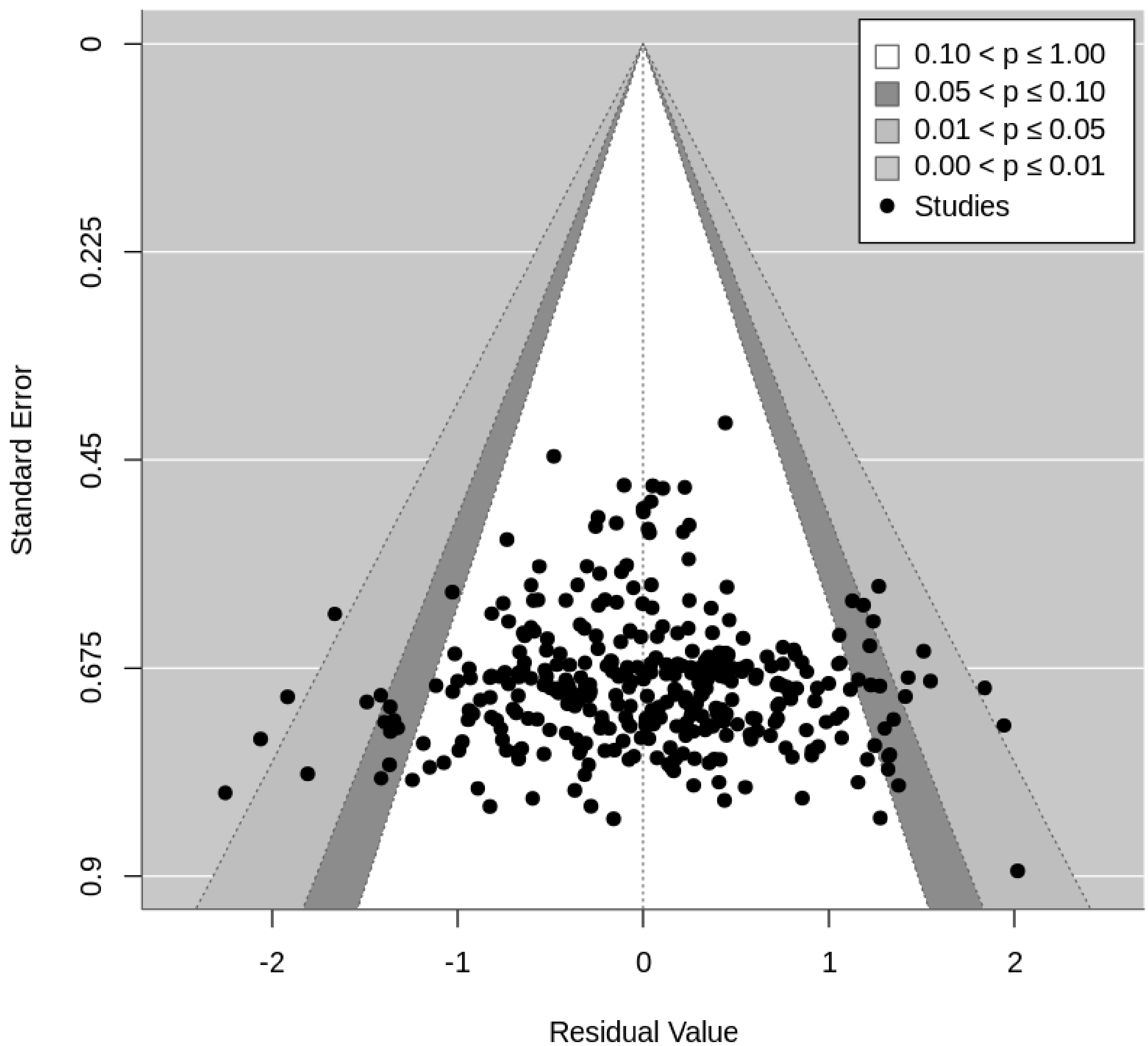
Publication bias was assessed with funnel plots in which an asymmetric plot indicates bias. The funnel plot (Figure 2) shows the learning effect sizes versus the standard error of those effect sizes for each condition within each experiment/study. Ideally, one would observe that the plot is symmetric, particularly in the lower section, where there is high standard error. The plot is symmetric, but there are values that fall outside of the ideal range, which would be in the white section. The plot shows that studies with larger standard error (less precise) had larger effect sizes than the pooled effect size.

In addition to the funnel plots, an Egger's regression test for publication bias (Egger et al., 1997) was applied by modifying the multi-level mixed effects models to include the standard error of the effect sizes as a moderator. If the intercept of the resulting regression significantly deviates from zero, the dataset is considered biased because the relationship between the precision (standard error) and size of studies is asymmetrical (Sterne & Egger, 2005).

The Egger's regression test yielded a statistically significant effect of the intercept, $\beta = -1.4$, 95% CI [-2.40, -0.38], SE = 0.51, $t(335) = -2.7$, $p = 0.008$, indicating possible publication bias. The funnel plot, however, is symmetrical, indicating that at least the publications are not skewed. See SI Table 2 for all parameters.

Figure 2

Funnel plot of the full features meta-analytic model



Subgroup Analyses

Group Membership - pre-registered

This analysis included 74 effect sizes from 21 experiments from 8 studies that included an ingroup-outgroup manipulation (Fujino et al., 2020; Gjoneska et al., 2019; Grueneisen et al., 2021; Macko, 2020; Telga et al., 2018; Telga & Lupiáñez, 2021; Vermue et al., 2018; Wu et al., 2021). The meta-analytic results (Table 2) show that there was no interaction effect of group membership and reciprocation rate, but a statistically significant positive effect of the reciprocation rate. This reflects the conflicting findings of how participants invest with their ingroup/outgroup partners. Figure 3 shows how the effect sizes vary widely for ingroup-outgroup conditions across studies.

Table 2

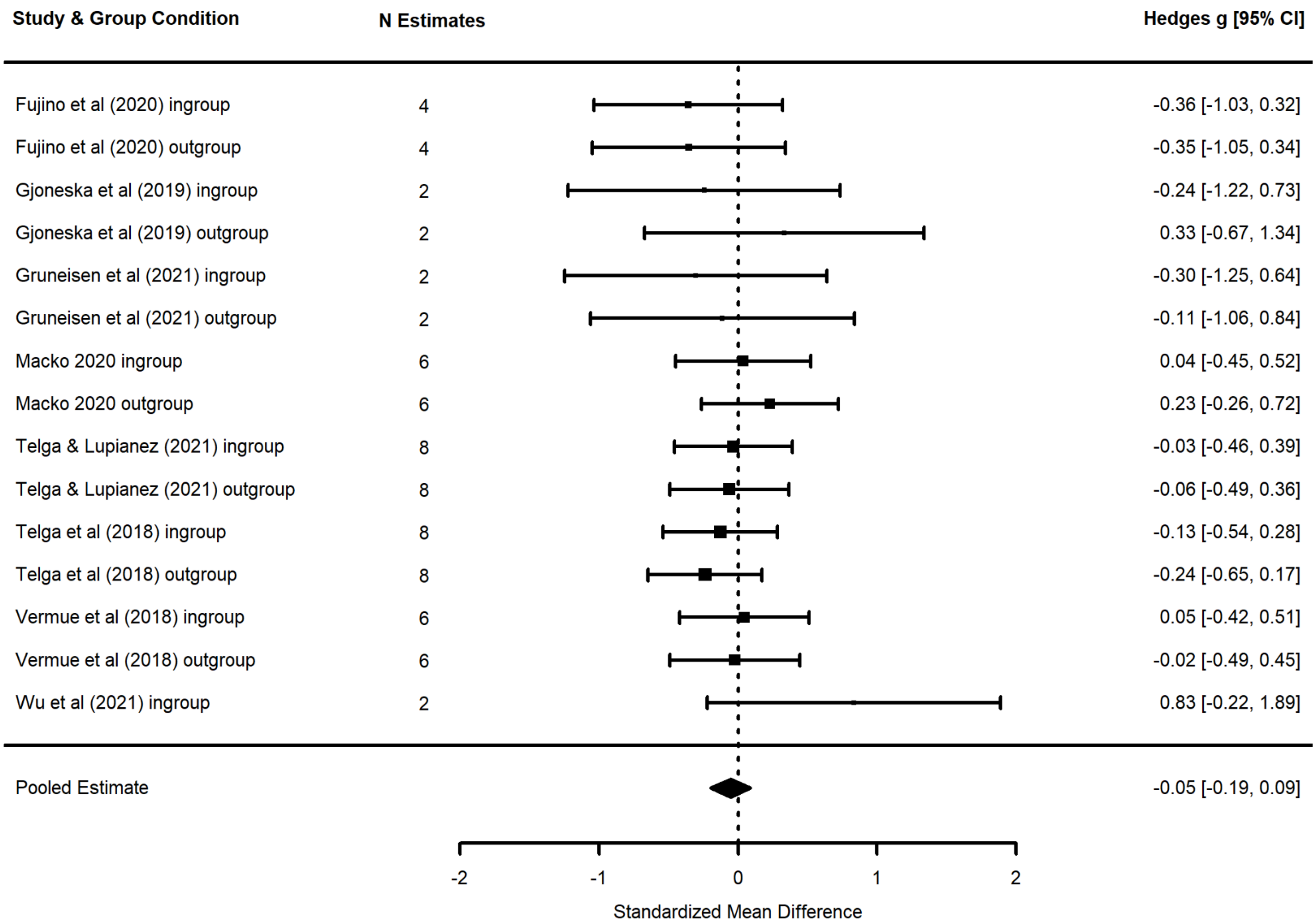
Group Membership (ingroup-outgroup) meta-analytic model results

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept***	-0.801	0.200	-1.200	-0.402	0.000
RR***	2.618	0.600	1.422	3.814	0.000
Outgroup	-0.241	0.285	-0.809	0.327	0.400
RR x Outgroup	0.854	0.859	-0.860	2.567	0.324
Random Effects					
	Effects	N levels			
Publication (level 1)	0.000	8			
Participant group (level 2)	0.000	21			
Effect size condition (level 3)	0.162	74			

Note. AIC = 147.5, BIC = 163.3 There was significant moderation of the moderator effects, F(df1 = 3, df2 = 70) = 16.9663, p < .0001 and a significant effect of heterogeneity, QE(df = 70) = 122.0476, p = 0.0001. RR = reciprocation rate; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Figure 3

Forest plot of ingroup and outgroup effects by publication



Social Closeness - pre-registered

This subgroup analysis included 15 effect sizes from 9 experiments from 3 studies that specifically manipulated social closeness not part of an ingroup-outgroup manipulation (Fareri et al., 2015; Walasek et al., 2019; Webb et al., 2016). Three closeness categories were created: close, distant, and neutral, and tested for an interaction effect with the reciprocation rate. The results of the meta-analytic model (Table 3) reveal no statistically significant effect, including the reciprocation rate. Figure 4 shows the pooled effect sizes for each social closeness category which show similar effects, explaining and illustrating the lack of a social closeness main effect. The groups for this subgroup analysis were smaller than expected, with just 11 effect sizes for distant and neutral categories, and only 5 for the "close" category. Therefore, this subgroup analysis is likely underpowered to detect effects, especially interaction effects.

Table 3

Social closeness meta-analytic model results

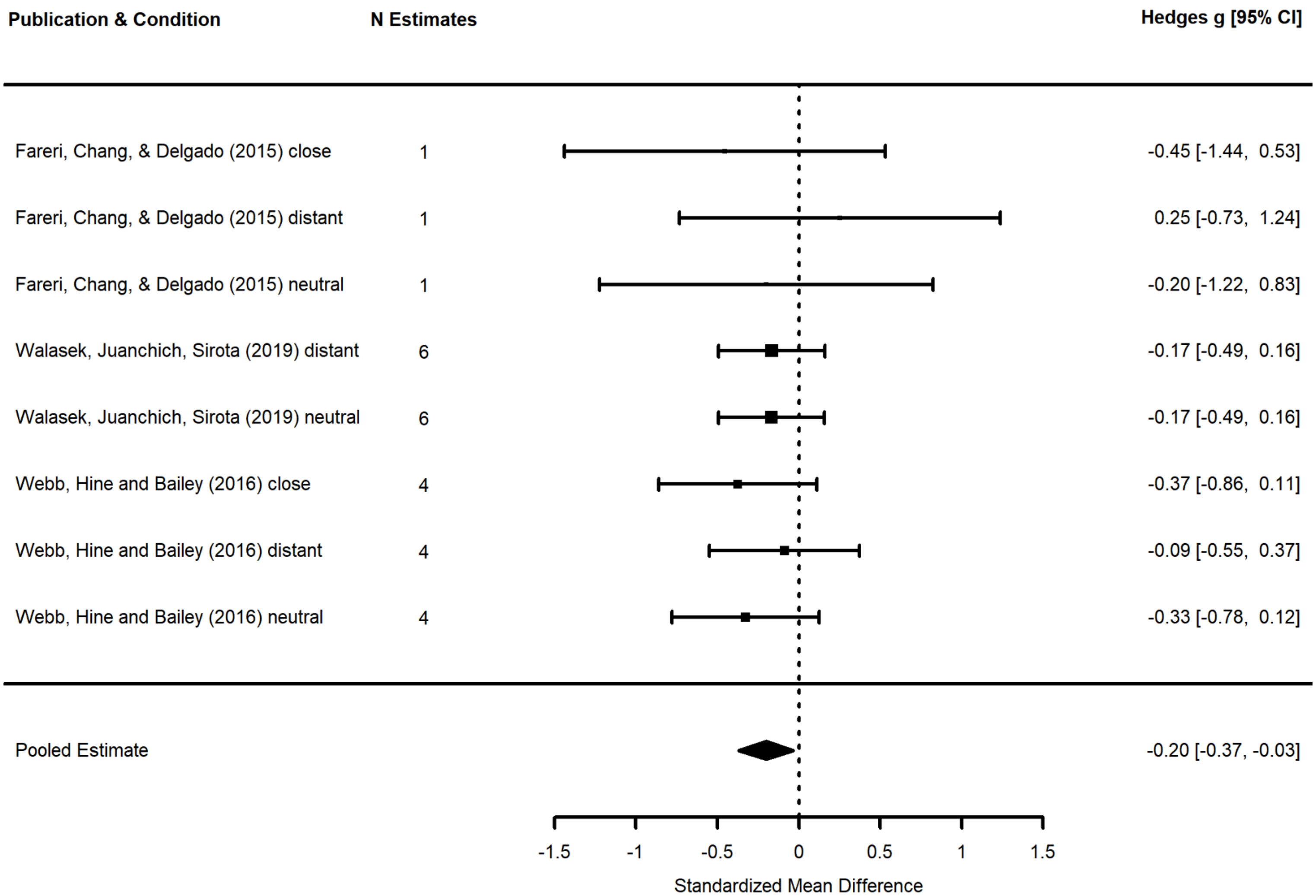
Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept	-0.533	0.464	-1.497	0.432	0.264
Distant vs. Close	-0.189	0.575	-1.385	1.008	0.746
Neutral vs. Close	-0.326	0.574	-1.520	0.867	0.576
RR	0.527	1.615	-2.832	3.886	0.747
Distant x RR	1.345	1.891	-2.588	5.278	0.485
Neutral x RR	1.455	1.888	-2.472	5.381	0.450
Random Effects					
	Effects	N levels			
Publication (level 1)	0.030	3			
Participant group (level 2)	0.000	9			
Effect size condition (level 3)	0.0.00	27			

Note. AIC = 30.5, BIC = 40.0. There was no statistically significant moderation of the moderator effects, F(df1 = 5, df2 = 21) = 1.78, p = 0.160 and no significant effect of heterogeneity, QE(df = 21) = 9.519, p = 0.985. RR = reciprocation rate; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

In order to adjust for the small number of samples for the social closeness categories, we ran the model again without the interaction term. Removing the interaction term resulted in an improved model fit (SI Table 3). Without the interaction term, the model showed a positive, statistically significant main effect of the reciprocation rate, β = 1.67, SE = 0.634, 95%CI = [0.36, 2.98], p = 0.015, and no other statistically significant effects. SI Figure 2 in the supplementary material shows the linear models with and without an interaction term.

Figure 4

Forest plot of publication and social closeness



Trustworthiness/Morality

As pre-registered, we analyzed the effects of manipulating partners' trustworthiness or morality apart from their trustworthiness behavior. This includes manipulations where the partners' prior trustworthiness was manipulated either through communicating that to the participant *or* the participant interacted with the partner and they behaved in a trustworthy/untrustworthy way. It also includes manipulations of morality, e.g. giving participants a vignette about the partners' moral behavior. This resulted in 100 effect sizes, 28 neutral/none, 36 negative and 36 positive from 32 experiments from 13 studies (Blue et al., 2018; Campellone & Kring, 2013; Fareri et al., 2012; Hooper et al., 2012; Knight et al., 2021; Lamba et al., 2020; Lee et al, 2016; Maurer et al., 2018; Radell et al., 2016; Rățală et al., 2019; Sutherland et al., 2020; Taylor & Stevenson, 2018; Yu et al., 2014).

The meta-analytic model results (Table 4) show a negative interaction effect of negative prior vs. none with the reciprocation rate. This indicates that the reciprocation rate has a weaker effect on the learning rate when there is a negative prior compared to when there is a neutral prior/no prior or positive prior (see Fig 5). The model also showed a statistically significant positive main effect of a negative prior and a statistically significant positive effect of the reciprocation rate.

Table 4

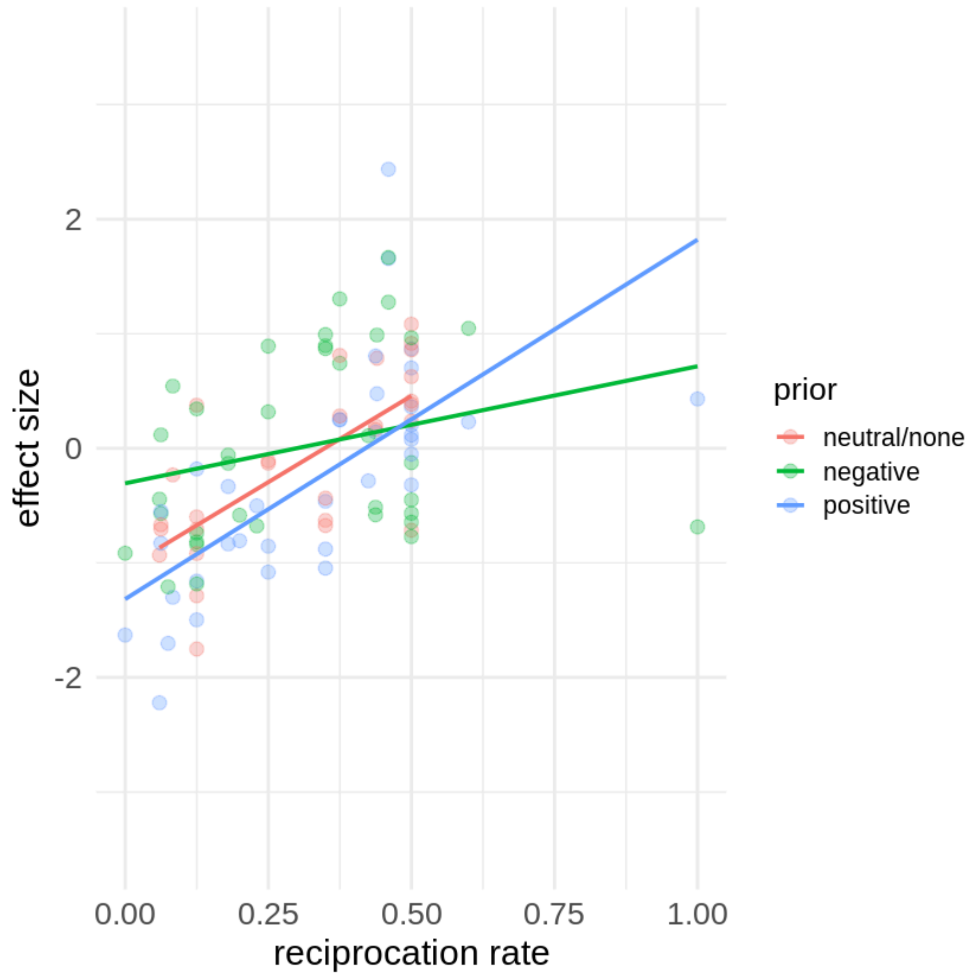
Trustworthiness/Morality meta-analytic model

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept	-1.131	0.276	-1.680	-0.583	0.000
RR	3.337	0.748	1.853	4.821	0.000
Negative vs. Neutral	0.787	0.334	0.123	1.451	0.021
Positive vs. Neutral	-0.308	0.344	-0.991	0.374	0.372
RR x Negative	-2.181	0.912	-3.993	-0.369	0.019
RR x Positive	0.010	0.914	-1.805	1.826	0.991
Random Effects					
	Effects	N levels			
Publication (level 1)	0.051	13			
Participant group (level 2)	0.000	32			
Effect size condition (level 3)	0.455	100			

Note. AIC = 210.5, BIC = 233.4. There was a statistically significant moderation of the moderator effects, F(df1 = 5, df2 = 94) = 11.617, p <.0001 and a statistically significant effect of heterogeneity, QE(df = 94) = 218.3, p < .0001. RR = reciprocation rate; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Figure 5

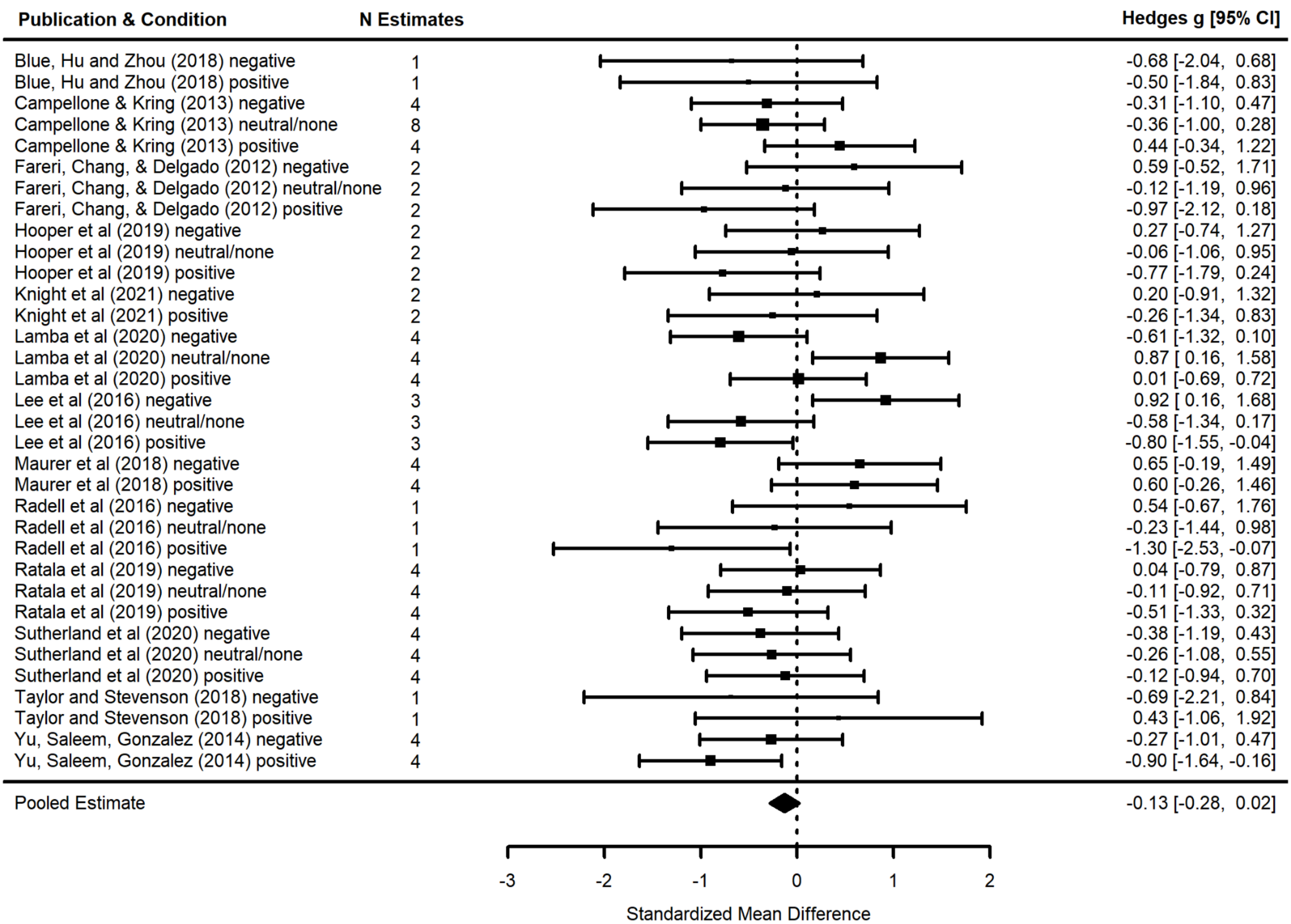
Trustworthiness/morality meta-analytic model interaction effect



The interaction effect is modeled in Figure 5 which shows that the relationship between the reciprocation rate and effect size changes depending on the prior that's present. For all priors, the effect size increases as the reciprocation increases, however, the slope is different for a negative prior compared to the other priors. At low and high reciprocation rates, there is a larger learning effect (investing less, investing more, respectively) for neutral and positive priors compared to negative priors. For the negative prior, the effect sizes are closer to zero for the same reciprocation rates. In other words, the reciprocation rate has less of an effect on the learning effect size when a negative prior is present compared to a neutral or positive one.

Figure 6

Forest plot of publication and priors in trustworthiness/morality studies



To further illustrate the effects, Figure 6 shows the pooled effect of priors within each publication and prior manipulation condition. As can be observed, the values vary widely across and within publications, again pointing to the importance of the reciprocation rate as the most explanatory variable for learning. It also shows that the overall learning rate was slightly negative - meaning people had a tendency, overall, to invest less over time with their partners.

Clinical populations

As stated in the pre-registration, we only performed analyses for the clinical groups for which we had at least 3 publications, which happened for psychosis and schizophrenia. Both models showed a positive, statistically significant effect for the reciprocation rate, but no difference between the participant groups based on a clinical diagnosis. See supplementary material SI Tables 4 and 5 for detailed results.

Priors across all studies - exploratory

We conducted an exploratory analysis to assess the effect of negative, positive, or neutral priors about the partners' trustworthiness apart from their behavioral trustworthiness. This is an extension of the previous analyses to examine if there is an effect of positive/negative priors on trust learning, regardless of the specific *type* of those priors.

Table 5

Priors and reciprocation rate meta-analytic model for all studies

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept	-1.153	0.121	-1.391	-0.915	0.000
Negative vs. Neutral/None	0.277	0.171	-0.060	0.613	0.107
Positive vs. Neutral/None	-0.198	0.177	-0.545	0.149	0.260
RR	2.723	0.251	2.228	3.217	0.000
Negative (vs. Neutral/None) x RR	-0.279	0.440	-1.145	0.586	0.526
Positive (vs. Neutral/None) x RR	0.453	0.436	-0.405	1.311	0.300
Random Effects					
	Effects	N levels			
Publication (level 1)	0.244	68			
Participant group (level 2)	0.000	167			
Effect size	0.126	404			

condition (level 3)

Note. AIC = 841.2, BIC = 877. There was significant moderation of the moderator effects, F(df1 = 5, df2 = 398) = 43.335, $p < .0001$ and a significant effect of heterogeneity, QE(df = 398) = 858.482, $p < .0001$. RR = reciprocation rate; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

As observed in Table 5, there is no statistically significant interaction effect of the reciprocation rate and the priors, however, there is a large, positive, statistically significant main effect of the reciprocation rate.

The above model used the neutral/none as the baseline for comparing the priors effects and how they interact with the reciprocation rate. To extend this, we additionally re-ran the model with the contrast between positive and negative priors and found no statistically significant interaction effect with the reciprocation rate, but a statistically significant negative main effect for the difference in positive and negative priors (SI Table 6).

Taken together, there is a main effect of the reciprocation rate and a difference between positive and negative priors, but neither of them differ from the neutral/none prior. Additionally, when removing the interaction term and testing purely for main effects (a common approach when interactions aren't significant), these results are further confirmed: negative priors having more positive learning rates than positive or neutral/none priors (SI Table 7; SI Figure 3)

This analysis indicates that participants have a more positive learning rate for partners with a negative prior than those with a positive prior, given an equal reciprocation rate. More specifically, at a low reciprocation rate, it means participants still have a negative learning rate (investing less over time), but it is less negative than with a positive prior. For a high reciprocation rate, it means participants have a positive learning rate (investing more over time) and it is more positive than with a partner with a positive prior. At a meta-analytic level, it can also suggest the negative priors work more effectively at altering participants' initial expectations on the first trial (more so than the positive priors) and that the reciprocation rate / behavior then takes over. In other words, participants' expectations are confirmed and there is less learning when a partner is portrayed negatively and behaves negatively, but learn more when interacting with someone with whom they had a negative expectation of and they behave positively.

Reciprocation Rate Definitions - Exploratory

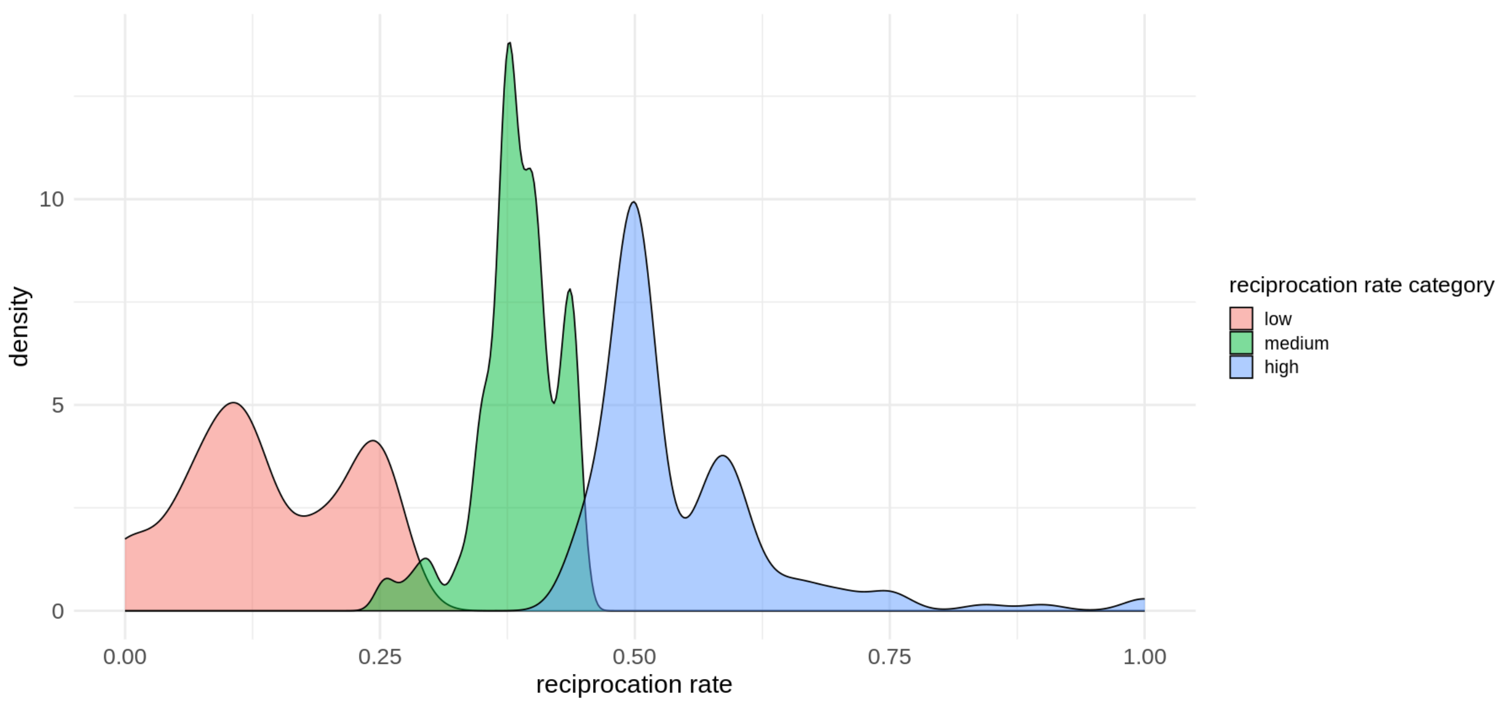
Distribution of effect sizes

Lastly, we performed an exploratory analysis on how the reciprocation rates were defined in the studies themselves and how this compares to the distribution of studies that we observed. We find that there is a difference in how some studies define a “fair” or “high” reciprocation rate compared to the distribution of reciprocation rates across studies.

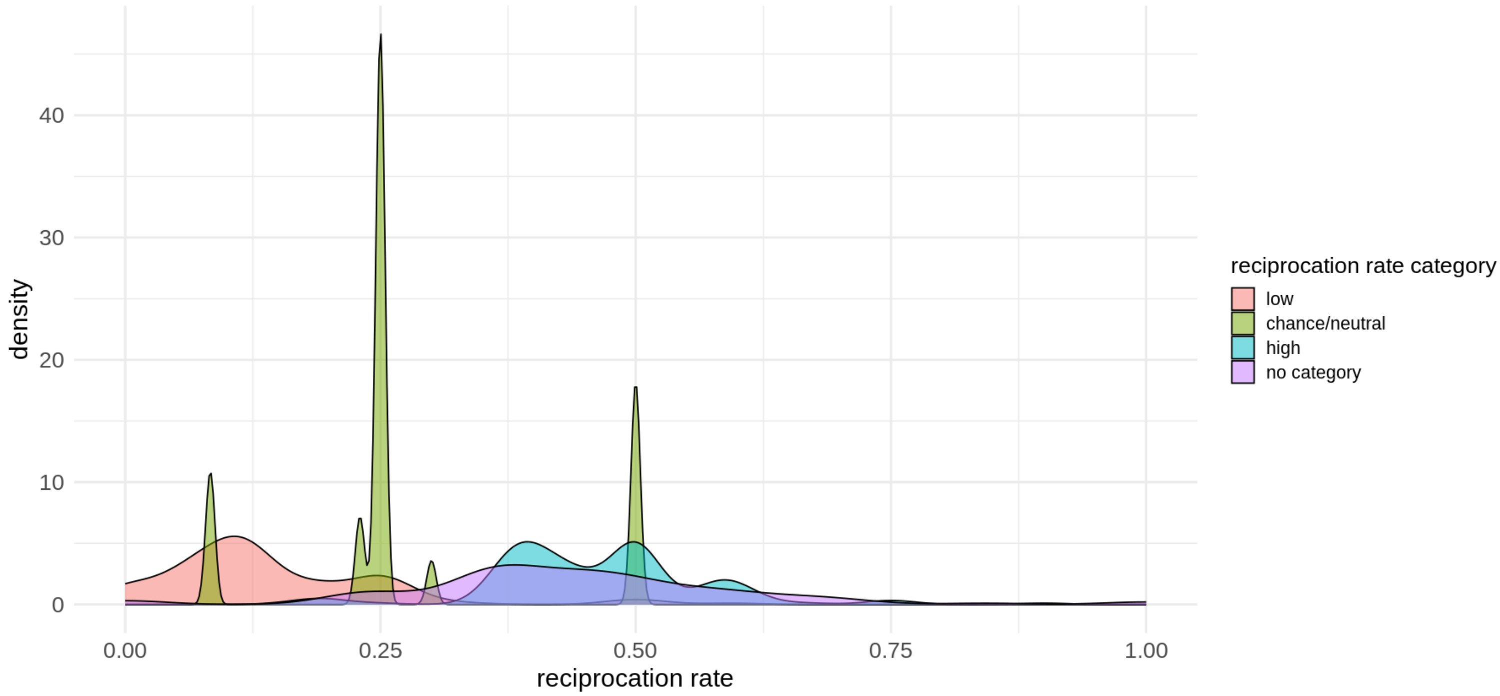
Figure 7 shows the distribution of each of the reciprocation rate categories when they were divided according to the distribution (A) and when they were divided according to how they were defined in the studies (B). As can be seen, there is quite some overlap of “chance/neutral” with both “low” and “high” reciprocation rate categories from other studies. Moreover, with a reciprocation rate not being specified as belonging to a particular category, the values range quite widely.

Figure 7

(A) Density plot of the distribution-defined reciprocation rate categories



(B) Density plot of the study-defined reciprocation rate categories.



Discussion

Results summary

In the present meta analysis, participant characteristics, manipulations of partner trustworthiness, game design, and their effects on learning in the repeated TG were analyzed. Our findings indicate that participant trust learning in the repeated TG is driven by their partners' behavioral trustworthiness, and other factors play a minimal or inconsistent role.

The subgroup analyses examined commonly used TG interpersonal manipulations, including group membership, social closeness, and trustworthiness/morality or partners. Specifically, social closeness and group membership did not show an effect on learning in the repeated trust game. However, within trustworthiness/morality manipulations, negative priors - portraying a partner as untrustworthy before the TG begins - are associated with a smaller learning effect (changing investment behaviour less) compared to other priors.

Given the mixed results from the different subgroup analyses, we then conducted an exploratory analysis on the effect of priors more broadly, regardless of the type of priors (group membership, social closeness, trustworthiness). This showed a positive statistically significant effect of the reciprocation rate and a statistically significant difference between positive and negative priors (but neither statistically different from neutral), with negative priors being associated with a more positive learning rate (investing more over time).

Lastly, we compared categories of the reciprocation rate based on the distribution we collected versus how the reciprocation rates were described in the studies themselves. We found reciprocation rates defined as “high” or “positive” in the studies are low on the distribution of reciprocation rates we collected.

Main Model

The full features model which included all pre-registered and exploratory TG and participant parameters showed that the reciprocation rate was the most important factor in participants’ learning, as hypothesized. Additionally, live games were associated with a negative effect (i.e. participants investing less over time) compared to programmed games, reflecting the end-game effect found in tit-for-tat strategies in live versions of the repeated TG (Engle-Warnick & Slonim, 2004). We did not find any effects of participant characteristics or other trust game features which were found by Johnson and Mislin (2011) in their meta-analysis of the single-shot trust game.

However, their meta-analysis focused on trustor investment in single-shot trust games, not on trust learning in a repeated TG, which can explain why our results differ. In the repeated Trust Game, there is the opportunity for reputation building, and participants adapt their investment according to their partners (Chang et al., 2010; Phan et al., 2010), and due to this learning, factors that influence the single-shot TG do not influence the repeated TG in the same way. Telga & Lupiáñez (2021) compared behavior in the iterated trust game between young and old participants and found participants’ age played a role in the initial tendency to trust (like the single-shot game) but not in trust learning. If a participant’s age has an effect in the single-shot game, but not in the repeated trust game (trust learning), other demographic characteristics may operate similarly. Furthermore, it has been shown that when comparing participant behavior in a single-shot vs. a repeated Trust Game, the amount invested by the trustor is higher in the repeated game than in the single-shot game (Cochard et al., 2004; Lenton & Mosley, 2011), indicating a more fundamental difference in how participants interact in the single-shot vs. repeated Trust Game and further explaining why our results do not replicate those of Johnson and Mislin (2011).

Subgroup Analyses

Group Membership Manipulation

The group membership analysis focused on the special case of priors and behavioral trustworthiness manipulation in which the priors manipulation was that of ingroup/outgroup membership. The result showed no effect of group membership on learning nor an interaction with partner trustworthiness (reciprocation level), going against our hypothesis that group membership would have an effect. We did not find any evidence for an ingroup preference bias in terms of how people learn trust at a meta-analytic level, also going against a substantial amount of literature that shows an ingroup bias is present in the (single-shot) trust game (Balliet et al., 2014; Stanley et al., 2011).

One reason for this is that there are conflicting findings from different studies, and therefore these effects cancel out at the meta-analytical level. In the repeated TG, some participants will invest more with the ingroup (Fujino et al., 2020) and others with the outgroup (Vermue et al., 2018; Telga et al., 2018) throughout the game. Despite investing more with one group than the other, participants do adjust their investment behavior toward their partners' trustworthiness (Vermue et al., 2018; Telga et al., 2018), and another study has demonstrated that participants can shed their ingroup bias entirely (Duncan et al., 2023). As such, it may be that ingroup bias is observed in the single-shot TG but in the repeated TG participants pay most attention to the behavioral evidence of trustworthiness.

It is important to note that this meta-analysis analyzed the *change* in investment behavior as evidence of participants' learning. This does not include the start or end point of participants' trust behavior. For example, if a participant learned from both ingroup and outgroup members equally, but had different trust starting points with them, the trust endpoints will differ for those groups.

Social closeness manipulation

The pre-registered social closeness manipulation analysis examined the effect of social closeness on trust learning and revealed no significant effects, including no effect for the reciprocation rate. This analysis went against our expectation that closeness would have an effect on learning - specifically that one would learn *less* from someone close to you because of the preferential bias you have toward them (Fareri et al., 2015).

There were far fewer studies than expected that fit the criteria for this subgroup analysis, and therefore it included just 27 effect sizes (from 9 experiments from 3 studies). As such, the results should be interpreted with caution as it was likely underpowered.

Additionally, the social closeness construct was not standardized across the different studies - for example, only one study included partners that were friends or family (Fareri et al., 2015). Instead, the scale is relative to the experiment that was being analyzed, e.g. in one study "close" means a friend and in (Walasek et al., 2019), "close" meant a fictional partner they had previously interacted with. As such, it could be the case that within the "close" category, there are sublevels of closeness to which participants would respond differently and therefore the "close" category in our classification did not capture the hypothesized closeness effect.

Trustworthiness/morality manipulation

The analysis of trustworthiness/morality prior manipulations revealed an interaction effect of priors and the reciprocation rate. Specifically, the learning rate tended to be smaller with a negative prior compared to when positive and neutral priors were present. In other words, participants changed their investment behaviour less over time with a negative trustworthiness/morality prior compared to positive and neutral priors.

An explanation for this is loss aversion or risk aversion. Loss aversion comes from prospect theory and describes the phenomenon that humans are more sensitive to potential losses than to gains in risky decision making (Kahneman & Tversky, 1972; Tversky & Kahneman, 1992). The drive for loss aversion is in asymmetric *emotional* responses to either potential or actual losses and gains (Sokol-Hessner & Rutledge, 2019). While loss aversion relates more specifically to the emotional impact of outcomes, risk aversion encompasses a broader decision making preference for avoiding risky or uncertain situations (Arrow, 1965; Pratt, 1964). Considering this, participants may have been risk or loss averse in this context: the negative prior may have made the participants somewhat apprehensive and less likely to invest. In turn, they changed their investment behavior less over time because they simply had less information about their partner's behavioral trustworthiness.

It's important to note that all but 4 of the reciprocation rates were at 50% of the participants investment *or less,* meaning that most reciprocation rates were low (this is different from the priors and reciprocation rate model for all effect sizes, discussed below, in which there were many data points with reciprocation rates above 50%). This subgroup analysis assessed learning under somewhat low reciprocation. Therefore, the participants may not have changed their investment partners much because the behavior matched the participants' expectations.

Additionally, although participants do update their investment behavior to the partners' behavior, the initial (un)trustworthiness manipulation has still been shown to have an effect throughout the remainder of the game, preventing changes in trust behavior (Chang et al., 2010; Hooper et al., 2019; Yu et al., 2014). In particular Chang et al. (2010) showed integrating the initial trustworthiness impression with the behavioral evidence in a cognitive model was more accurate in modeling participant's behavior than just behavioral evidence.

Priors and reciprocation rate across all studies

We performed an exploratory analysis examining the effect of negative, positive, and neutral/no priors and their interaction with the reciprocation rate across *all* studies, regardless of the type of priors that were present (e.g., morality, group membership etc.). The model revealed a main effect that negative priors lead to a more positive learning rate compared to the positive prior. Thus, participants tended to invest more with partners over time with the negative prior compared to those with the positive prior.

One explanation is the interaction effect coming from the trustworthiness/morality studies which is subsequently weakened by the lack of effect from the other types of manipulations. However, it is important to note that these results do not necessarily conflict: in both analyses, under low reciprocation rates, the negative prior is associated with a more positive learning rate (less change in behaviour) compared to positive priors. In other words, the learning was larger for positive priors compared to negative priors when reciprocation was low in both analyses. Under high reciprocation rates, the analyses show a different effect, with the trustworthiness/morality negative prior having a smaller learning effect compared to positive and neutral priors.

Subgroup analyses summary

The subgroup analyses show that the *type* of manipulation matters in terms of the effects that can be observed. The interaction of priors with the reciprocation rate depends on the type of manipulation, at least in the studies collected here. Interestingly, there is no effect of social closeness or group membership - in both cases, participants seem to discard that information and the learning rate is only related to the partners' reciprocation. For trustworthiness/morality manipulations, a negative prior is associated with less learning - participants change their investment behaviour less compared to positive or neutral priors. When analyzing priors across all manipulations, the reciprocation rate still has the largest effect on learning, however the learning rate is slightly more positive for negative priors compared to positive (but not neutral) priors. In sum, the type of manipulation plays a role in terms of how priors interact (or don't) with the reciprocation rate in terms of how much participants change their trust behavior in the repeated trust game.

Defining a reciprocation rate

The exploration of "high, low, medium/chance" reciprocation rates revealed differences in the distribution we found and how authors define them in their studies. We suggest that authors designing algorithms for the reciprocation rate not only pay attention to the relative difference between fair and unfair or high and low, but also how the reciprocation rate stacks up against a larger distribution, e.g. a "high" reciprocation rate is one in which participants should receive, on average, more than half of what they invested. This is likely to elicit more of a response from participants. It is very well the case that researchers will continue to find relative effects in their studies even if they are using reciprocation rates on the lower end of the scale. However, we recommend researchers to consider the full scale as this may affect the absolute estimates, and therefore have an impact not only on the learning rate but also in planning studies with effect sizes, for example.

Limitations

Our analysis did not include unpublished data. However, we anticipate this is not a problem because the majority of studies did not report learning rates or changes in trustworthiness behavior over time; instead they reported average investment behavior. Because learning rates were not the focus of the studies, these results were less likely to be cherry-picked or subject to publication bias. However, we acknowledge it as a limitation nonetheless.

A methodological limitation is that we examined learning a pre-post context, anticipating that more studies would have pre-post trustworthiness ratings, when in fact, very few included this. Therefore, learning could also be examined in terms of a correlation value which would take into account more data points, i.e., investment behavior correlating with trial number, as opposed to the change in trust on the first and last trials. Both present with advantages and disadvantages in terms of how “learning” should be defined; our approach was meant to be more flexible to allow for studies that used pre-post trust ratings, however there were far fewer of those than anticipated. The difference between these approaches could be explored in the future.

Additionally, the studies included in this meta-analysis were quite heterogeneous evidenced by most models having a statistically significant effect of heterogeneity. However, the purpose of the meta-analysis was to identify overarching effects from particular game designs/features, over a broad sample of trust game studies, and therefore heterogeneity was anticipated. It may be the case that when more studies are conducted, more specific meta-analyses can be done that look at experiments that are designed more similarly and find more specific manipulation effects, such as what was found in this study with trustworthiness/morality manipulations.

Conclusion

The meta-analytic results demonstrate that the most important factor in participants’ learning is their partners’ reciprocation rate, or in other words, their *behavioral* trustworthiness. We do not replicate the meta-analytic effects of trust game features and participant characteristics in the Johnson & Mislin (2011) meta-analytic study of the single-shot trust game, highlighting that the effects on a participants’ initial behavior and their learning behavior are different. In the repeated Trust Game, trial-by-trial learning as a behavioral indicator matters more than game or participant characteristics. The subgroup analyses show that the *type* of prior information and manipulation has different effects on learning. Specifically, there is a lack of an effect for social closeness and group membership on learning in the repeated trust game. However, when it comes to trustworthiness/morality manipulations, negative priors are associated with learning less (changing investment behaviour less). When pooling all studies together across all types of manipulations, negative priors compared to positive (but not neutral) were associated with participants investing more with their partners over time. Exploratory analyses show that the definitions of high/fair and low/unfair reciprocation vary a lot by study, with a skew toward low reciprocation rates, and this should be taken into account when designing future studies, including power analyses.

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