Trust is heritable, whereas distrust is not

Martin Reimann[a,1], Oliver Schilke[b], and Karen S. Cook[c,1]

[a]Department of Marketing, Eller College of Management, The University of Arizona, Tucson, AZ 85721-0108; [b]Department of Management and Organizations, Eller College of Management, The University of Arizona, Tucson, AZ 85721-0108; and [c]Department of Sociology, Stanford University, Stanford, CA 94305

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Why do people distrust others in social exchange? To what degree, if at all, is distrust subject to genetic influences, and thus possibly heritable, and to what degree is it nurtured by families and immediate peers who encourage young people to be vigilant and suspicious of others? Answering these questions could provide fundamental clues about the sources of individual differences in the disposition to distrust, including how they may differ from the sources of individual differences in the disposition to trust. In this article, we report the results of a study of monozygotic and dizygotic female twins who were asked to decide either how much of a counterpart player's monetary endowment they wanted to take from their counterpart (i.e., distrust) or how much of their own monetary endowment they wanted to send to their counterpart (i.e., trust). Our results demonstrate that although the disposition to trust is explained to some extent by heritability but not by shared socialization, the disposition to distrust is explained by shared socialization but not by heritability. The sources of distrust are therefore distinct from the sources of trust in many ways.

trust | distrust | behavioral genetics | cooperation | experiments

Understanding why people distrust others is pivotal, because distrust can hinder social exchange, thereby undermining a central component of an effective society (1–4). Individuals possess enduring tendencies to be distrustful of others, with fundamental ramifications for the way they approach a variety of social relationships, especially those social relationships in which relevant information about one's interaction partner is lacking (5, 6). An individual's disposition to distrust others creates a strong "default" value influencing how that individual will approach interpersonal interactions.

Given the well-documented prevalence of distrust, surprisingly little is known about its sources. Specifically, it remains unknown to what degree the disposition to distrust is influenced by genetic variations (and is thus heritable) and the extent to which it is socialized in families and peer groups. When simply referring to distrust (or, respectively, trust) in this article, we mean the disposition to distrust (or trust), also sometimes referred to as the propensity to distrust (or trust) or as generalized distrust (or trust). Substantial attention has been paid to the sources of trust, as reviewed below; however, it is highly questionable whether we can generalize from the sources of trust to the sources of distrust. An emerging consensus among scholars suggests that distrust is a construct in its own right, which is separate from the construct of trust (3, 7). Indeed, the absence of trust does not necessarily signify distrust, and vice versa (8, 9). More generally, it would be useful to know why people distrust others in social exchange.

Regarding trust, recent work provides evidence that there is an additive genetic influence on people's decisions to trust others (10). The presence of such genetic influences signifies that genes predispose an individual toward trusting choices (11). Other investigators have provided evidence in support of trust having (at least in part) a biological basis, using indicators of trust that range from measures of personality (12, 13) to measures of psychopharmacology (14, 15), physiology (16), and neuroanatomy (17, 18; a different result is presented in ref. 19). According to this body of work, the reasons for some people's willingness to make themselves vulnerable to the actions of another party seem to be, at least partially, biologically based.

Despite the existing research on the heritability of trust, little attention has been paid to the sources of distrust thus far. Distrust has previously been defined as involving predisposed negative perceptions or expectations related to a fear of, a propensity to attribute sinister motives and intentions to, or a preordained desire to buffer oneself from the effects of others' actions (20–22). In earlier discussions, scholars have predominantly viewed distrust at one end of a unidimensional construct ranging from distrust to trust (23–26). More recently, however, scholars have begun to separate the two concepts and to view distrust as a construct in its own right (8, 20, 21, 27). The idea of separating distrust from trust suggests a bidimensionality of valence, such that negative and positive valences can co-occur (28) or can vary independent of each other (29, 30). This view implies that distrust and trust correspond to a negative valence and a positive valence, respectively, and are thus to be understood as separate constructs (21). Indeed, more and more scholars view distrust and trust as distinct constructs with unique antecedents and consequences (7, 31).

Given the notion of the bidimensionality of trust and distrust (i.e., the idea that they work differently and separately), it logically follows that earlier findings on the heritability of trust cannot be automatically generalized to distrust. There are several reasons why a better understanding of the sources of distrust, as well as their separation from the sources of trust, could benefit sociology, psychology, economics, and their applied sciences. First, distrust is often viewed as a generally undesirable and potentially contagious trait, which has the power to obstruct social exchange in

Significance

Social scientists have devoted much attention to studying the sources and consequences of the disposition to trust but have only recently begun to investigate the disposition to distrust. An increasing consensus is emerging that distrust is not merely the opposite of trust. This article provides initial empirical evidence indicating that the sources of the dispositions to trust and distrust indeed do differ in important ways. Notably, although both trust and distrust are strongly influenced by the individual's unique environment, interestingly, trust shows significant genetic influences, whereas distrust does not. Rather, distrust appears to be primarily socialized, including influences within the family. These findings provide new support for the bidimensionality of trust and distrust by demonstrating their distinct antecedents.

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[1]To whom correspondence may be addressed. Email: kcook@stanford.edu or reimann@arizona.edu.

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families, peer groups, organizations, and societies at large (distrust has recently been reviewed in refs. 21, 31). Knowledge of the sources of distrust may therefore provide important insights into the functioning of social exchange. Second, contrary to the aforementioned view, some scholars have highlighted possible positive ramifications of distrust, such as the encouragement of constructive skepticism and healthy suspicion; the support of vigilance; and the monitoring of vulnerabilities, such as the leakage of valuable information (21). Having a "healthy" dose of distrust can thus represent a valuable antiexploitation trait that counteracts the exploitation strategies of others. In consumer research, for example, scholars have suggested that some consumers may acquire distrust that leads them to be suspicious of intended persuasion (also referred to as "persuasion knowledge") as a counterstrategy to advertisers' manipulative intents (32–34). In this sense, distrust may possibly enable some people more than others to use suspicion to signal that one is not exploitable. Along similar lines, distrust may constitute an antiviolence trait that enables people to anticipate and circumvent potential aggression from others.

Where is such distrust coming from? To what degree is distrust due to additive genetic influences, and to what degree is distrust due to shared and/or unshared environmental experiences? One approach to studying the sources of distrust is to compare siblings with identical genetic relatedness to siblings with different genetic relatedness [i.e., monozygotic (MZ) and dizygotic (DZ) twins], so as to estimate the influence of environmental and heritable sources. Our line of work follows recent calls to integrate behavioral genetics with sociology (35, 36). By studying both the heritable and socializable components of distrust, we acknowledge that the two components are interdependent; thus, a study of only one or the other would be incomplete and could potentially be confounded. Because heritability is a population-specific estimation of the relative importance of genetic sources in explaining individual differences, it permits direct comparisons of the same behavioral trait across populations and of different behavioral traits within a population (37).

In this article, we investigate the question as to what degree distrust and trust are influenced by additive genetic factors and environmental factors, using a sample of MZ and DZ twins who engage in experimental distrust and trust tasks. Following the core principles of behavioral genetics (11, 38, 39) and the approach of prior twin research on trust (10), we assume that if genetic differences indeed explain variations in distrust/trust behaviors, then MZ twins should reveal a higher within-pair association in these behaviors than DZ twins, because the genes of MZ twins are shared, whereas the genes of DZ twins are only imperfectly correlated. This approach is based on the assumption that MZ and DZ twins share comparable environments in their upbringing, enabling us to estimate the relative influence of heritable factors (A; i.e., additive genetic influences), shared environmental factors (C; e.g., common experiences of growing up in the same family and interacting with the same immediate peers, to the extent that the twins are each other's peer or to the extent that twins share the same peers), and unshared environmental factors (E; e.g., unique experiences throughout life) on variation in twins' distrust/trust behaviors in the established ACE model (40). The assumptions underlying this procedure have been heavily scrutinized, but heritability estimations have been found to be largely robust to possible violations of these assumptions (35, 36).

Three preparatory analyses were conducted before estimating the ACE model. First, we compared MZ and DZ twin samples on several variables to investigate differences and commonalities between the two types (Table 1). Results revealed nonsignificant differences between MZ and DZ twin samples regarding participants' college degree attainment, marital status, behavioral distrust, and behavioral trust. However, we did find significant differences in terms of race and age. These results imply that, except for race and age, the MZ and DZ twins in our sample are largely comparable. Robustness analyses revealed that heritability estimations remained substantively unchanged when including covariates for race and age in the model (*SI Appendix*, Table S1).

Table 1. Comparison of MZ and DZ twin samples

	MZ twin sample (n = 324)		DZ twin sample (n = 210)		
Variable	Mean	SD	Mean	SD	P
College degree	0.78	0.42	0.75	0.43	0.47
Married	0.49	0.50	0.50	0.50	0.81
Race (white)	0.93	0.26	0.97	0.17	0.04
Age	44.52	14.14	49.04	15.92	0.00
Behavioral distrust	4.75	4.01	4.86	4.03	0.75
Behavioral trust	7.47	3.64	7.54	3.59	0.84

Second, valuable information about possible nonresponse bias in the sample for the variables under study can be gained by comparing singleton participants (in which only one twin agreed to participate) with paired participants (in which data were collected from both members of the pair; these data are used for the main analyses in this article) (40). As shown in Table 2, we ran a series of t and F tests to compare means and variances of the distrust and trust variables between singleton and paired participants. Results revealed that none of these tests were significant at $P < 0.1$, showing that there is no bias with respect to sampling from the population of twins in the twin registry.

Third, we tested the assumption that total variances of MZ and DZ pairs are not significantly different (41). Comparison of a model in which the phenotypic variances for MZ and DZ twins are free parameters to a restricted model in which the phenotypic variance is constrained to be the same for both groups revealed no evidence for heterogeneity.

After completion of these three preparatory analyses, we estimated ACE structural equation models using OpenMx software (42). Our specifications of the ACE structural equation models follow standard model specification procedures in twin research (43) and are illustrated in *SI Appendix*, Fig. S1 *A* (the trust model) and *B* (the distrust model).

Results

This research focuses on the sources of individual differences in distrust and in trust. A first indication of possible genetic influences comes from a comparison of correlations between MZ and DZ twins (39). For the trust phenotype, results showed that MZ twins are consistently more similar in their behavior than DZ twins; trust is correlated slightly more than twice as strongly in MZ twins than in DZ twins ($r_{MZ}^{trust} = 0.31$, $r_{DZ}^{trust} = 0.15$). However, there is no indication of genetic influences based on the comparison of correlations of distrust between MZ and DZ twins ($r_{MZ}^{distrust} = 0.17$, $r_{DZ}^{distrust} = 0.22$).

Results from ACE structural equation modeling confirmed that heritable and environmental influences on trust do not generalize to heritable and environmental influences on distrust (Table 3). Specifically, ACE analyses revealed that the estimated heritability to distrust is 0%, whereas the estimated heritability to trust is 30%. Our results therefore demonstrate that the heritability of distrust is likely to be small, or even nonexistent, as shown here. ACE analyses further revealed that the estimated contribution of twins' shared environment to distrust was 19%, whereas for trust, the estimated contribution of twins' shared environment was 0%. This result represents almost a mirror image of the heritability estimations (i.e., 0% for distrust vs. 30% for trust). In addition to the contribution of heritability (factor A) and the contribution of twins' shared environment (factor C)

Table 2. Comparisons of means and variances between singleton and paired participants

		Singleton (s) participants			Paired (p) participants			Tests	
								$\mu_s = \mu_p$	$\sigma_s^2 = \sigma_p^2$
Variable	Group	n_s	$Mean_s$	σ_s^2	n_p	$Mean_p$	σ_p^2	*t*	*F*
Distrust	MZ	101	5.04	0.17	324	4.75	0.05	0.64	0.41
	DZ	135	4.61	0.11	210	4.86	0.08	0.58	0.34
Trust	MZ	101	7.47	0.13	324	7.47	0.04	0.02	0.00
	DZ	135	6.94	0.09	210	7.54	0.06	1.53	2.33

None of the eight tests is significant at $P < 0.1$.

to trust and, respectively, distrust, results revealed a considerable estimated contribution of twins' unshared environment (factor E): It was 81% for distrust, whereas it was 70% for trust. Both E estimations are very large, showing that a large component of both distrust and trust is neither heritable nor commonly socialized.

In addition to summarizing these estimations from our ACE model, Table 3 shows the estimations for the submodels AE, CE, and E to understand which factor or combination of the three factors (A, C, and E) contributes to explaining the observed variance in distrust and trust. We primarily base our assessment on a combination of parsimony model fit statistics. The fit statistics for the different models show a clear pattern whereby the CE model appears to be the best-fitting model for distrust, whereas the AE model appears to be the best-fitting model for trust, indicating that shared socialization contributes to variance in distrust and that heritability contributes to variance in trust.

Discussion

This research contrasts sources of individual differences in distrust and trust to shed new light on their commonalities and dissimilarities. First and foremost, results show that the ways in which people distrust others are influenced by both unshared and shared socialization, but are not subject to additive genetic influences. Further, as shown here, distrust is not only rooted in an individual's early-life experiences, in which family and immediate peers play a crucial role in socializing distrust, but is further embossed during unique experiences later in life, as shown by the high proportion of the unshared environment in the total variation. This latter finding suggests that people are vulnerable to negative experiences not only in childhood and adolescence but also during adulthood. Our findings also contribute to and extend the notion that parents and immediate peers reinforce suspicion of others such that distrust is a strongly socialized attribute based on one's extrapolations from early-life experiences (24–26, 44). Relevant negative experiences may include parental violence, schoolyard bullying, and deception by peers, among others. Because humans are especially psychologically vulnerable during childhood and adolescence, the experience and fear of parents' or peers' negative motives, intentions, or behaviors may heavily emboss distrust into young people as they grow up, thus laying the foundation for a greater tendency to distrust later in life (45, 46).

Additional conceptual support for distrust being driven by early-life experiences comes from Hardin's Bayesian updating account (47). This account begins with the assumption that, especially in the absence of relevant information about a counterpart's characteristics, interpersonal behavior is strongly determined by one's stock of past experiences in similar situations. Every new interpersonal experience will add to the stock of knowledge from which people can draw, making interpersonal assessment processes highly path-dependent. As in other path-dependent processes, early-stage experiences have a profound and long-lasting impact. In particular, Hardin (47) emphasizes how the degree to which parents instill optimism, rather than neglect or even abuse their children, early in life has important ramifications. Parents who teach their children to trust may lead these children to enter new relationships, thus adding to their children's stock of idiosyncratic experiences, based on which they can adjust their trust propensities. On the other hand, parents instilling distrust can result in children's incapacity to enter relationships with others, depriving them of the ability to accumulate unique data that might change their individual distrusting stance.

The current work also shows that the ways in which people trust others are affected by a mix of unshared socialization and additive genetic influences. These results replicate extant twin research on the heritability of behavioral trust, which has also estimated trust to be determined by a mix of socialization (between 8% and 12% from the shared environment and between 68% and 82% from the unshared environment) and genetic influences (between 10% and 20%) (10). We also note that another investigation has identified negligible heritability of self-reported trust (i.e., absent heritability of trust in others and trust in self, as measured on three-item scales) (19). Our work adds to prior investigations by providing evidence that the socializable sources of trust are more likely to be based on unique experiences later in life than on

Table 3. Models and their fit statistics for the heritability and socialization of distrust and trust

	Mean estimated proportions of total variance (95% CIs)							
Model	a^2 (contribution of heritability)	c^2 (contribution of shared environment)	e^2 (contribution of unshared environment)	χ^2 (df)	$\Delta\chi^2$	Δdf	AIC	BIC
Distrust								
ACE	0.00 (0.00, 0.31)	0.19 (0.07, 0.30)	0.81 (0.70, 0.93)	2.28 (6)	—	—	1,928.97	27.73
AE	0.20 (0.06, 0.33)	—	0.80 (0.67, 0.94)	3.62 (7)	1.34	1	1,928.31	23.48
CE	—	0.19 (0.07, 0.30)	0.81 (0.70, 0.93)	2.28 (7)	0.00	1	1,926.97	22.14
E	—	—	1.00 (1.00, 1.00)	11.66 (8)	9.38	2	1,934.35	25.94
Trust								
ACE	0.30 (0.17, 0.42)	0.00 (0.00, 0.31)	0.70 (0.58, 0.83)	5.87 (6)	—	—	1,809.92	−91.32
AE	0.30 (0.17, 0.42)	—	0.70 (0.58, 0.83)	5.87 (7)	0.00	1	1,807.92	−96.91
CE	—	0.24 (0.12, 0.35)	0.76 (0.65, 0.88)	8.24 (7)	2.37	1	1,810.29	−94.54
E	—	—	1.00 (1.00, 1.00)	23.93 (8)	18.06	2	1,823.99	−84.43

A significant proportion of variance in distrust is due to shared and unshared environments but not due to heritability; accordingly, the best-fitting model assumes a role for shared and unshared environments (CE). A significant proportion of variance in trust is due to heritability and unshared environment but not due to shared environment; accordingly, the best-fitting model assumes a role for heritability and unshared environment (AE). Model fit is assessed using the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). The model with the lowest AIC/BIC is preferred.

early-life experiences. In particular, in our work, the shared environment, that is, those family and peer experiences we encounter when growing up, explained 0% of the total variance in trust, whereas the unique environment explained 70%. These findings seem to stand in contrast to earlier psychoanalytic accounts, which held that the tendency to trust is socialized in early childhood (48). A closer look into these accounts reveals that psychoanalysts suspect trust to be rooted in the earliest infantile experiences between mother and child (48). One possible explanation for the discrepancy between our findings and these psychoanalytic accounts could be that these earliest infantile experiences are actually indicators of a genetic grounding of trust. Indeed, it is now known that a certain hormone (oxytocin), which has typically been associated with mother–child bonding, also predicts trust behavior (14). On the basis of these hormonal studies, other scholars have implied that because certain genes are required for the expression and regulation of oxytocin, genetic influences may therefore partially explain trust (10).

Taken together, our findings strengthen the notion that a significant component of behavioral trust is owed to heritability, which then can be reinforced by one's unique experiences throughout the life span. For example, situational aspects, such as the length of the social exchange relationship (18) and one's level in the social hierarchy (49), have been found to be crucial for trust reinforcement and maintenance. Cultural factors may also play an important role in the development of trust and distrust (50, 51). Future work should investigate further which types of unique life experiences are especially relevant to the ways in which trust is reinforced.

This work also broadens the extant debate on whether distrust and trust are two sides of the same coin or, in fact, two separate but related dimensions (3, 20, 21, 27, 31). Because the present work shows that the sources of distrust and trust are likely to differ, our results add further credibility to the notion of the bidimensionality of distrust and trust. According to our findings, the capacity to distrust is relatively more socializable. On a positive note, this finding implies that the capacity to distrust could possibly not be developed in the first place or be shut off in an individual if distrust has already settled in with someone earlier in life. If distrust is indeed relatively more socializable, then the level of distrust could become attenuated in any given individual. On the other hand, trust seems to be, in part, influenced by an additive genetic component. Nonetheless, it is clear that it is possible for one's capacity to trust to be strengthened or weakened throughout one's life, given that genetic does not equal immutable.

Because trust and distrust have previously been described as being rooted in cognitive judgments (44, 52), future research could investigate how cognitive functions interact with heritable and socializable influences on these constructs. Prior work has provided preliminary insights that cognitive ability may be positively associated with trust (53), although it has remained silent about the cognitive basis of distrust. Further, future work might investigate the role of education in moderating A, C, and E estimates for distrust and trust or, more broadly, consider probing the moderating role of socioeconomic status.

Future investigations could also compare distrust to established personality factors, especially to those factors that have been referred to as the "dark triad of personality" [Machiavellianism (i.e., the tendency to be manipulative of others), subclinical narcissism (i.e., the tendency to feel grandiose, entitled, or dominant), and subclinical psychopathy (i.e., the tendency to act impulsively and to show low empathy and anxiety)] (54). Although such comparisons go beyond the scope of the present research, it is plausible that distrust may be associated with these factors. Indeed, personality researchers have discovered that distrust (e.g., being suspicious and wary of others) is negatively associated with the Big-Five factor structure's agreeableness (55) and that agreeableness negatively correlates with Machiavellianism, narcissism, and psychopathy (54).

The present work used an all-female sample to control for gender. Because prior work found that separating the sample by gender does not generate significantly different results in the heritability of trust (10), our work built on the rigidity of a same-gender sample. Although we cannot think of convincing hypotheses for why the heritability/socializability of distrust should be different in men than in women, future research might consider using mixed-gender samples to address possible nuances that may exist between those individuals who identify as male and as female.

On a more general level, this research heeds the call to integrate behavioral genetics with sociology further (35, 36). Sociologists have sometimes voiced agnosticism or even skepticism about the heritable effects of behavioral traits (56). Our work shows that the methods of behavioral genetics can be used to elucidate and differentiate behaviors of long-standing concern to sociology. Genetic differences may indeed be understood as possible mechanisms underlying how we respond to social exchanges over time (36).

Our work also suggests that propositions about the heritability of traits that predict social and economic behavior may not be universally valid. The first law of behavioral genetics states that "all behavioral traits are heritable" (ref. 38, p. 160). More recently, some scholars have suggested that there may be a need for additional studies on the heritability of traits in the behavioral sciences (11). Although it is, of course, hard to establish conclusively the absence of an effect, our results suggest that heritability does not contribute substantially to explaining a particular behavioral trait (i.e., distrust) that is of increasing importance in several different behavioral sciences, including sociology (57), psychology (46), marketing (33, 58), management and organizational studies (21, 31), and information systems research (59). Following our findings, future research should continue to investigate and contrast further the heritability and socializability of specific traits that are crucial to human behavior in the marketplace, in the workplace, and at home. The fact that we found nonheritability for one trait and heritability for another trait is a valid reason to expect that a better understanding of the heritable and social influences that underlie our individual differences in behavioral traits will facilitate scientific advances in many disciplines.

Materials and Methods

This study was conducted in collaboration with the Washington State Twin Registry (WSTR), a community-based archive including more than 9,500 twin pairs as of 2016. The twin pairs are primarily recruited from the pool of driver's license or identification card applicants in the State of Washington (60). A total of 4,298 twin pairs were initially identified as being potentially eligible for the study based on age and being female twin pairs. Pairs where both members had valid contact information (i.e., email addresses) were considered for the smaller random sample (called the contact list). The contact list was a random sample of the larger sample. A total of 1,545 same-sex (all female) adult twin pairs born between 1930 and 1996 (average of 1969) were contacted by email between December 2015 and July 2016 in exchange for the opportunity to receive monetary compensation (which was determined by both their monetary choices and the monetary choices of a counterpart player) and participate in a raffle of two tablet computers. Only twins 18 y of age and older were allowed to participate. A total of 1,019 individuals started the online study. After email and phone reminders, 770 individuals returned complete, usable responses (i.e., they made a choice on both the distrust task and the trust task). Participants provided informed consent to a protocol approved by the Institutional Review Board of The University of Arizona. Of the participants, 210 individuals were in 105 complete DZ twin pairs and 324 were in 162 complete MZ twin pairs. The remaining 236 individuals were singletons (i.e., an individual from a twin pair in which only one twin agreed to participate). We acknowledge that the remote administration of the experiment no doubt reduced experimental control, but several studies have found that it is relatively rare for online participants

to violate study instructions (61). Zygosity, age, gender, marital status, race, and level of education were self-reported and were provided to the authors by the WSTR. Self-reported zygosity was calculated using five questions on the WSTR's enrollment survey. Twins were asked if they were as similar as two peas in a pod or of ordinary family resemblance, as well as how often parents, relatives, teachers, and strangers were unable to tell them apart. The WSTR has also confirmed DNA-based zygosity on a subset of twins in the registry, which allows for the estimation of zygosity for all of the twins in the registry with 97% accuracy (60).

Each participant was engaged in two decision-making tasks, one assessing behavioral distrust and the other assessing behavioral trust. We chose a behavioral approach to measuring trust and distrust over a questionnaire-based approach because of (*i*) the close match of behaviors in the tasks with corresponding construct definitions (62), (*ii*) known validity concerns with existing trust indices (63), and (*iii*) the strong association of behavioral tendencies in trust experiments with other trust proxies (64).

Note that the survey instrument randomized the task version that participants saw first. The two tasks were taken from prior experimental work on distrust and trust (8). Both tasks are identical in their outcome spaces, with the only difference being in how outcomes are achieved: In the distrust game, money is taken away from a counterpart's endowment, whereas in the trust game, money from one's own endowment is sent to a counterpart (8). In the distrust game, taking money (rather than expecting the counterpart will share voluntarily) is closely aligned with previous operationalizations of behavioral distrust as an action to mitigate one's vulnerability to a counterpart (65). In particular, the desire to buffer oneself from the effects of others' actions is reflected in taking the money in anticipation of the counterpart not intending to share it. In the trust game, sending money (rather than opting for the certain payoff) matches the definition of behavioral trust as an action to make oneself vulnerable to a counterpart (66). As such, the way in which the decision alternatives were framed (67) is fundamental to producing qualitative differences between the two tasks, such that the decision to distrust (i.e., to take money in the distrust game) is distinct from the decision not to trust (i.e., not to send money in the trust game). The former reflects an act of commission, and the latter reflects an act of omission (8). Before starting with the tasks, participants were made aware that they would be connected with a counterpart, and that their monetary choices therefore had real economic consequences.

In the distrust task, each participant (i.e., each twin) was initially endowed with \$0 and an anonymous counterpart player was endowed with \$4. The distrust task consisted of two stages. In the first stage, the participant was asked to decide how much of her counterpart's \$4 endowment she wanted to take, in 30-cent increments up to a maximum of \$3. The experimenter divided the amount that the participant took by 3 before she received it. For example, if the participant chose to take 30 cents, her payoff after the first stage was 10 cents (30 cents divided by 3), whereas her counterpart's payoff was \$3.70 (\$4 minus 30 cents). In the second stage, her counterpart was asked to decide to send any amount to the participant equal to or smaller than the amount she holds after the first stage (in 10-cent increments), and this amount was not altered (8). For example, if her counterpart sent 30 cents, then the participant received 30 cents.

In the trust task, both the participant and the counterpart were initially endowed with \$1. The trust task also consisted of two stages. In the first stage, the participant was asked to decide how much of her \$1 endowment she wanted to send her counterpart, in 10-cent increments. The experimenter multiplied the amount that the participant sent by 3 before the counterpart received it. For example, if the participant chose to send 10 cents, her payoff after the first stage was 90 cents, whereas her counterpart's payoff was \$1.30 (her initial endowment of \$1 plus the 10 cents multiplied by 3). In the second stage, her counterpart was asked to decide to send back to the participant any amount equal to or smaller than the amount she held after the first stage (in 10-cent increments), and this amount was not altered (8). For example, if her counterpart sent 30 cents, then the participant received 30 cents.

A complete description of the design and procedures of the two decision-making tasks can be found in *SI Appendix*.

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Supporting Information

SI Appendix

Each participant received a unique hyperlink leading to an online survey, which included two decision-making tasks—one assessing behavioral distrust and the other assessing behavioral trust. The unique link allowed us to later pair each participant with his or her twin sibling. Note that the survey instrument randomized the task version—either the distrust game or the trust game—that participants saw first. Participants were guided through the games at once. After the completion of the study, we paired each twin participant with another human counterpart. Further details are provided next and in an overview of the experimental protocol in SI Appendix, Fig. S2.

First, participants provided informed consent to a protocol approved by the Institutional Review Board of the University of Arizona. Participants were also told that their choices in the decision-making tasks would have real economic consequences; they would be paired with a counterpart, and the experimenter would determine their winnings based on their own and their counterpart's choices.

Second, participants were provided with the following information:

In this part of the study, you will engage in two different tasks—called the decision task and the choice task—in which you have the opportunity to earn actual money (that the WS twin registry will send you by mail shortly after completion of the study). Although their format may appear similar on first sight, the two tasks have important differences in terms of their instructions and payoff distributions. Thus, please pay close attention to the instructions of both tasks. You are not told who your partners are either during or after the tasks nor are they told who you are.

Third, each participant engaged in both decision-making tasks. The order of presentation of the two tasks was counterbalanced. For the distrust task, participants read the following information:

In this task, a Person X is paired with a Person Y. Some participants are assigned to be Person X, others to be Person Y. Whether you are assuming the role of Person X or Person Y will determine the options available to you in this task.
***You** are chosen to be **Person X**. You will be paired with a Person Y.*

ABOUT THE DECISION

The study is conducted in two stages:

Stage 1
As Person X, you are allocated $0; Person Y is allocated $4. You make the first decision: you can decide how much, out of the money Person Y currently holds, you want to take (up to a maximum of $3). Each amount taken by you is divided by three before you receive it. For example, if you take $0.30 from Person Y, you receive $0.10. You can take any of the following amounts (including zero):
$3, $2.70, $2.40, $2.10, $1.80, $1.50, $1.20, $0.90, $0.60, $0.30, $0.

Stage 2
Person Y then decides how much of the amount s/he holds after Stage 1 to give to you. You will receive exactly the amount of money given by Person Y. For example, if Person Y gives $3, you receive $3.
Person Y can give any amount, in $0.10 increments, equal to or smaller than the amount of money s/he holds after Stage 1 (including zero).

Illustrative example:
In Stage 1, if you decide to take $1.20 from Person Y:
Your payoffs after Stage 1 are $1.20 / 3 = $0.40;
Person Y's payoffs after Stage 1 are $4 - $1.20 = $2.80.
In Stage 2, Person Y can give any amount of money out of his/her $2.80 to you. For example, if Person Y decides to give $0.70:
Your payoffs after Stage 2 are $0.40 + $0.70 = $1.10;
Person Y's payoffs after Stage 2 are $2.80 - $0.70 = $2.10.

THE DETAILS OF THE EXPERIMENT

Conduct of study:
(i) You were chosen to be Person X.
(ii) We start with Stage 1. You decide how much to take from Person Y.
(iii) We continue with Stage 2. Person Y decides how much of the money they hold after Stage 1 to give to you.
(iv) Person Y knows the final outcome; you are informed about the outcome.
(v) We calculate your earnings.

Participants were then shown three examples and asked to respond to several comprehension questions. Next, participants were asked to make their decision:

DECISION FORM

Now that we are done with the instructions and examples, please make your actual decision in the decision task.

Stage 1:
As Person X, how much money (if any) do you take from Person Y? Please choose one:

- I take $3.00 → My payoffs after Stage 1: $1.00; Y's payoffs after Stage 1: $1.00
- I take $2.70 → My payoffs after Stage 1: $0.90; Y's payoffs after Stage 1: $1.30
- I take $2.40 → My payoffs after Stage 1: $0.80; Y's payoffs after Stage 1: $1.60
- I take $2.10 → My payoffs after Stage 1: $0.70; Y's payoffs after Stage 1: $1.90
- I take $1.80 → My payoffs after Stage 1: $0.60; Y's payoffs after Stage 1: $2.20
- I take $1.50 → My payoffs after Stage 1: $0.50; Y's payoffs after Stage 1: $2.50
- I take $1.20 → My payoffs after Stage 1: $0.40; Y's payoffs after Stage 1: $2.80
- I take $0.90 → My payoffs after Stage 1: $0.30; Y's payoffs after Stage 1: $3.10
- I take $0.60 → My payoffs after Stage 1: $0.20; Y's payoffs after Stage 1: $3.40
- I take $0.30 → My payoffs after Stage 1: $0.10; Y's payoffs after Stage 1: $3.70
- I take $0.00 → My payoffs after Stage 1: $0.00; Y's payoffs after Stage 1: $4.00

Similarly, for the trust game, participants read the following information:

In this task, a Person A is paired with a Person B. Some participants are assigned to be Person A, others to be Person B. Whether you are assuming the role of Person A or Person B will determine the options available to you in this task.
***You** are chosen to be **Person A**. You will be paired with a Person B.*

ABOUT THE DECISION

The study is conducted in two stages:

Stage 1
As Person A, you are allocated $1; Person B is allocated $1.
You make the first decision: you can decide how much out of $1 you currently hold, you want to send to Person B. Each amount sent by you is multiplied by three before Person B receives it. For example, if you send $0.10, Person B receives $0.30.
You can send any of the following amounts (including zero):
$0, $0.10, $0.20, $0.30, $0.40, $0.50, $0.60, $0.70, $0.80, $0.90, $1.

Stage 2
Person B then decides how much of the amount s/he holds after Stage 1 to give to you. You will receive exactly the amount of money given by Person B. For example, if Person B gives $0.30, you receive $0.30.

Person B can give any amount, in $0.10 increments, equal to or smaller than the amount of money s/he holds after Stage 1 (including zero).

Illustrative example:
In Stage 1, if you decide to send $0.60 to Person B:
Your payoffs after Stage 1 are $1 - $0.60 = $0.40;
Person B's payoffs after Stage 1 are $1 + ($0.60 x 3) = $2.80.
In Stage 2, Person B can give any amount of money out of his/her $2.80 to you. For example, if Person B decides to give $0.70:
Your payoffs after Stage 2 are $0.40 + $0.70 = $1.10;
Person B's payoffs after Stage 2 are $2.80 - $0.70 = $2.10.

THE DETAILS OF THE EXPERIMENT

Conduct of study:
(i) You were chosen to be Person A.
(ii) We start with Stage 1. You decide how much to send to Person B.
(iii) We continue with Stage 2. Person B decides how much of the money they hold after Stage 1 to give to you.
(iv) Person B knows the final outcome; you are informed about the outcome.
(v) We calculate your earnings.

Participants were then shown three examples and asked to respond to several comprehension questions. Next, participants were asked to make their decision:

DECISION FORM

Now that we are done with the instructions and examples, please make your actual decision in the choice task.

Stage 1:

As Person A, how much money (if any) do you send to Person B? Please choose one:

- I send $0.00 → My payoffs after Stage 1: $1.00; B's payoffs after Stage 1: $1.00
- I send $0.10 → My payoffs after Stage 1: $0.90; B's payoffs after Stage 1: $1.30
- I send $0.20 → My payoffs after Stage 1: $0.80; B's payoffs after Stage 1: $1.60
- I send $0.30 → My payoffs after Stage 1: $0.70; B's payoffs after Stage 1: $1.90
- I send $0.40 → My payoffs after Stage 1: $0.60; B's payoffs after Stage 1: $2.20
- I send $0.50 → My payoffs after Stage 1: $0.50; B's payoffs after Stage 1: $2.50
- I send $0.60 → My payoffs after Stage 1: $0.40; B's payoffs after Stage 1: $2.80
- I send $0.70 → My payoffs after Stage 1: $0.30; B's payoffs after Stage 1: $3.10
- I send $0.80 → My payoffs after Stage 1: $0.20; B's payoffs after Stage 1: $3.40
- I send $0.90 → My payoffs after Stage 1: $0.10; B's payoffs after Stage 1: $3.70
- I send $1.00 → My payoffs after Stage 1: $0.00; B's payoffs after Stage 1: $4.00

The behavioral choices on the two tasks' "Decision Forms" were used to construct distrust and trust scores, coded as integer values between 1 and 11 in such a way that greater values indicate higher distrust and higher trust, respectively. In line with prior research following a behavioral approach (e.g., 1, 2), these scores were used as proxies for individuals' distrust and trust dispositions.

Fourth, after responding to the online survey, participants were debriefed and told that the purpose of the research was to investigate commonalities and differences of social preferences in twins. Participants were also asked to refrain from showing the debriefing sheet or discussing any aspect of the study with their twin sibling.

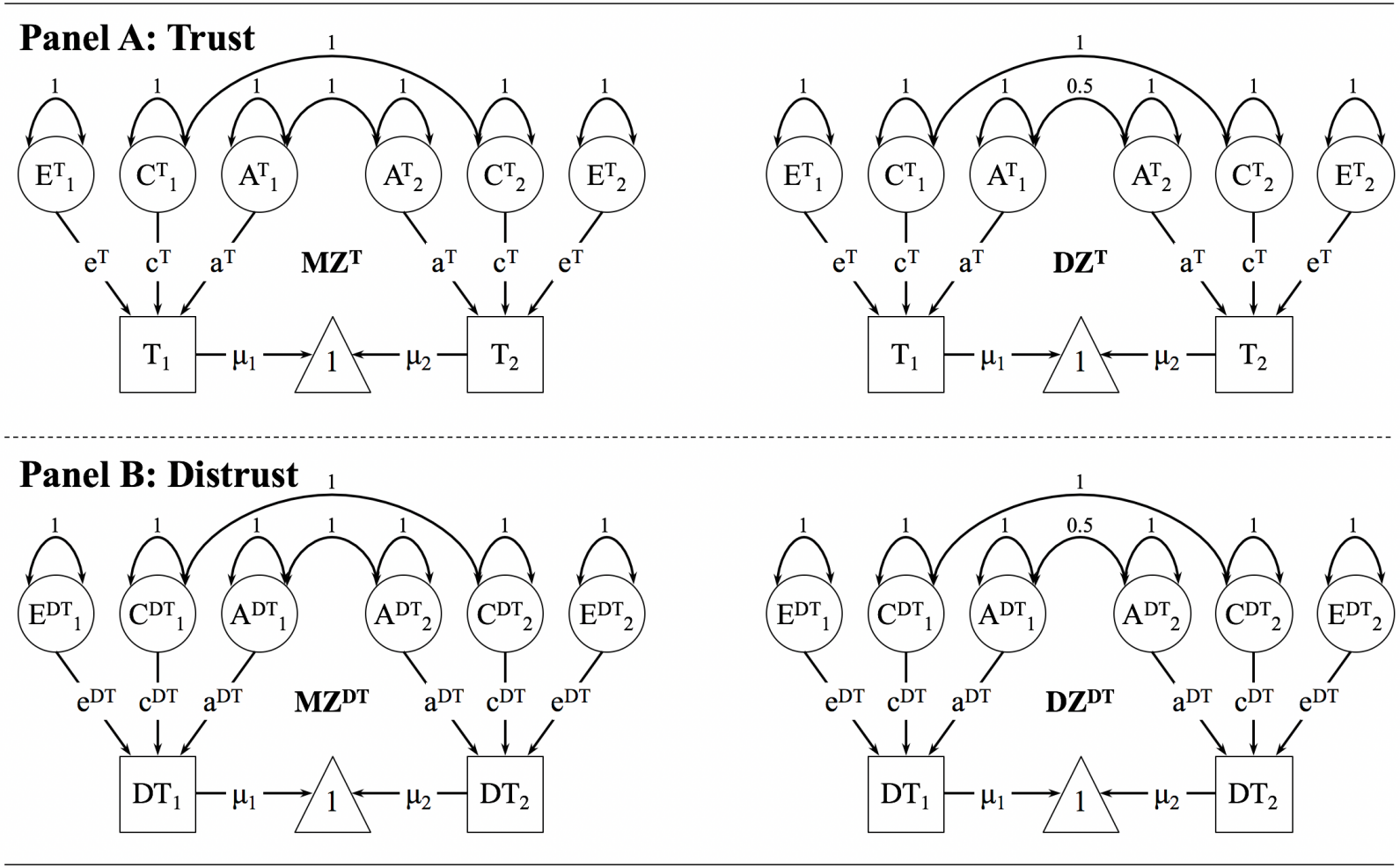
Fifth and finally, after the completion of the data collection, we paired each twin participant with another human counterpart in order to determine the twin participants' payouts. The counterpart players were recruited through the online panel of Amazon Mechanical Turk, an online crowdsourcing service offering large volumes of small web-based tasks to anonymous online workers. Based on each twin participant's monetary choice, we presented counterpart players with the same two decision-making tasks, the only difference being that the counterpart players engaged in stage 2 of the task. For

example, in the distrust task, we told counterpart player that *Person X has decided to take the following amount from you: Person X took $0.00 → X's payoffs after Stage 1: $0.00; Your payoffs after Stage 1: $4.00*. Based on this information, we asked the counterpart player how much money (if any), between $0 and $4 (in 10-cent increments), he or she would give to Person X. The counterpart player's final decision determined the actual payout amount that was then paid out to each twin participant by the WSTR. The counterpart players also received the corresponding dollar amount.

References in Supporting Information

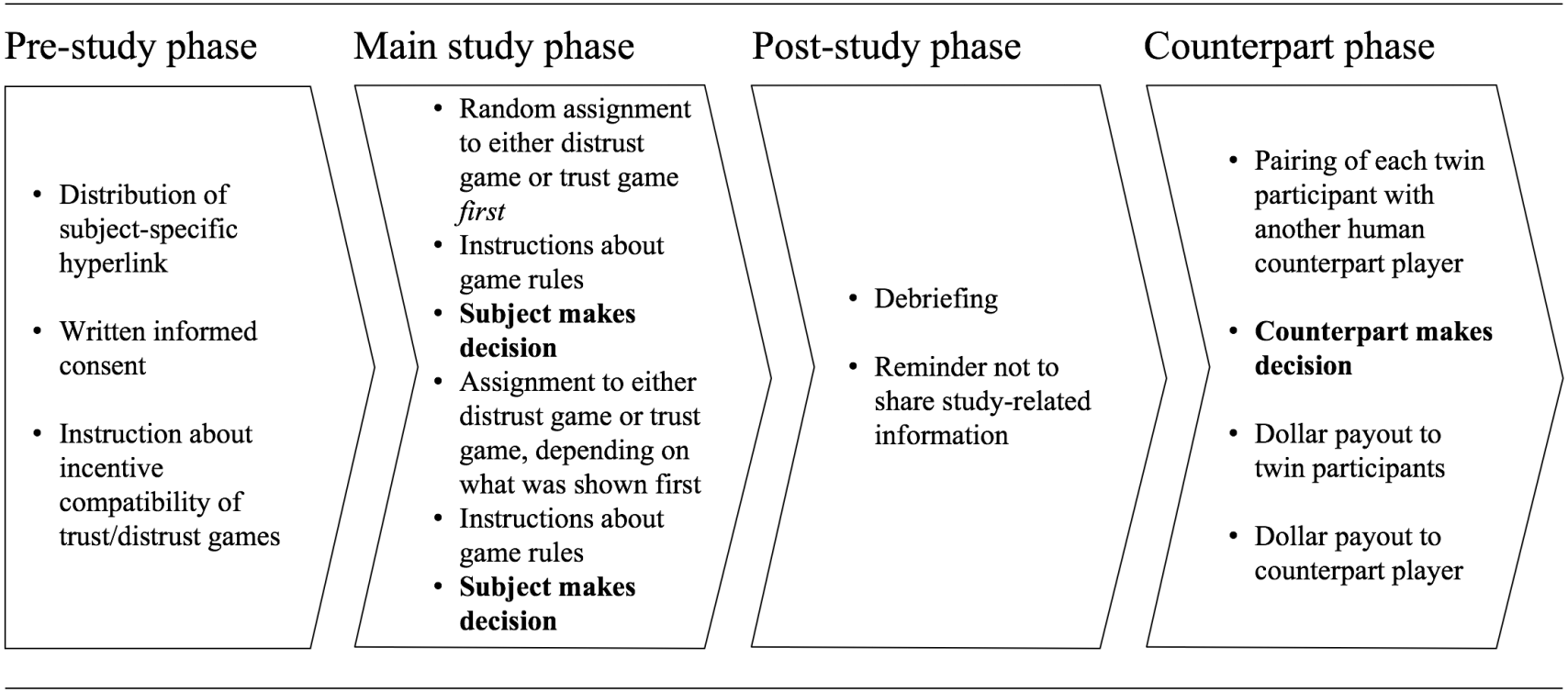
1. Cesarini D*, et al.* (2008) Heritability of cooperative behavior in the trust game. *Proc Natl Acad Sci USA* 105:3721-3726.
2. Yamagishi T*, et al.* (2012) Rejection of unfair offers in the ultimatum game is no evidence of strong reciprocity. *Proc Natl Acad Sci USA* 109:20364-20368.

SI Appendix, Fig. S1: Model specification



Note. MZ: monozygotic twins; DZ: dizygotic twins; T: Trust; DT: Distrust.

SI Appendix, Fig. S2: Experimental protocol



SI Appendix, Table S1: Heritability of distrust and trust – with covariates for race (whites) and age (in years) included

	Mean estimated proportions of total variance		
Model	**a^2** (contribution of heritability)	**c^2** (contribution of shared environment)	**e^2** (contribution of unshared environment)
Distrust			
ACE	0.00	0.18	0.82
AE	0.20	-	0.80
CE	-	0.18	0.82
E	-	-	1.00
Trust			
ACE	0.28	0.00	0.72
AE	0.28	-	0.72
CE	-	0.22	0.78
E	-	-	1.00

Note. To further explore the robustness of the results, we reran the models while including covariates for race (dummy-coded as 1 if whites, 0 otherwise) and age (in years). Results were not notably different from those that did not include the covariates (see Table 3).