Human social preferences cluster and spread in the field

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While it is undeniable that the ability of humans to cooperate in large-scale societies is unique in animal life, it remains open how such a degree of prosociality is possible despite the risks of exploitation. Recent evidence suggests that social networks play a crucial role in the development of prosociality and large-scale cooperation by allowing cooperators to cluster; however, it is not well understood if and how this also applies to real-world social networks in the field. We study intrinsic social preferences alongside emerging friendship patterns in 57 freshly formed school classes (n = 1,217), using incentivized measures. We demonstrate the existence of cooperative clusters in society, examine their emergence, and expand the evidence from controlled experiments to real-world social networks. Our results suggest that being embedded in cooperative environments substantially enhances the social preferences of individuals, thus contributing to the formation of cooperative clusters. Partner choice, in contrast, only marginally contributes to their emergence. We conclude that cooperative preferences are contagious; social and cultural learning plays an important role in the development and evolution of cooperation.

cooperation | social preferences | social networks | collective action | cultural evolution

Human prosociality lies at the heart of our success as a species. Unlike any other species, humans live in large societies characterized by altruism, trust, and cooperation between ephemeral interactants. However, the widespread existence of these cooperative dispositions poses a challenge to the biological and social sciences (1, 2): Even when everyone benefits equally from cooperation, those who bear the costs of cooperative actions are often exploited and, therefore, at an evolutionary disadvantage. Two important aspects, in which we differ from other animals, may explain this evolutionary paradox. First, we developed distinctive moral sentiments and social preferences, such as fairness and the desire to help, which are not limited to our relatives, but extend to strangers. Second, we heavily engage in complex, intertwined social relationships and structures, long-standing friendships among unrelated individuals, which serve no direct reproductive purpose (3, 4). These networks can determine the frequency and intensity of social interactions. Several theories assume social structures either implicitly or explicitly to be essential for the emergence of cooperation (5–11). Accordingly, the structure allows prosocials to interact with one another more frequently and, thus, preferentially to distribute the benefits of cooperation among those who also bear the costs (8, 12). Such a co-occurrence of cooperativeness in spatial or social structures is called clustering (or positive assortment). Since clusters protect us from exploitation, costly traits such as social preferences, in turn, may yield an (evolutionary) advantage.

In recent years, the theoretical prediction that clustering can promote cooperation has been tested in several simulations (13–15) and laboratory experiments (16–23), which have also shown that choosing similar interaction partners (partner choice) and copying the interaction partners' behavior (social learning) can foster clustering. Partner choice allows us to leave exploitative partners in favor of more cooperative ones (16–19), which can even lead to competition in cooperation (11). However, social learning involves acquiring behavior or norms through existing social interactions. In simple cases, people condition their actions on the behavior in their environment (24). Interestingly, however, cooperative behavior can spread in cascades from person to person, even in the absence of reciprocity (25), suggesting that intrinsic social preferences can be subject to adaptation and learning on their own.

Despite the considerable body of work and progress in understanding clustering and the underlying mechanisms in controlled environments, field evidence confirming the clustering of cooperation in human social networks and its mechanisms is still rare. A recent field study found clustering by showing that contemporary hunter-gatherers who live together in the same camp also cooperate in similar ways when it comes to within-camp cooperation (26). It also has been observed that hunter-gatherers do not practice partner choice based on the willingness to cooperate; they also reveal a low individual persistence in prosociality, as camp composition changes (27). While the evidence shows that conditional behavior may have played a significant role for cooperation in earlier small-scale societies, several points remain open and require further investigation. First, by measuring within-group cooperation and comparing different groups with different levels of social coherence, previous field studies have been biased toward the apparent appearance of clustering. It remains to be seen

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Significance

How does society maintain the high levels of prosociality in humans, which are so puzzling to explain? Previous laboratory evidence suggests that human social networks play a critical role; however, if and how this role is played out in field settings is not well understood. We demonstrate that intrinsic social preferences, such as fairness and altruism, cluster and spread in human real-world friendship networks. More importantly, however, our findings show that individuals do not choose friends based on cooperativeness—friendship networks influence whether individuals become cooperative or selfish. We conclude that social learning contributes substantially to the ontogeny of prosociality, signifying the role of culture for the development and maintenance of large-scale human cooperation.

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whether intrinsic prosocial tendencies that are not directed toward the immediate social environment also cluster in human social networks. Second, most of the evidence in favor of partner choice comes from laboratory experiments with Western, Educated, Industrialized, Rich, and Democratic (WEIRD) subjects. Studying WEIRD subjects in their natural environment delivers additional insights on partner choice, especially since only weak evidence was found among hunter-gatherers. Third, much of the controversy in the field is about understanding cooperation in large-scale societies among ephemeral interactants, which reciprocal altruism and conditional behavior cannot explain. This is where our study departs, extending our understanding of human prosociality by addressing these issues, studying the role of social preferences, partner choice, and social learning in the development of large-scale human cooperation. Moreover, our study provides several further advantages in tackling causal inference and providing insights into human ontogeny, described in more detail below.

We study whether social preferences cluster in human friendship networks. If so, how do they emerge, and can they promote cooperation? Our large-scale longitudinal field study evaluates theoretical and experimental predictions in two observational periods over 9 mo. We study 1,217 adolescents, alongside their emerging friendships and social preferences in 57 newly formed school classes. During each observation, we examine the participants' prosociality and social relationships within the school class. Students were provided with a full list of classmates and asked to evaluate each relationship. To operationalize friendship strength, we asked: "How strong is your friendship with your classmates?" and "How many times did you talk to your classmates about things that are important to you?" Respondents answered each question on a six-point scale. The average scores determined their relational intensity. Mapping dyadic relationships and their relational intensity within a stable environment enables us to test even for small alterations in personal relationships, allowing a precise examination of partner choices. We measure the respondents' distributional concern for others through their social preferences, elicited by six monetary distribution tasks. In each task, students had to allocate money between themselves and an anonymous student from a different school class. Depending on how a person allocates the money, the resulting social value orientation (SVO) reflects her social preferences by the weight she assigns to the welfare of others (28). These can range between competitive (the willingness to sacrifice resources to harm others), selfish (maximizing own payoffs), prosocial (maximizing joint payoffs), and altruistic preferences (maximizing the others' payoffs), with small steps in between. This fine-grained measurement allows us to determine precisely the degree of prosociality students face in their environment and identify small changes in their social preferences. Observing how respondents distribute real money with real consequences, providing them with equal opportunities to cooperate, yields an advantage over self-stated measures. Studying cooperation with strangers also excludes strategic motivations and allows us to analyze cooperation independently of people's position and integration within the social network. Our study also provides insights into the development of prosociality during childhood. Several studies found substantial variation between societies in the willingness of adults to provide costly help (1, 29). Recent evidence suggests that cultural differences in prosocial behavior emerge around the middle to late childhood (30), proposing that children may become sensitive to cultural influences during this age, which modulates prosocial behavior. Our study tests whether and how children are sensitive to cooperative norms in their environment, which provides further insights into the ontogeny of human prosociality. Overall, our design allows us to tackle causal inference problems: We study people in an environment that is new to them. Since most other factors remain constant during the period, changes in the students' preferences can mostly be attributed to their new social environment.

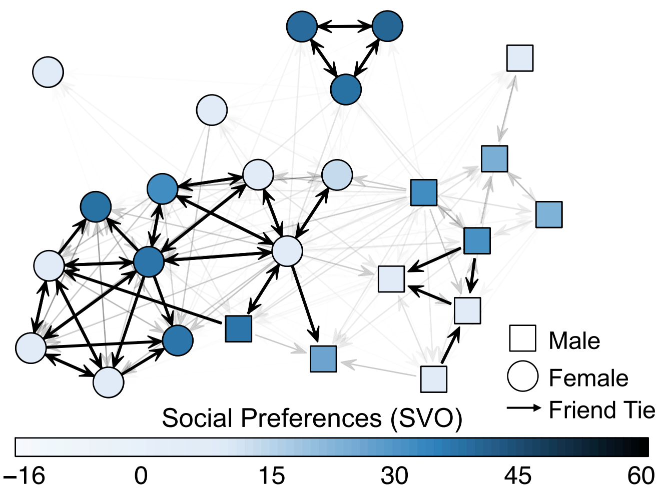

Fig. 1. Graph of the largest school class showing the social preferences in the friendship network during the first observation. Each arrow indicates that the receiving subject (alter) was named as a friend by the sending subject (ego). Arrow opacity shows the strength of the friendship. Strong friendships (strength > 5) are colored black, and relationships at or below three are suppressed.

Moreover, students and their teachers received an additional questionnaire regarding fundamental human values and behavior (31, 32). Together with a large number of respondents to select from, it enables a comparison of highly similar pairs of individuals who only differ in whether friends of high or low prosociality surround them. More in-depth information regarding our measures can be found in *Materials and Methods* and *SI Appendix* (including the explicit wording).

Results

Can we observe clusters of friends with similar social preferences in real-world social networks? We assess the degree of clustering on three different layers of the social structure—school classes, friendship cliques, and dyadic relationships. Fig. 1 shows how social preferences (mean [M] = 31.3, SD = 13) and friendships (M = 2.8, SD = 1.41) are distributed in the largest school class during the first wave. Although social preferences differ only marginally between male and female subjects (30.3 vs. 31.4, $t(1067) = 1.45$, $P = 0.15$), gender homophily plays an important role in all three layers of our network.* Therefore, we use network permutation methods to study the degree of clustering that exceeds the clustering due to gender homophily and other structural characteristics of the network. To do so, we compare the clustering of the original network with those of 1,000 null networks, in which we randomly permuted SVO within subsets of the network, while preserving basic characteristics of the original network. The resulting null distribution of network statistics allows us to determine the extent of clustering that is due to chance, in combination with the basic characteristics of the original network (e.g., gender homophily). CIs and P values of the original network statistic are obtained by comparing network statistics with its null distribution (*SI Appendix*). All statistical tests are two-sided.

We first examine the distribution of social preferences across school classes to test whether members from the same class are more similar in their social preferences than due to chance. To this end, we estimate the average variance of social preferences within classes and compare it to its null distribution in which

*During our first observation, two school classes consisted of females only. With regard to cliques, 68% of them are homogenous in terms of sex. In strong friendship relationships (strength > 5), 85% of them are among same-sex individuals.

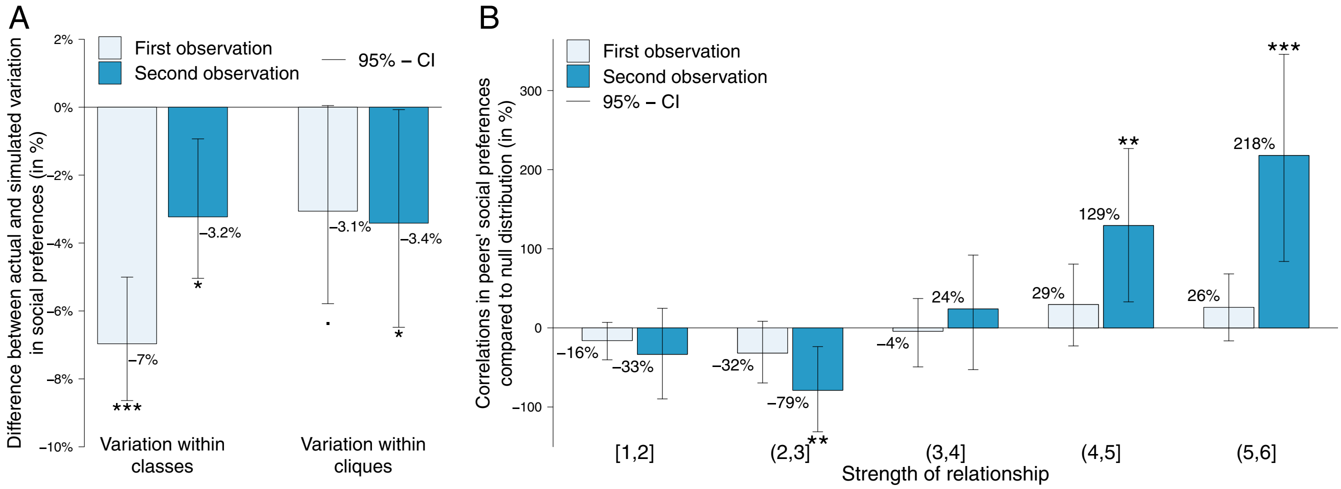

Fig. 2. Clustering of social preferences emerges at all layers of real-world social networks. (*A*) Shows differences between actual and simulated variances of social preferences for school classes and cliques within them. Simulations permute SVO among individuals of the same school, track, gender, and class, depending on the layer. (*A*, *Left*) Classmates are substantially more similar in their cooperative preferences than expected by chance. The homogeneity within classes reduces over time, pointing at the development of heterogeneous clusters within classes. (*A*, *Right*) At the same time, members of cliques become more similar in their cooperativeness from the first (light blue bar) to the second observation (dark blue bar). (*B*) Comparison of actual and simulated correlations among the peers' social preferences, separated by friendship intensity and observational period. In the initial visit, associations between the friends' cooperativeness are indistinguishable from randomly occurring patterns (light blue bars). Nine months later, strong social contacts are substantially more similar in their social preferences than we would expect by chance, due to their class membership and gender (dark blue bars).

SVO is randomly permuted. Since our sample contains individuals from different educational stages and locations, we permute SVO within the same educational track, school, and among same-sex individuals. We find that students from the same class are much more similar in their social preferences than what would be expected by chance. To put it more technically, the observed variations of social preferences within school classes are significantly smaller than those of the permuted null networks ($P_{t1} < 0.001$, $P_{t2} = 0.016$; Fig. 2*A*). Thus, social preferences cluster in school classes. Two critical aspects are worth being noted. First, the initial measurement was preceded by a probation period of several months, during which the students already spent time together. Class-related factors and social influence can therefore have caused the initial clustering in school classes. In subsequent permutation analyses, we therefore account for the preexisting clustering within classes, by permuting SVO additionally only within the same school classes. Second, the data suggest that heterogeneity in preferences increases over the 9 mo between the two observations, indicating an emerging polarization among groups of individuals within classes.

We proceed by looking more closely at the distribution of cooperativeness within school classes. Within each class, we identify cliques,[†] using community detection. We test whether social preferences are nonrandomly distributed among cliques from the same class. We compare the variance of social preferences in originally observed cliques with the variances of the permuted networks, in which we randomly shuffle the same-sex classmates' SVO. In our first observation, the clique members' social preferences are indistinguishable from those that are likely to appear by chance ($P_{t1} > 0.05$; Fig. 2*A*). However, 9 mo later, we do find evidence for the clustering of cooperativeness among clique members ($P_{t2} < 0.05$; Fig. 2*A*). The increasing similarity of the cliques' social preferences shows that students tend to form homogeneous groups, even in environments that are already characterized by high similarity.

We complete our triangulation on the existence of unconditional cooperative clusters in the field by examining the deepest layer in the social structure—individual relationships. We investigate how the intensity of personal relationships is associated with similarities in social preferences. To do so, we estimate the correlation between every two classmates' social preferences for each level of friendship strength separately. By using the network permutation method, each correlation coefficient is compared to its corresponding null distribution from data based on 1,000 permutations, in which SVO is randomly permuted among classmates of the same sex. As expected in the initial observation, social preferences are not more similar among more intense friendships ($P_{t1} > 0.05$ for all comparisons; Fig. 2*B*). However, 9 mo later, we find that students with strong relationships are substantially more similar in their social preferences than what would be expected by chance (Fig. 2*B*). A very good friend (strength > 5) is 218% more similar in cooperativeness than a randomly chosen student, accounting for gender homophily and class-related factors ($P < 0.001$).

Mechanisms Causing Clustering of Social Preferences. Exploring the causes which might have led to the clustering, one major factor is partner choice. When a critical mass of actors mutually chooses interaction partners based on their cooperativeness, the structural side-effect is the emergence of clusters. To test this, we compare how friends with similar and different social preferences reinforce or dissolve their friendships over time. Since partner choice models assume stable social preferences, our focus is on the proportion of 76% of respondents who have time-invariant, stable social preferences with respect to the dichotomization into self-regarding or other-regarding preferences (see Fig. 3 legend for computational details). For simplicity, we label these individuals defectors and cooperators, referring to the typical terminology used in laboratory studies. Using logistic regression, we analyze the probability of friendships between different cooperator-defector constellations intensifying over time compared to actors

[†]Cliques are defined as networks consisting of strong relationships within and weak relations between them. On average, we find 3.7 of such cliques per class and observation. Cliques are on average composed of 6.6 students; see *SI Appendix* for details.

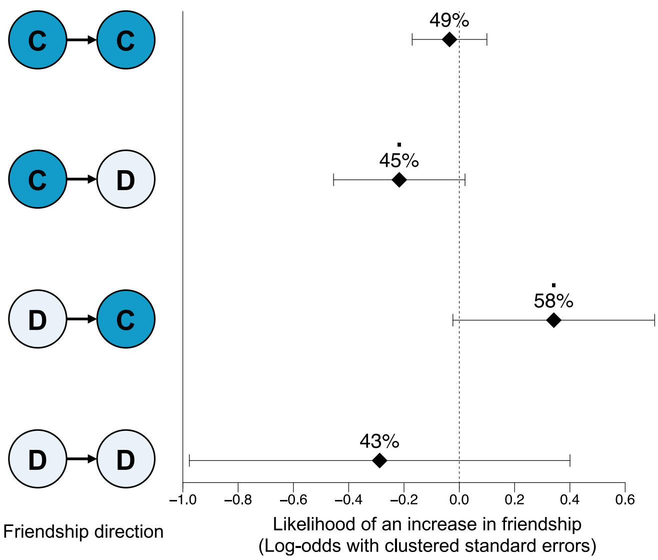

Fig. 3. Weak patterns of partner choice among people with stable social preferences. The coefficients of one logistic regression are shown. The regression estimates the likelihood of an increase in friendship relations, depending on the social preferences of the involved parties. First letters specify the social preferences of ego, whereas the second letter represents the social preferences of ego's friend. The letter C (dark blue) denotes stable other-regarding preferences (SVO > 22.5 in both waves, n = 475). The letter D (light blue) denotes stable self-regarding preferences (SVO ≤ 22.5 in both waves, n = 51). The threshold represents the midpoint of the SVO scale between competitive-selfish and prosocial-altruistic archetypes (28). Dyads from or to respondents with unstable preferences served as a reference category in the regression. The regression further controls for the initial level of the friendship and uses clustered SEs at the respondent level. Error bars indicate 95% CIs. The full regression table can be found in *SI Appendix*.

with unstable social preferences (controlling for initial friendship strength).

Our results indicate only weak patterns of partner choice (Fig. 3). In line with prior experimental work (16, 17), we find that defectors seek friendships with cooperators (D-C; prob = 58%, P = 0.07) and cooperators dissolve friendships with defectors (C-D; prob = 45%, P = 0.07). However, these effects are only marginally significant. Friendships among cooperators (C-C; prob = 49%) and among defectors (D-D; prob = 43%) are relatively stable; however, defectors have a higher tendency to dissolve their friendships. This within-type stability is indicated by nonsignificant changes in friendship intensity among defectors and among cooperators (both $P > 0.4$; Fig. 3). This overall weak evidence that cooperators are preferentially chosen as friends is supported by simple network statistics. Consistently cooperative individuals are not more popular than their less cooperative peers—neither in their degree distribution (Kolmogorov–Smirnov test, $P > 0.24$ for both comparisons) nor in their average in-degree (t test, $P_{t1} = 0.27$, $P_{t2} = 0.24$). Thus, the emerging clusters of social preferences are only marginally driven by partner choice.

The second mechanism that can cause clustering of social preferences is social learning. Does the social environment influence the individuals' social preferences? In other words, is cooperation contagious in the sense that the concern of individuals for others is elevated, when they are embedded in a particularly cooperative environment? To determine the effect a social environment has on individual preferences, we compare the changes in preferences of people who are exposed to a particularly cooperative environment (friends' weighted average SVO above 75th percentile) with those of people in less cooperative environments. To make the comparison as suitable as possible, we use matching methods to balance 41 covariates. See *SI Appendix* for a full table of the achieved balance and additional information on the matching.

Although the differences in exposure decline over time, there is a strong treatment effect; exposure to cooperative friends reinforces cooperation. Nine months after having started with similar social preferences, we find that distributional concerns have developed differently in the group with highly cooperative friends, compared to the control group with less cooperative friends (35.2 vs. 29.7, $t(174) = 3.02$, $P < 0.003$). For a more intuitive understanding of effect sizes, we convert the SVO from the payoff space of allocating resources to oneself or the other into a measure of the willingness to pay for others' well-being (Fig. 4). More specifically, we calculate the maximum amount students are willing to pay in order to provide a one-unit benefit to a stranger. On average, those in the control group are willing to pay no more than 60 cents per dollar benefit, whereas those in a cooperative environment are willing to pay up to 74 cents to provide a one-dollar benefit to a stranger. The presence of a cooperative environment therefore increases the maximum willingness to pay—for a one-dollar benefit, on average, by around 14 cents (plus or minus an error margin of 7 cents). Therefore, being embedded in a cooperative social environment substantially lowers the temptation to free-ride and considerably enhances social preferences.

We perform a number of robustness analyses using our complete sample. Compared to the previous matching of a subset of particularly comparable individuals who only differ in their cooperative environment, we provide sensitivity analyses for the full population. We analyze whether the average social preferences of friends influence ego's preferences over time. To this end, we regress a person's current social preferences on the current weighted social preferences of her friends and her previous social preferences. We find that, with each SVO-point increase in friends' social preferences, individual SVO increases by around 0.61 points ($b = 0.61$, $t(686) = 6.17$, $P < 0.001$). We also find an effect of previous social preferences on current social preferences ($b = 0.31$, $t(688) = 8.30$, $P < 0.001$), which highlights the dispositional nature of social preferences and the difference

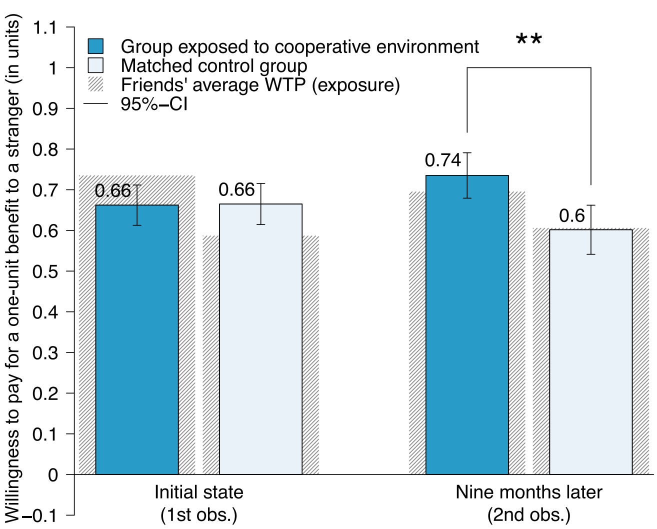

Fig. 4. Cooperation is contagious. Being embedded in cooperative environments promotes the individuals' concern for others. Shown is the willingness to pay for a one-unit benefit to a stranger (WTP) for 176 highly similar students (based on 41 covariates) in either particularly cooperative environments (blue) or less cooperative environments (light blue). *Left* shows the individuals' average WTP shortly after the classes were formed, whereas *Right* shows the same measure after being exposed to their social environment for 9 mo. Additional information is found in *Materials and Methods* and *SI Appendix*.

to purely conditional behavior that has been found among hunter-gatherers (27). This result remains significant when controlling for demographics and further variables (*SI Appendix*). These regressions demonstrate the robustness of our result that social learning seems to be the main mechanism driving clustering of social preferences in human networks.

To summarize, these results demonstrate that adaption is more important than selection for the emergence of cooperation in networks. There is only weak evidence that people select their interaction partners based on their social preferences. This is indicated by a number of findings; for example, cooperative individuals are not more popular or central in the network than selfish interaction partners. In contrast, there is strong evidence for the second mechanism of social learning. We find that people are inclined to adopt other-regarding preferences from their social environment, which is also supported by the observed initial clustering of cooperative students in school classes. Such a conformity-driven transmission process fosters the formation of groups with homogeneous social preferences and can protect cooperators from exploitation. Intuitively speaking, our real-world empirical data suggest that people rather choose to be similar than to be with similar others.

Discussion

Understanding cooperation is an integral part of understanding all kinds of human behavior. This is a challenging, but likewise important, objective, which almost certainly requires a combination of a wide range of approaches and perspectives. This work makes three main contributions to our understanding of the complex interplay between the formation of social networks and the development of other-regarding preferences.

First, our results demonstrate that preferences for cooperation are strongly clustered in real-life social networks. This evidence is the precondition for our argument that segregated networks of more and less cooperative groups enable the emergence and survival of cooperation. Cooperative clustering can be found on different nested layers of the social structure—classmates, clique members, and friends. With increasing strength of the relationships, people's social preferences become more and more alike. The resulting clusters protect cooperative individuals from exploitation and provide their members with advantages over self-regarding individuals. Recent evidence has found similar structural properties in reciprocal collaboration behavior among hunter-gatherers (26, 27). We presume that the clustering of cooperativeness is a universal property of real-world human social networks, which may also shed light on the evolutionary success of humans and their small- and large-scale societies.

Second, our results suggest the relative importance of different mechanisms for the formation of cooperative clusters. Partner choice does not seem to be the driving factor of clustering. There is only weak evidence that defectors are repellent as friends and that similarity in social preferences is relevant for friendship choices. This is in partial contradiction of theory (10, 11) and previous laboratory evidence, where it has been suggested that the rejection of defectors is important for the emergence of cooperative clusters (16–18, 20). Some differences between our field study and prior laboratory experiments may explain the lower relevance of partner choice. Participants in laboratory experiments receive minimal information regarding their potential partners. This reduced set of information (often previous cooperation behavior) may become overly important and overestimated for partner choices compared to realistic field environments. Also, partner choices require a reliable assessment of partners' cooperativeness. Although students can predict their classmates' dictator game giving (33), inherent social preferences, which we have measured, are hardly visible in the field. Thus, in the presence of reputation and other strategic concerns, actual behavior and other factors are likely to play a more important role for partner choices than the underlying social preferences. Nevertheless, selecting partners with cooperative preferences is extremely important, perhaps even more so because social preferences are more reliable as a factor for sustainable cooperation.

Third, our results demonstrate the importance of social learning and culture for the emergence of cooperation. Peers have a tremendous influence on their friends' social preferences. Over the course of 9 mo, our data suggest that students, embedded in cooperative friendship environments, become substantially more cooperative than their comparable peers in less cooperative environments. Our field evidence supports findings from laboratory experiments (25, 34) and a recent study with hunter-gatherers (27). They all emphasize the spreading of cooperative behavior through repeated or even single interactions. Our study extends the scope of cultural learning to (intrinsic) social preferences. By measuring cooperation toward strangers, we eliminate reciprocal generosity toward friends or relatives as an explanation for clustering and peer effects. Instead, we show that even unconditional moral sentiments toward uninvolved third parties spread over meaningful social relationships. Moreover, our results show that children at the age of 12–14 are sensitive to cultural and normative information, which may explain the development of cultural differences in the ontogeny of human prosociality.

While our results suggest that social preferences are likely to be reinforced in networks, we argue that they do not imply that individual preferences are predetermined or lead to self-fulfilling prophecies. First, the choice of interaction partners seems to be driven only marginally by cooperativeness, creating plenty of opportunities to change interaction partners within a given social environment. Second, at several stages of life, people face entirely new social settings that can break the cycle of self-reinforcing influences. Both points emphasize the role and relative importance of mobility for cooperation and individual success (14).

Our work is not without limitations. Although we measure human characteristics, preferences, and behavior in great detail, the data are not necessarily comprehensive. We have increased experimental control by studying a large set of respondents in a stable environment that is new to them. However, this choice comes at the cost of limited generalizability (35). Nevertheless, many of our findings are in line with previous work. A further limitation of this study is that we collected the data in discrete time points; however, we opted for a short interval between the periods to be able to capture the social processes and behavioral changes more reasonably.

Future research should aim to extend generalizability by investigating and combining evidence from different subject pools and populations using different methods. Furthermore, an interesting avenue for future investigations may be research on the consequences of cooperative clusters on individual and collective outcomes, such as educational and career success, happiness, or health.

Materials and Methods

A total of 1,217 adolescents (53% female, grades 7–9) from eight Swiss schools[‡] participated in our study. All students joined a newly formed class, around 78% also entered a new school. The school year started in August–September 2015; subjects were initially surveyed after their probation period in February 2016, as well as 9 mo later in November 2016. Between observations, students primarily spent time in their school environment, except for the spring break in April 2016, the summer break in July–August 2016, and the fall break in October 2016. The data collection was carried out during class by research assistants in pen-and-paper form, while the teachers were present, but not involved in the collection process. Students were reseated and not allowed to communicate with each other. All procedures were approved by the Human Subject Committee of the Faculty of Economics,

[‡]One of which rescinded its participation during the study.

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Business Administration and Information Technology of the University of Zurich. Passive parental consent was required and obtained for all participants.

Social preferences were measured using the Social Value Orientation Slider Measure (28). In six tasks, respondents could anonymously allocate points between themselves and a stranger from another class by choosing one of nine allocation pairs. For illustrative purposes, we converted the SVO° into the maximal willingness to pay for a one-unit benefit to a stranger by taking the negative slope of the unit circle at that angle. A full list of all allocation pairs and the computational details can be found in *SI Appendix*.

Earned points multiplied by one-half were paid out in Swiss Francs (CHF) using the lottery method: In each class, one student was randomly determined to be paid out either as a decision-maker or receiver of another class's decision-maker. Which of the six decision-makers' choices would be paid out was likewise determined randomly. They received their payoff in a closed envelope without further information. Payoffs varied between 7.5 and 50 CHF, with an average of 39 CHF (about US $38 at the time). The data collection took around 45 min.

To analyze the clustering of social preferences in the different levels of the social structure, we use network permutation methods. This resampling technique allows us to determine the probability of observing a network-related statistic given that an individual's position in the network (or within a subset) is random. In each test, we resampled the data 1,000 times without replacement. The resulting distribution of the statistic under randomness is called null distribution. The two-sided *P* value of an observed network statistic indicates the likelihood of observing a value that is more dispersed from the center of the simulated (null) distribution. The permutation overcomes the problem of nonindependent observations by taking the specific network structure into account when the null distribution is generated. When we control for a specific condition in the permutation test, we shuffle SVO only within the subsets of the network that fulfill these conditions, calculate the resulting global-level statistic, and compare it to the actual one. For example, if we control for gender and school classes, we only shuffle the SVO of students from the same school class and sex. These restrictions have the advantage that when we compare a network-related statistic of the original network with the resampled networks, basic characteristics of the original network remain preserved.

To estimate the effect of social environments on individual social preferences, we use a propensity score matching procedure with a Mahalanobis caliper. Based on 41 covariates —including personal, teachers', and friends' characteristics and attitudes—we estimate the likelihood to be exposed by particularly high (above upper quartile) cooperative preferences in one's social environment during the first observation. Due to the large number of covariates, missing values were imputed for the matching. Imputed values were mainly missing teacher characteristics, corresponding to 1.8% of the data, and do not include main variables such as exposure or social preferences (*SI Appendix*, Table S4). Subsequently, exposed and unexposed individuals were matched one-to-one within a caliper width of 0.25 SD of the propensity scores. We achieved a balance of covariates by using an iterative Mahalanobis procedure, which is more fully described in *SI Appendix* together with more information concerning the matching.

Data Availability. All of the data and code used in this article have been deposited in the Open Science Framework and can be accessed at https://osf.io/2kefc/.

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