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The 1/d Law of Giving

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Abstract

We combine survey data on friendship networks and individual characteristics with experimental observations from dictator games. Dictator offers are primarily explained by social distance – giving follows a simple inverse distance law. While student demographics play a minor role in explaining offer amounts, individual heterogeneity is important for network formation. In particular, we detect significant homophilous behavior – students connect to others similar to them. Moreover, the network data reveal a strong preference for cliques – students connect to those already close. The study is one of the first to identify network architecture with individual behavior in a strategic context.

The recent empirical literature has identified the importance of social networks in diverse environments such as technology adoption, job search, and crime.[1] Despite the wealth of fascinating data there are several inherent problems that appear in the empirical analysis of networks. First, the strategic interactions that underlie field observations are usually hard to pinpoint. Second, the attributes of individual nodes in the network tend to be restricted or missing altogether. Third, the endogeneity of the network structure itself is difficult to account for. These problems draw a wedge between the developing theory and the extant empirical work studying the impacts of social structure on individual and collective outcomes.[2] The current paper contributes a first step toward connecting social network structure and strategic behavior by combining standard survey techniques with controlled experimentation.

We collected data from a unique population of 10 to 18 year old students in an all-girls school in Pasadena, California. Our data set was assembled in two stages. In the initial stage, we elicited the entire network of friendships, as well as a wide range of personal characteristics of each of the girls, including height, race, confidence, shyness, etc. In the second stage, we conducted an array of experimental dictator games with fifth and sixth graders, varying the social distance between dictator and recipient as determined by the length of the shortest path connecting them in their (elicited) network of friends.

We chose this subject pool since we wanted to conduct experiments in a self-contained network where peer effects are important. Indeed, the impact of social networks on behavior can likely be discerned only when the information about the network is accurate and complete, which requires high levels of participation by the entire *relevant* population. Our design allows us to play the dictator experiments with almost all students in the fifth and sixth grades. Because 95% of them completed the social network survey we are able to account for the entire network structure when analyzing giving behavior.[3]

Several insights come out of the analysis of our data. We find that dictator offers are poorly explained by individual characteristics alone. The few characteristics that are significant indicate that shy subjects give and receive less while popular subjects (as measured

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[1] E.g., Oriana Bandiera, Iwan Barankay, and Imran Rasul (2007), Antoni Calvo-Armengol, Eleonora Patacchini, and Yves Zenou (forthcoming), Timothy Conley and Christopher Udry (forthcoming), Edward Glaeser, Bruce Sacerdote, and Jose Scheinkman (1996), Mark Granovetter (1994), and Giorgio Topa (2001).

[2] Recent theoretical works investigating strategic interactions on networks include Glaeser and Scheinkman (2002), Andrea Galeotti, Sanjeev Goyal, Matthew Jackson, Fernando Vega-Redondo and Leeat Yariv (forthcoming), and Arun Sundararajan (2006).

[3] By playing the game in the field we are able to sidestep many of the selection problems identified by Steven Levitt and John List (2006) and we control for some of the experimental "context" by explicitly measuring the nature of the existing network that the games are played within.

by the number of subjects naming them as friends) give less but receive more. We find no significant differences between kids in the fifth and sixth grades.[4] The model's explanatory power dramatically improves once social distance is included: the regressions reveal a simple *inverse distance law of giving.*

The second set of results pertains to the endogenous structure of the network itself. Using a logit discrete choice model applied to the data from all grades, we assess what affects each individual link's creation, given the network in place (a notion reminiscent of stability). We find that by and large links are significantly more likely between students with similar attributes. This is consistent with the wide sociology literature identifying homophily, the tendency of people to connect with those similar to them (for a survey and references, see Miller McPherson, Lynn Smith-Lovin, and James Cook, 2001). Hence, while personal characteristics do not directly affect strategic outcomes they may have an important indirect effect by determining the friends one ultimately interacts with. We also uncover evidence for a form of preferential attachment manifesting itself as a strong preference for cliques: students like to link to those that are already "close."

To summarize, our study serves as one of the first to identify the importance of the underlying social network for dictator generosity. More generally, the combination of survey techniques (to elicit student demographics and friendship networks) and controlled experimentation allows for a careful measurement of network or peer effects in strategic situations. As such, our approach should prove useful in evaluating some of the recent theoretical work that investigates the interplay of social structure and strategic play.

Furthermore, the analysis suggests a mechanism by which individual attributes affect outcomes. Namely, attributes can help determine one's neighborhood of friends (i.e., the number of direct friends, friends of friends, etc.), which can in turn affect outcomes.

Finally, our paper relates to a strand of the anthropology literature investigating giving behavior. Our findings suggest a possible alternative to the "culture" effects observed in dictator games played with members of small scale societies around the world (Joseph Henrich et al., 2001). It seems reasonable to assume that these small scale societies differ in terms of the underlying network structure, in particular in terms of average distances. Our results predict that in a more tightly-knit society, more generous dictator offers can be expected.

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[4]In important studies with children ranging in age between 7 and 18, William Harbaugh and Kate Krause (2000) show that students who have been at the same school longer give more to class mates and Harbaugh, Krause and Steven Liday (2003) find that older children make larger offers in dictator and ultimatum games. These authors suggest that children internalize social norms during childhood. Since their study does not include information about the children's friends, they cannot determine to what extent student behavior stems from generalized norms or from social preferences.

I.A. Related Literature

There are several recent papers that connect experimental games with social networks. Specifically, Steve Leider, Markus Mobius, Tanya Rosenblat, Quoc-Anh Do (forthcoming) pioneered the methodology of network elicitation followed by a controlled altruism experiment. They obtained a social network of college students and illustrated that dictators give more to "friends," i.e., recipients with social distance equal to 1.[5] Pablo Brañas-Garza, Miguel Durán, and Maria Espinosa (2005) replicate this finding under weaker conditions: they compare giving behavior when dictators are matched with *one of their friends* (not knowing which friend) or with a stranger.[6] This alternative setup allows them to rule out the possibility that generous giving occurs because the dictator knows the recipient's identity and personal characteristics.[7]

Our study directly adds to this literature by looking at a very different subject pool that, in particular, allows us to analyze network effects across ages. Importantly, our methods and results differ in several crucial ways. First, our evidence comes from a self-contained social network. Compared to the previous studies our results show a dramatic effect of social distance on dictator giving, possibly because the social networks of 10-12 year olds are concentrated at their school (unlike, for example, college students who may have some friends at home, at the place they work, etc.). Second, besides eliciting data on friendships, we also gathered information about individual students' characteristics. This allows us to correct for the effects of the recipient's characteristics on the dictator's offer (if any such effects exist). Third, there are several elements of our design that mitigate or eliminate the possibility of strategic reciprocity.[8]

Another related strand of literature pertains to the formation of social networks. Denise

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[5]Leider, Mobius, Rosenblat, and Do (forthcoming) study several versions of the dictator game in which they vary the amount received by the recipient when the dictator gives up part of the pie (see James Andreoni and John Miller, 2002). Their main interest is to define and measure "social capital," defined as the extent to which subjects are able to internalize the externalities that arise from dictator giving.

[6]The experiments were conducted during class and subjects were paid in terms of credit toward their grades.

[7]Brañas-Garza, Ramon Cobo-Reyes, Natalia Jiménez, and Giovanni Ponti (2006) report results from a related setup in which dictators have some (known) chance of being matched with one of their friends (not knowing which friend) or a stranger. In this case, dictator giving does not significantly increase with the chance of being matched with a friend. The aforementioned studies are further evaluated by Brañas-Garza and Espinosa (2006).

[8]Dictators were randomly matched with three of their friends, three friends of friends, and four strangers. Dictators made ten allocation decisions in our design, one of which was randomly selected by us to determine actual payments. Moreover, all subjects played the roles of dictators as well as recipients simultaneously, which should balance out any claims for *ex-post* favors. Finally, subjects' payments from being a dictator or a recipient were collected in envelopes, which they were supposed to take home before opening them several days after the experiment.

Kandel (1978) followed adolescents over time and documented the interplay between social connections and four behavioral attributes: frequency of current marijuana use, level of educational aspirations, political orientation, and participation in minor delinquency. David Marmaros and Bruce Sacerdote (2006) illustrated that geographical and racial proximity are key determinants of friendships in a population of students and recent graduates of Dartmouth. Similarly, Aldabert Mayer and Steven Puller (2008) use Facebook data on Texas A & M college students and document that proximity of major, dorm, and race are significant proxies for friendship formation. These studies are consistent with the similarity-based connections that we observe when eliciting a wide range of demographic and psychological characteristics across different age groups. Interestingly, we also find evidence for a form of preferential attachment that complements the tendency to connect to those who are similar, and is in line with recent theoretical models of network formation (e.g., Albert-Laszlo Barbasi and Reka Albert, 1999, and Jackson and Brian Rogers, 2007).

Our study also contributes to an ongoing debate regarding giving behavior in the dictator "game," where the typical outcome is that dictators give up non-negligible amounts.[9] "Dictator generosity" has inspired theories of other-regarding preferences that incorporate notions of fairness into the standard utility-maximizing paradigm.[10] Complementing these preference-based explanations, further experimentation has investigated the effects of "social context" on dictator giving. Elizabeth Hoffman, Kevin McCabe, and Vernon Smith (1996) vary the instructions and administration of the dictator game so that each variation makes the game a closer approximation of standard social interactions. They find that lowering the degree of the dictator's anonymity results in more generous offers, and conjecture that a less anonymous experimental design evokes levels of strategic reciprocity common to everyday repeated social interactions. Iris Bohnet and Bruno Frey (1999), however, provide evidence that dictator generosity is driven not by reciprocity but by the ability to identify with the recipients, whether by knowing something about them or seeing their faces. Likewise, Charness and Uri Gneezy (2008) show that recipients (located in a different city) identified by their family names receive significantly larger amounts.[11]

These experiments are suggestive of the importance of "social distance" in explaining

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[9]See Gary Bolton, Elena Katok, and Rami Zwick (1998) for an overview of early dictator game experiments, including Daniel Kahneman, Jack Knetsch and Richard Thaler (1986) and Robert Forsythe, Joel Horowitz, Savin, and Martin Sefton (1994).

[10]See, e.g., Ernst Fehr and Klaus Schmidt (1999), Bolton and Axel Ockenfels (2000), and Gary Charness and Matthew Rabin (2002).

[11]Deborah Small and Uri Simonsohn (forthcoming) find that knowing a "victim" increases dictator giving to another victim of the same misfortune.

dictator giving, where social distance is taken to be synonymous with anonymity.[12] However, Martin Dufwenberg and Astrid Muren (2006) demonstrate that reducing anonymity, by paying dictators in public, *lowers* the amount given even when recipients are visible or known to the dictator. Dufwenberg and Muren conclude that "...it is problematic to organize experimental data in terms of social distance if this notion is taken to vary one-to-one with anonymity." In this paper, we follow their suggestion and instead formally define social distance as the geodesic distance in the elicited network of friends.

I.B. Structure of the Paper

The paper is organized as follows. Section 2 describes the survey used to elicit the network of friendships and students' demographics and the protocol for the dictator experiments. In section 3, we report regression results to explain observed dictator offers. Section 4 analyzes the determinants of network formation, i.e., what causes a link between two subjects to be formed. Section 5 reports simulation results showing the effects of network position and individual characteristics on students' welfare. Section 6 concludes. Summary statistics of our data can be found in Appendix A. Appendix B contains the instructions, dictator decision sheet, and survey.

II. Design and Protocols

We collected data from students at an all-girls school in Pasadena, California. Our design was comprised of two components. We first conducted a survey among all students (grades 5 through 12) eliciting their network of friends and their personal characteristics. Four months later, we conducted an array of dictator experiments with girls from grades 5 and 6.

II.A. Student Characteristics and Friendship Survey

The survey was conducted in January 2006. We approached teachers with the request to give up 10 to 15 minutes of class time at the start of a class. Students were instructed not to talk while filling out the survey nor glance at others' responses. One of us was present to monitor and to answer any questions about the survey. The response rate in the entire population was 77%. In grades five and six, two out of forty students were absent, so for this group the response rate was 95%.

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[12]In the words of Hoffman, McCabe, and Smith (1996), social distance is "... a sense of coupling between the dictator and her counterpart, or others who know the dictator's decision."
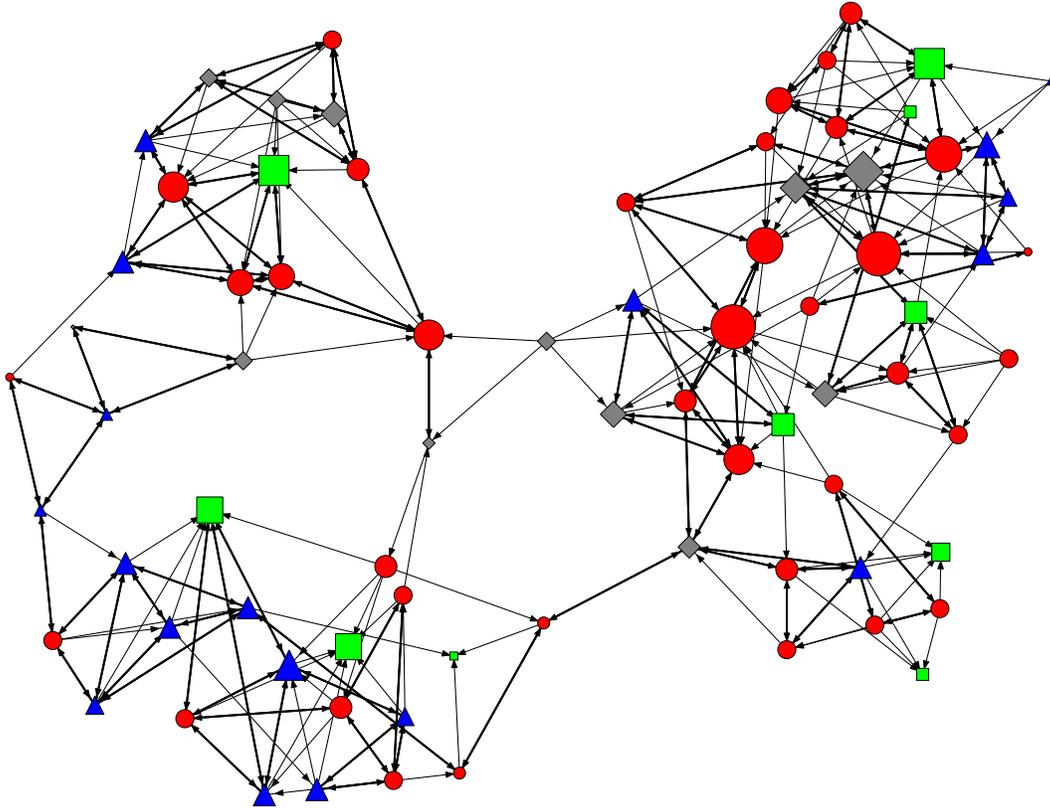
Figure 1. *Network of fifth and sixth graders.*

Key: *Nodes are sized according to degree and the different symbols indicate race: Caucasian (red circle), Asian (blue triangle), Mixed (gray diamond), and Other (green square). Thin (light grey) lines indicate one-way links, thick (dark grey) lines indicate two-way links.*

The survey (see Appendix B) consists of two parts: questions (1-11) concerning individual characteristics and questions (12-14) concerning friendships. The former include height, age, number of siblings, personality traits, and a few questions regarding physical appearance (e.g., hair and eye color and whether the student wears braces). In the final three questions, students were asked to name up to five friends and indicate how much time was spent with each. In addition, they were asked how much time they spent with *other* friends (possibly from a different school) not addressed in questions 12-14 and how much time they spent doing extra-curricular activities (e.g., playing an instrument, sports, etc.).

The summary statistics for the entire population are contained in Appendix A. Here we list some relevant statistics for fifth and sixth graders that play a role in our analysis of giving behavior below. The grades 5-6 subject pool is predominantly Caucasian (51%), followed by Asian (27%), and Mixed (16%). The remaining 6% are split between African-

American, Middle-Eastern, and Hispanic. The average height is 4'11" (ranging from 4'1" to 5'9"). Ages range from 10 to 12 years old (with an average of 10.8); the number of siblings ranges from 1 to 4 (average 1.1); 30% wear glasses and 40% wear braces. The questions concerning personality characteristics show answers ranging from 1 (corresponding to the most left bubble in question 11) to 5 (corresponding to the most right bubble in question 11) with means of 2.9 (optimistic), 2.5 (extroverted), 2.4 (confident), and 2.3 (outgoing), respectively.[13]

Subjects reported anywhere from 2 to 5 friends (where 5 is the maximum by design)[14] with an average of 4.4. The resulting friendship network is displayed in Figure 1, where the nodes are sized by degree and the different symbols represent race. The left cluster corresponds to grade 6, whereas the right cluster corresponds to grade 5. A thin (light grey) directed arrow is drawn from subject i to j when i names j as a friend but not vice versa, and a thick (dark grey) line is drawn when both i and j name each other as a friend. The data from the time estimates (questions 13 and 14) are used in the simulation approach of section 5 to provide a measure of how much time is spent with friends vis-à-vis friends of friends.

II.B. Dictator Game Experiment

The experiments were conducted on April 20th, 2006. We ran the dictator games with fifth and sixth graders during four separate classes, each of size 20. In each of these classes the teacher would start by taking 10 subjects outside after which we would read the instructions to the remaining ten subjects in the class (the instructions for the dictator game are simple and standard, see Appendix B). Subjects were allowed to ask questions during the instructions phase and afterward. We then handed out envelopes (labeled by name) that contained 10 decision sheets (see Appendix B), each sheet indicating the name of the dictator and that of the recipient.[15] Each dictator had to take a numbered decision sheet out of her envelope, record her allocation decision (i.e., how to split $6 between her and the recipient) and then take out the next decision sheet. After all ten allocation decisions had been made

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[13]One possible concern about these psychological measures is that answers would cluster around a focal answer. It is not the case that the majority of individuals chose the median answer. The percentages choosing the median answer of 3 were 38% (optimistic), 33% (extroverted), 35% (confident), and 23% (outgoing).

[14]While the majority of subjects do report five friends, this constraint seems to have had little effect on the substantive conclusions. All of the analysis reported in the paper were repeated on a sample restricted to those who reported less than five friends, yielding similar estimates and conclusions. The results are available from the authors upon request.

[15]In other words, decision making is not anonymous: the dictator knows the identity of the recipient but not vice versa. Of course, the recipient's name had to be disclosed in order to capture network effects.

the decision sheets were put back in the envelopes.[16] One of us would then roll a ten sided die and mark the decision sheet to be used for actual payment. Once all ten dictators were finished they were asked to join their teacher outside, at which point the other ten subjects played the game. The allocated class time (one hour) proved more than sufficient to run the games with two groups of ten dictators.

After the dictator game experiments were completed in all four classes, we took the envelopes with us to determine actual payments. We returned the envelopes the next day, which now contained only the subjects' payments from the experiment (total payment from all selected decisions in which the subject appeared in the role of dictator or recipient) plus an additional $2 that served as a "show up fee."[17] All subjects played the role of both dictator and recipient so it would be hard for a dictator to extract favors from anyone that appeared on her list of recipients, since the recipient could credibly claim to have already returned that favor. The subjects received their envelopes a few days later and were instructed to bring these home before opening them.

Of special interest is the matching protocol we used. To be able to discern the effects of social distance on giving, we matched each dictator with three friends (distance 1), three friends-of-friends (distance 2), and four others (distance 3 or higher). We borrowed this design element from the innovative study of Leider, Mobius, Rosenblat and Do (forthcoming) who conducted dictator games and network surveys among college undergraduates.

III. Experimental Results

In this section, we describe the results derived from the experimental segment of our design. Here, we take the elicited network of friendships as given. In Section 4 below we analyze the determinants of the network itself.

III.A. Explaining Giving Behavior by Individual Characteristics

Average offers in our experiment were 34% (approximately $2 of the $6), which is larger than standard results but comparable to average offers of 27% reported by Charness and Gneezy (2003), where subjects make offers to a recipient identified by family name.[18] Furthermore,

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[16]This within-subject design enables us to more accurately measure the effects of social distance on giving behavior and to generate enough data from the sample of fifth and sixth graders.

[17]This amount was suggested to ensure no subject had to feel her friends were not generous toward her.

[18]This difference has an intuitive explanation: Charness and Gneezy's subjects were playing with individuals in a different town, while our subjects know the recipients socially.

offers to strangers (defined as those of distance 3 or greater) in our experiment were 18% on average, which is comparable to average amounts reported in other dictator experiments. In our experiment, the game theoretic prediction of making no offers is seen in 36% of the offers to strangers, which is consistent with numbers reported by Hoffman, McCabe and Smith (1996) for their single-blind treatment.

We first analyze offer amounts using only individual characteristics collected from our survey to explain the share of the pie ($6) given to the recipient. *Height* controls for each individual's deviation from the mean height, *shy* controls for individuals' deviation from mean shyness, *asian* is a dummy equal to 1 if the participant's race is Asian, and *popular* proxies for a student's popularity by counting the number of people who call that student a friend. We also control for the recipient's characteristics: *shy_recipient* represents the recipient's deviation from the mean shyness, *popular_recipient* controls for the deviation of the recipient from the mean in-degree measure, *samerace* is 1 if the dictator and recipient are of the same race and *sameheight* is 1 if both dictator and recipient are above or below the mean height. *Sameconf* is 1 if both dictator and recipient are above or below the average on ranking how confident they are. The results are summarized in Table 1.[19] Since each individual makes 10 separate decisions, we report heteroskedasticity-robust standard errors that take into account the cluster structure of the data.[20]

Of the demographic and network variables, only the survey measure assessing the "shyness" of a subject is significant at the 5% level. Popular students (as measured by their indegrees) receive slightly larger offers suggesting a "popularity premium."[21] Note that the individual and pair characteristics all represent relatively small effects. Moreover, the explanatory power of the model is poor ($R^2 = .05$).[22]

III.B. Explaining Giving Behavior by Individual and Network Characteristics

To glean some insight into the importance of social distance on giving behavior we computed the mean amount given for distances ranging from 1 to 10 (we pooled the data for distances

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[19]Table 1 reports results from an OLS regression. We find qualitatively similar results from an ordered probit regression: asian 0.248 (0.164), shy -0.157 (0.075), shy_recipient -0.034 (0.042), popular -0.051 (0.039), popular_recipient 0.048 (0.020), samerace -0.058 (0.104), sameheight 0.002 (0.091), sameconf 0.100 (0.092).

[20]Similar estimates (not reported) were obtained using a random effects model. We also estimated a fixed-effects model but could not reject the null hypothesis that the fixed-effects model and the random-effects model were similar (using a Hausman test at the 5% significance level).

[21]If the dictator game proxies for a typical social interaction where giving is common, one possible explanation is that shy students give less because they participate less in standard social interactions.

[22]We also considered the importance of individual demographic variables in giving, restricted to offers made to friends only and offers made to strangers only. Even after this conditioning on social distance, dictator and recipient demographics cannot explain offer amounts.

Variable	Coefficient	
Share of 6$	(Standard Error)	
	Model 1	**Model 2**
delta (δ)		0.356***
		(0.040)
gamma (γ)		-0.852***
		(0.153)
order		-0.047***
		(0.009)
height	-0.002	-0.003
	(0.004)	(0.004)
asian	0.057	0.039
	(0.039)	(0.040)
shy	-0.037**	-0.036**
	(0.018)	(0.018)
shy_recipient	-0.010	-0.001
	(0.01)	(0.009)
popular	-0.011	-0.017
	(0.009)	(0.012)
popular_recipient	0.010**	-0.003
	(0.005)	(0.004)
samerace	-0.014	-0.022
	(0.024)	(0.022)
sameheight	0.005	-0.006
	(0.021)	(0.018)
sameconf	0.028	0.006
	(0.022)	(0.019)
closeness		-0.011
		(0.009)
betweenness		0.003
		(0.002)
power		-0.002
		(0.007)
Constant	0.324***	0.156***
	(0.020)	(0.037)
Observations	629	629
R-squared	0.05	0.29
Robust clustered standard errors in parentheses		
* significant at 10%; ** significant at 5%; *** significant at 1%		

Table 1. *Explaining dictator offers by personal traits only (model 1) and by including network variables (model 2).*

greater than 10 for which we have relatively fewer data).[23] The results are displayed in Figure 2, where each of the 11 bars reflects the mean share of the pie that was offered and the error bars indicate twice the standard deviation (the theoretical black line is discussed below). Clearly, offers significantly decline with distance.

The effect of distance is captured in the regressions by including a term δd^γ, where $\gamma < 0$ reflects the decaying effect of social connection as distance increases. An additional measure of social distance is captured by the variable *order*, which refers to the order (1-5) a first-degree friend was listed (see question 12 of the survey in Appendix B). In the estimations,

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[23]Recall that we measure social distance as the minimum number of "steps" between any two individuals in Figure 1. A distance of 1 indicates (direct) friends, a distance of 2 indicates indirect friends (friends of friends who are not direct friends), etc. When individuals are not connected by the network their distance is coded 1001.
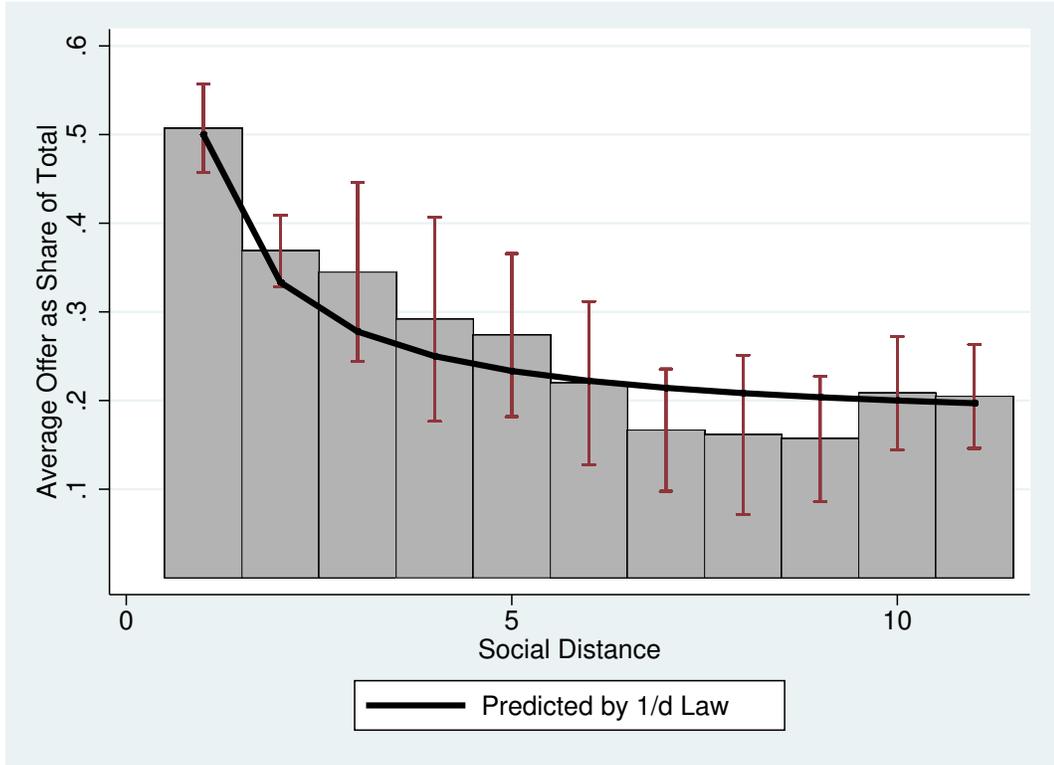
Figure 2. *Observed and predicted offers by social distance.*

the variable *order* is coded as the deviation from the mean. We also include three standard measures of network structure. *Betweenness* measures the share of times an individual is between any two other individuals on a path over all paths in the network, *closeness* is the sum of the inverse distance from i to all other individuals in the network and *power* is a measure of the centrality of other individuals when i is removed from the network (see Phil Bonacich, 1987). For each of these three network variables we take the deviation from the mean as the explanatory variable. We take into account the panel structure, using a clustered design, and report heteroskedasticity-robust standard errors. The results are summarized in the right-most column of Table 1.

Shy is still significant, but remains small in size. The three social network structure measures are not statistically significant and represent very weak effects. One possible explanation is that for these measures to play a role, subjects would effectively need to understand the entire network structure, which is unlikely the case in practice. The social distance measures, in contrast, represent very large effects. The model estimates that strangers, i.e., those of infinite distance, will receive 16% of the pie while a second-degree friend receives an additional 20% and another 16% is added for the median first-degree friend. Moving one deviation below the mean in the ordering of friends is equivalent to losing 5% of the

pie. None of the partner characteristics are significant when we include controls for social distance. In particular, the effects of the partner's popularity vanish. Finally, note the dramatic improvement in fit once social distance is included ($R^2 = .29$).

The variation in offer amounts across different recipients is not driven by only a few individuals. Most individuals showed substantial variation in offer amounts across the recipients they faced. Only 5% of the individuals who participated in the experiment offered the same amount to all recipients. We also consider the distribution of offers conditional on social distance. Figure 3 shows that the distribution of offers for recipients of distance 1 (friends), distance 2 (friends-of-friends), and those of distance greater than 3 (strangers). Note that the offer distributions are ranked in the sense of first-degree stochastic dominance, which illustrates that dictators make a clear distinction between friends, friends-of-friends, and strangers.
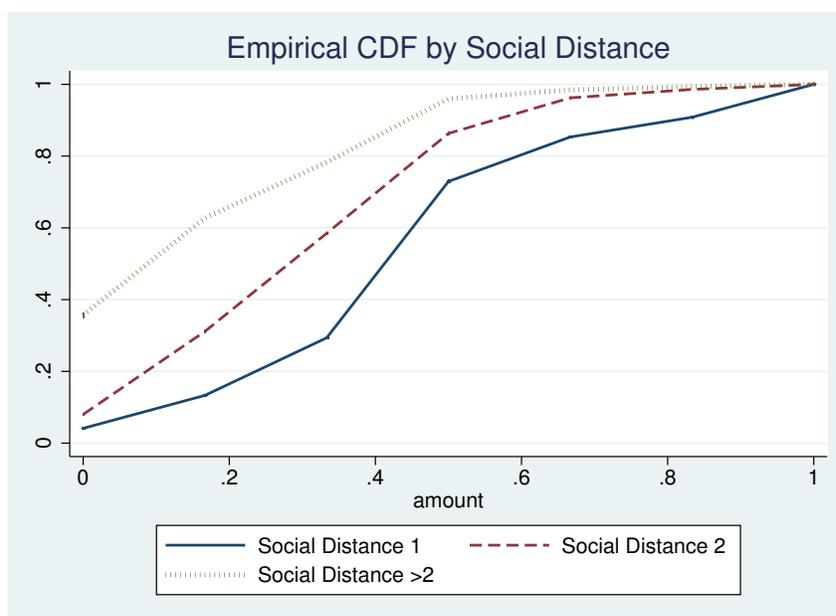
Figure 3. *Empirical Distributions by Social Distance.*

Compared to other studies our results show a dramatic effect of social distance on dictator giving, possibly because the social networks of 10-12 year olds are concentrated at their school. Another reason could be that ingroup/outgroup effects are much more pronounced among adolescents – relative differences between giving to friends and others may be exaggerated at age 12. To summarize, introducing controls for social distance significantly improves the fit of the model and introduces large and significant effects, particularly in comparison

with the individual and pair effects reported above. The equation governing dictator giving in terms of social distance may be neatly summarized as[24]

$$\text{share given} = \frac{1}{6}\left(1 + \frac{2}{d}\right).$$

The predictions of this *inverse distance law of giving* are superimposed in Figure 2.

IV. Determinants of Network Formation

The previous section suggests the potential significance of the underlying social network for individual outcomes. In fact, personal characteristics had far weaker predictive power than network attributes in determining strategic behavior. Nonetheless, personal characteristics may have an important (albeit indirect) role in determining outcomes by affecting the social network at place, and thus the type, in terms of social distance, of interactions an agent with certain characteristics experiences.

Our data allow us to measure the effects of individual characteristics on linking choices. Furthermore, we observe links made by students from *all* grades (373 students in total), not just grades 5 and 6. We analyze subjects' linking choices with a logit discrete choice model: for every link made by a subject we evaluate its "value" and compare it to the values of other links the subject could have made (holding fixed all other links in the network). This has the flavor of stability in the sense that if a subject had a more valuable link available than one of her existing links, we would expect her to shift social resources to that link and the network would not be stable.

Consider first a model where link values are determined by individual characteristics alone. In particular, suppose a link from subject i to j has a value v_{ij} that is a function of i's and j's characteristics $v_{ij} = f(X_i, X_j)$. Then, using a logit model, the probability that this link occurs is given by

$$P_{ij} = \frac{e^{v_{ij}}}{\sum_k e^{v_{ik}}}. \tag{1}$$

Estimating this model using a clustered structure to take into account that each individual makes five independent decisions to link to a friend, we find that individual and partner characteristics a role primarily when the characteristics of i and j match up, see Table 2.[25] This is consistent with the extensive sociology literature on homophily, a phenomenon referring

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[24]Note that the estimated parameters governing the social distance part are not significantly different from $\frac{1}{6}, \frac{1}{3}$, and 1 respectively.

[25]We restrict logit choices to students within the same grade, which captures almost all data. The dummy

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to people's apparent tendency to connect with others similar to them (for an overview, see McPherson, Smith-Lovin, and Cook, J. M., 2001).[26] The one individual characteristic that appears to affect the probability of linking is the height of the network partner. Individuals are more likely to link to make friends with girls who are taller.

There are network effects that seem intuitively appealing and do not appear in the estimation of equation (1). Following the network formation literature on *preferential attachment* (see, e.g., Barabasi and Albert, 1999, and Jackson and Rogers, 2007, and references therein), it is natural to entertain subjects' preference to form cliques, i.e., subjects' preference to link to friends of friends. We model this by posing that the probability that i links to j depends on the distance between i and j without the link. Table 2 incorporates these network or distance effects into our logit model.[27] For example, the dummy variable $d2$ is equal to 1 if, without the direct link between i and j, there is already a path from i to j of length two. In other words, j is already a friend-of-a-friend and a direct link from i to j closes the "triad." Finally, the dummy variables $d3$ and $d4$ are 1 if, without the direct link from i to j there is already a path from i to j of length 3 or 4 respectively.

As in the previous section, the inclusion of network variables results in a dramatically improved fit (the log likelihood increases by roughly 1400 or 25%). Students seem to have a strong preference to link to those that are already close. The resulting "cliques" are apparent from the network graph in Figure 1. These observations are important when considering the distance of agents one chooses to interact with. Indeed, girls in one's clique are of short social distance. Our experimental results suggest that dictator-like interactions with them are expected to yield high returns relative to interactions with girls outside of the clique. Once we account for network structure, the height of a partner is no longer a significant predictor of making a link. In our data, height is weakly correlated with popularity (significant at 10%). Nicola Persico, Andrew Postlewaite and Dan Silverman (2004) find that height affects early childhood confidence, which could also suggest a tendency for taller individuals to have more friends. This relationship between height and popularity may also explain the fact that once we control for the network position of existing partners, height is no longer an important

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variable *sameboyfriend* is 1 if the girls that form the link both have a boyfriend. Other recipient characteristics we tried include *confident*, *shy*, *boyfriend*, *Asian*, *height*, *braces*, *glasses*, and *only child* but none of them are significantly different from 0, and neither are *sameshy*, *sameonlychild*, *samebraces*, *sameglasses*, *sameoptimistic*, and *sameextroverted*.

[26]There are several recent studies that explore the foundations and impacts of similarity-based connections, e.g., Sergio Currarini, Jackson, and Paolo Pin (forthcoming) and Mariagiovanna Baccara and Yariv, 2008.

[27]There are potential endogeneity issues when incorporating these variables in the estimations. Note, however, that the non-network estimates do not change significantly when the network variables are included, which provides evidence that the resulting estimates are not biased.

| Variable | Coefficient | |
| Link | (Standard Error) | |
	Model 1	Model 2
samerace	0.618***	0.491***
	(0.084)	(0.084)
sameheight	0.263***	0.289***
	(0.064)	(0.069)
sameconf	0.158**	0.158**
	(0.066)	(0.071)
sameboyfriend	0.683**	0.562**
	(0.324)	(0.225)
shy_recipient	-0.019	0.030
	(0.032)	(0.035)
height_recipient	0.023**	0.010
	(0.011)	(0.013)
d 2		3.657***
		(0.130)
d 3		0.940***
		(0.169)
d 4		0.473***
		(0.169)
Log Likelihood	-5451.151	-4027.450
Observations	1753	1753
Robust clustered standard errors in parentheses		
* significant at 10%; ** significant at 5%; *** significant at 1%		

Table 2. *Explaining linking decisions by personal traits only (model 1) and by including network variables (model 2).*

predictor of making a link.[28]

IV.A. Network Position and Earnings

The homophilic preferences underlying linking choices together with the dependence of giving behavior on social distance identified in the previous section, suggest the potential (indirect) significance of individual characteristics on outcomes. To illustrate, note from Figure 1 that Asian students tend to form cliques. Moreover, Table 1 shows that Asian students tend to give more (although the result is not significant, possibly because of our matching protocol). If each girl interacts with a fixed number of closest friends (or, alternatively, with all the girls that are of particular distance from her) Asian students will, on average, receive higher

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[28]One natural question (raised by a referee) is "if similar characteristics determine network formation (model 1 in Table 2), and network positions determine giving (model 2 in Table 1), then why do we not see a big effect of individual characteristics on the amounts given (model 1 in Table 1)?" For example, one could characterize a certain clique in the network by two characteristics, i.e. a group of tall Asian girls. In this clique, girls are "close" and give a lot to each other, so the interaction term *sameheight × Asian* could be expected to be a significant explanatory variable for the amount given. Other cliques could be described similarly by constructing interaction terms that involve two or more individual characteristics. We tried several models that included interaction terms of this type, but found no improvement in fit. Basically, the interaction terms filter out few subjects that satisfy multiple criteria, and our data set is not large enough to produce significant effects. We do think that in a larger data set the network effects should be reproducible, although less perfectly so, by considering individual characteristics.

benefits in dictator-like settings. In other words, personal characteristics affect the type of agents one interacts with and, hence, social distances, which in turn affect earning outcomes.
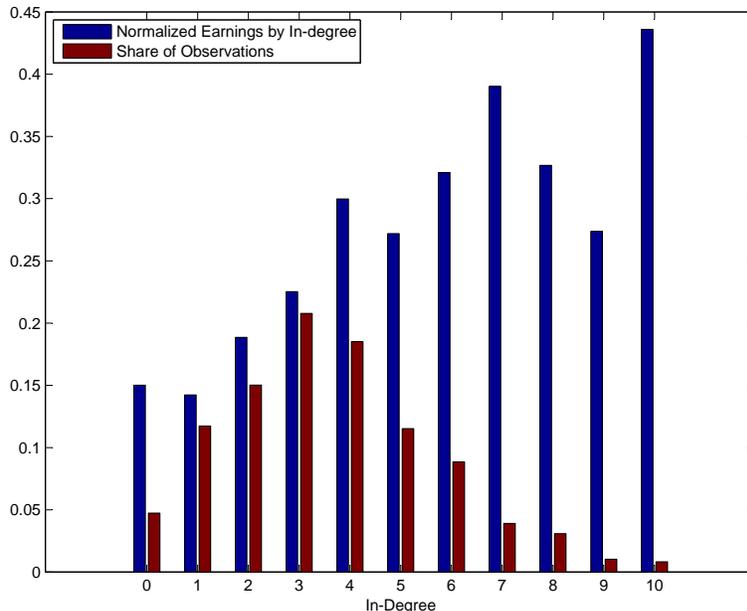
Figure 4. *Simulated earnings by popularity.*

Actual earnings in the experiment exhibit some variance, but our design of randomly choosing one of ten decisions effectively dampens out network or demographic effects. To gain more insight into the connection between network position, individual characteristics, and earnings, we simulate interaction over the entire network and generate a normalized measure of the share of the $6 each individual is expected to receive. In particular, first we predict offer amounts from i to j for all possible interactions in the network using the results from estimating the inverse distance model in Section 2. Using survey responses, we next generate a weight that represents the ratio of time spent on average with direct friends to the total time spent with all friends. We then generate a weighted sum that represents the value any individual is expected to receive from a pairwise interaction with any other member of the network (we assume an individual is as likely to be a dictator as a recipient). We find that these simulated average earnings have a strong positive relationship with in-degree or popularity, see Figure 4.

Using the simulated earnings we are able to measure the importance of individual and network characteristics, see Table 3. First, note that without the inclusion of network variables such as popularity, betweenness, closeness, and power, the model's predictive power is weak (left-column). Including the network variables (right-column) improves the fit dra-

| Variable | Coefficient | |
| Simulated Received Earnings | (Standard Error) | |
	Model 1	**Model 2**
height	0.002	0.001
	(0.001)	(0.001)
asian	0.020	0.023*
	(0.015)	(0.013)
shy	-0.003	0.005
	(0.007)	(0.006)
confident	0.005	0.002
	(0.007)	(0.006)
only child	0.024	0.018
	(0.016)	(0.014)
optimistic	-0.001	0.000
	(0.006)	(0.005)
braces	0.008	0.007
	(0.013)	(0.012)
glasses	-0.028**	-0.016
	(0.013)	(0.011)
popular		0.026***
		(0.003)
between		-0.003**
		(0.001)
close		0.002
		(0.002)
Power		-0.000**
		(0.000)
Constant	0.204***	0.100***
	(0.009)	(0.013)
Observations	330	330
R-squared	0.03	0.28
Robust standard errors in parentheses		
* significant at 10%; ** significant at 5%; *** significant at 1%		

Table 3. *Explaining earnings by personal traits only (model 1) and by including network variables (model 2).*

matically and predicts that the few most popular girls earn close to four times as much as the least popular ones (see also Figure 4). In particular, each time a student is named by someone else as a friend, their in-degree goes up by 1 and their normalized earnings by 2%. This raises the normalized earnings from roughly 10% for someone who was never listed as a friend to 32% for someone who was listed eleven times (the maximum in our sample) - a more than three-fold increase.

Note that the value of being listed as a friend by one extra person is roughly the same as the value of being Asian. The underlying reason is quite different, however, and ties back to the homophilic preferences discussed above. Asian girls tend to form small cliques and they tend to give more on average – as a result the normalized earnings of Asian girls are higher. This illustrates our earlier argument for why individual traits (which do not explain the amount given) are important in explaining subjects' earnings – they affect linking choices and average distances, which are the main determinants of giving behavior.

V. Conclusion

We collected survey data on friendship networks and individual characteristics from the entire student body at an all-girls school in Pasadena, California. In addition, we conducted several dictator games with 5th and 6th graders, varying social distances between proposers and receivers (using the *elicited* social network structure).

There are two main insights that shine through. First, network effects are extremely important in explaining dictator behavior, far more so than any individual characteristic. In fact, the data reveal a simple $1/d$ law of giving, where d denotes social distance between a proposer and receiver. Second, individual characteristics are important in explaining the network formation process. We identify strong homophilous behavior in that girls tend to link to others similar to them.

These two insights suggest that social networks may constitute an important channel through which personal characteristics affect outcomes. Indeed, personal characteristics may affect the agents one faces (say, the number of direct friends, friends of friends, etc.) in a variety of strategic interactions. These, in turn, play a crucial role in determining the resulting outcomes.

More generally, the study contributes to the rapidly expanding literature pointing to the importance of social networks to economic consequences. It provides one of the first to elicit both network and personal attributes and tie them to a controlled strategic interaction.

The paper also provides a contribution to the literature on social capital (see, e.g., James Coleman, 1990, Robert Putnam, Robert Leonardi, and Raffaella Nanetti, 1992, Glaeser, David Laibson, and Sacerdote, 2002, and references therein). While our population of subjects is very particular, in view of the social capital literature, our results suggest that social network characteristics may serve as a useful proxy for social capital (coarse network characteristics, such as joint memberships in organizations, have, in fact, already been used in some empirical work). In our setup, social capital captured in that way have power in explaining outcomes, namely dictator giving. Furthermore, our results suggest that social capital formation may be impacted by non-malleable physical characteristics. In particular, having an attribute that is common in the population can ease the creation of close connections, since similar individuals are easier to find, and consequently raise one's potential for acquiring social capital.

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Appendix A. Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
grade	8.9 (5.5)	2.2 (0.5)	5 (5)	12 (6)	487 (80)
age	13.9 (10.9)	2.2 (0.7)	10 (10)	18 (12)	373 (76)
height	63.2 (58.8)	3.7 (3.4)	49 (49)	73 (69)	370 (75)
siblings	1.2 (1.1)	0.9 (0.8)	0 (1)	6 (4)	373 (76)
boyfriend	0.07 (0)	0.26 (0)	0 (0)	1 (0)	487 (76)
optimistic	3.0 (2.9)	1.0 (0.9)	1 (1)	5 (5)	368 (75)
extroverted	2.6 (2.5)	1.0 (1.0)	1 (1)	5 (5)	366 (75)
confident	2.7 (2.4)	1.0 (0.9)	1 (1)	5 (5)	368 (74)
outgoing	2.5 (2.3)	1.0 (1.0)	1 (1)	5 (4)	370 (74)
hours: friend 1	25.1 (25.0)	20.0 (17.4)	0 (1)	155 (64)	368 (75)
hours: friend 2	22.2 (21.7)	18.0 (15.6)	0 (1)	147 (56)	368 (75)
hours: friend 3	21.3 (21.0)	18.7 (15.5)	0 (1)	189 (50)	367 (74)
hours: friend 4	20.1 (19.6)	18.8 (15.4)	0 (0)	148 (50)	361 (69)
hours: friend 5	19.5 (21.0)	19.0 (16.1)	0 (0)	168 (56)	345 (63)
socializing	15.6 (12.8)	16.7 (15.7)	0 (0)	100 (80)	365 (72)
white	59.2% (50.7%)				368 (75)
black	3.8% (2.7%)				368 (75)
asian	22.6% (26.7%)				368 (75)
mixed	9.5% (16.0%)				368 (75)
hispanic	2.4% (2.7%)				368 (75)
in-degree	3.6 (4.4)	2.1 (2.4)	0 (0)	11 (10)	487 (76)
Number of friends	4.8 (4.7)	0.6 (0.7)	1 (2)	5 (5)	370 (76)
Number of Surveys					373 (76)

Table A1. *Summary statistics for the entire population (and grades 5 and 6).*

Appendix B. Instructions, Decision Sheet, and Survey

Instructions: Welcome to this experiment! If you have any questions you may ask _____.
You are not allowed to talk with anyone except _____ during the experiment.

We will ask everyone from this class to make a series of 10 decisions. For each decision, you get a separate sheet of paper (numbered 1-10) that lets you divide $6 between yourself and another student from this school: the name of the other student is printed on the sheet. The other student might be someone in your class or someone from a different grade. On each sheet you should write down how much you want to keep for yourself and how much you want to give to the other student: any division is allowed as long as the numbers add up to $6. When you are done, we will pick up your sheet and give you a new sheet, which will have the name of a different student printed on it.

Once you made all 10 decisions, we will roll a ten-sided die to decide which of the 10 decision sheets to use. The amount you wrote down on this sheet to keep for yourself is put in your "money envelope" and the amount you wrote down on this sheet for the other student is put in the other student's "money envelope." No student in your class (or in a different grade) will ever know their name was on your sheet or how much money you gave to them.

After the experiment is done, each student will receive her own money envelope. The amount of money in your envelope depends on how much you decided to keep for yourself and how much others decided to give to you. The money in your envelope is yours to keep and you do not have to tell anyone how much money you got.

Decision sheet (#1 out 10): Hello <u>dictator's name</u>! Please choose how you want to divide $6 between you and <u>recipient's name</u>.

Amount for You	**Amount for <u>Recipient's Name</u>**
$___	$___

<u>Please make sure that the amounts in the boxes add up to **$6**</u>.

Survey

Thank you for participating in this survey. Please be assured that your answers will be kept <u>completely confidential</u> and your identity will be protected. While your name is required for this survey, we assure you that your identity will not be disclosed to any third parties nor published.

1. What is your first and last name: _____

2. How old are you? _____

3. What grade are you in? _____

4. How would you describe your race/ethnicity? _____

5. How tall are you? _____ft _____in

6. How many siblings do you have? _____

7. What color are your eyes? Please circle one:

   Blue   Brown   Green   Hazel

8. What color is your hair? Please circle one:

   Brown   Blonde   Black   Red

9. Do you currently wear braces? Please circle one: Yes   No

10. Do you currently wear glasses? Please circle one: Yes   No

11. Please select a bubble closest to the word which best describes your personality.

Optimistic	○	○	○	○	○	Realistic
Extroverted	○	○	○	○	○	Introverted
Confident	○	○	○	○	○	Self-conscious
Outgoing	○	○	○	○	○	Shy

12. In the spaces below, list up to five of your closest friends **that currently attend your school**. Please include their full names, ages, and grade. In addition, please include the approximate number of hours spent with this friend during the week. If you have a best friend, please place his/her name at the top of the list.

Name	Age	Grade	Hrs/Week
1.			
2.			
3.			
4.			
5.			

13. On average, how many hours per week do you spend socializing with **other** friends (not listed under 12): _____

14. Please list some of your team sports, activities and hobbies. (For example: basketball, knitting, playing an instrument, cheerleading, drawing etc…)

Activity	Hrs/Week
1.	
2.	
3.	
4.	
5.	