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Measuring Tie Strength*

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Abstract

Little attention has been given to the measurement of the concept of tie strength. Using survey data on friendship ties, we apply multiple indicator techniques to construct and validate measures of tie strength. We conclude that: (1) there may be two distinct aspects of tie strength, having to do with the time spent in a relationship and the depth of the relationship; (2) a measure of "closeness" or intensity is the best indicator of strength; (3) there are difficulties with frequency and duration of contact as indicators of strength; (4) predictors of strength (e.g., kinship, neighboring) are not especially strongly related to the concept; and (5) the constructed measures of strength, particularly the one of "time spent," are valid in that they are related to predictor variables in anticipated directions.

Tie strength is probably the network concept that has attracted the most research attention and the one that has led to the most in the way of substantive contributions. Research using the concept was initiated by the publication of Granovetter's (a) paper entitled "The Strength of Weak Ties," and Granovetter (c) has recently provided an overview of many of the studies that have invoked the concept. Substantive successes have been especially visible in the literature on the process of social mobility, where variations in tie strength have been shown to be systematically related to the outcomes of job search efforts, but there have been applications to other substantive concerns as well.

These accomplishments based on the tie strength concept are notable ones. We find, however, an important gap in this literature. Little sustained attention has been given to the measurement of the concept of tie strength, and the (presumably differential) accuracy of the different mea-

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sures that have been used to index it. We do not know whether the concept is uni- or multidimensional, or whether different indicators that have been used to measure it covary with other variables in similar ways.

This paper will address the problem of measuring tie strength, using multiple indicator techniques and available data on friendship ties in an effort to measure the concept. We will define strength, insofar as possible with the data available, in terms of the indicators suggested by Granovetter: time spent in the relationship, and the intensity, intimacy and reciprocal services within the tie. Additionally, we will attempt to construct-validate the measure of tie strength we derive, by examining the manner in which indicators of the concept covary with indications of the foci (Feld) on which ties may be based, and other predictors. This also provides an opportunity to examine the question of whether specific measures of tie strength are contaminated by other features of dyadic relationships.

Tie Strength and Its Indicators

An initial problem encountered in designing measures of tie strength is that it has never been given a precise conceptual definition. Granovetter's introduction of the concept proceeded on an "intuitive" basis (a, 1361) by defining the concept in terms of its indicators. He suggested that "the strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding) and the reciprocal services which characterize the tie," but indicated that "[d]iscussion of operational measures of and weights attaching to each of the four elements is postponed to future empirical studies" (a, 1361). To date, however, such studies have not been forthcoming. Most research has been focused on substantive applications, such as the efficacy of weak ties in job search efforts (Granovetter, b; Lin et al., b) or in the integration of scientific communities (Friedkin). None of this research, to our knowledge, has empirically studied Granovetter's provisional definition of tie strength. Instead, it has followed his intuitive lead, relying on single indicators of strength without examining their quality or their convergence with other indicators.

The most common tactic used to measure tie strength has been to use indications of the "closeness" of a relationship; thus, close friends have been said to be "strong" ties, while acquaintances or friends of friends have been called "weak" ties (Erickson et al.; Granovetter, b; Lin and Dumin; Murray et al.). Sometimes this approach to measurement is combined with one that presumes that the source of a relationship is an accurate indication of its strength; often, therefore, relatives are assumed to be strong ties, while neighbors or co-workers are treated as weak ones.

Numerous other measures of strength have also been used or pro-

posed. These include frequency of contact (Granovetter, b; Lin et al., a), with strong ties assumed to be more frequent ones; and (in research conducted in closed populations, where perceived relationships are studied from both sides) by mutual acknowledgement of contact (Friedkin), with strong ties assumed to be those acknowledged by both parties. Other plausible indicators of tie strength include the extent of multiplexity within a tie (noted by Granovetter, a, 1361), the duration of the contact, the provision of emotional support and aid within the relationship (Wellman), the social homogeneity of those joined by a tie (indexed in terms of occupational status by Lin et al., b), the overlap of memberships in organizations between the parties to a tie, and (for closed populations) the overlap of social circles (Alba and Kadushin). The latter three measures are of particular appeal because they index directly the extent to which a tie provides access to diverse rather than homogeneous others—that is, the extent to which a tie provides *range* in an egocentric network (Burt, b)—and it is the provision of range on which much of Granovetter's argument about the value of weak ties is founded.

This variety of measures indicates that tie strength is at least a sensitizing concept that squares with the intuitions of many researchers. What is not yet clear is whether these intuitions refer to one concept or to several. In the following sections we will address this question by operationalizing tie strength, as nearly as possible, in terms of Granovetter's proposed indicators, using multiple indicator methods to assess the quality of these measures. We will begin by describing the data to be analyzed, and the measurements of strength available in those data.

Data

The data for our analysis are drawn from three cross-sectional surveys. Two of these were conducted in American cities, while the third took place in a small city in the Federal Republic of Germany. In all three studies, respondents were asked to identify their three closest friends, to report characteristics of these persons (age, occupation, religion, and so on), and to describe various features of these relationships. Of course, respondents also provided information on their own socioeconomic and demographic characteristics. The fact that these studies contain multiple measures of tie strength for large numbers of relationships makes them suitable to our objectives for this paper.

The first survey we will analyze is the 1965–66 Detroit Area Study, which has been analyzed previously by Laumann, Verbrugge, and Fischer et al. This study drew a multistage probability sample of 1,013 native-born white males in the Detroit metropolitan area, and therefore yields data on up to 3,039 relationships (for further details, see Schuman). The second

survey was conducted in late 1974 and early 1975 in Aurora, Illinois, then a city of 80,000 residents. In the Aurora study, a multistage probability sample of 496 noninstitutionalized adults (and therefore, potentially 1,488 relationships) was drawn; this sample did not include restrictions on the race or sex of respondents (for further details, see Marsden and Laumann). The third survey was conducted during 1971 in the West German community of Altneustadt (a pseudonym), then a city of about 20,000 persons. The Altneustadt survey interviewed a systematic sample of 820 drawn from the eligible voters of the city, with no restrictions on sex; it therefore provides data on up to 2,460 relationships (for additional details, see Verbrugge).

None of the three studies analyzed has a simple random sampling design for the selection of respondents. Moreover, the designs cluster-sample relationships in groups of three within respondents. These considerations mean that these samples of ties are considerably less efficient than simple random samples of the same size. To roughly adjust for this, we have proceeded as if our available numbers of cases were half the actual numbers of relationships.

The main limitation of these three studies, for present purposes, is that they focus on the three closest contacts of each respondent. This means, of course, that the studies have oversampled comparatively strong ties. We do not think that this limitation is so severe as to call the usefulness of these data into question. Although the sampled relationships in these studies are drawn from the "strong" end of any presumed continuum of tie strength, they nonetheless vary considerably as far as the available measures of tie strength are concerned (see, e.g., the standard deviations in Table 1 below). The variability in strength might be less than ideal in these studies, but it should be sufficient to permit indications of the extent to which different measures covary with one another to emerge. If there were greater variability, correlations among measures could be expected to be larger, and evaluations of the quality of measures correspondingly higher; in this sense, the results to be presented provide conservative evaluations.

Measures

Two types of variables are included in the measurement models we have formulated: *indicators* and *predictors* of tie strength. While previous researchers have not always differentiated between the two, the distinction is an important one. Indicators are actual components of tie strength; those used in this study correspond to Granovetter's definition of tie strength given above. "Closeness" is used as a measure of the intensity of a relationship; duration and frequency of contact index the amount of time

Table 1. CORRELATIONS,* MEANS, AND STANDARD DEVIATIONS OF VARIABLES: DETROIT, AURORA, AND ALTNEUSTADT

	Correlations								
	Closeness	Duration	Frequency	Neighbor	Co-worker	Overlap	Kinship**	Prestige Difference	Educational Difference
A. Detroit (N = 1,415)* **									
Closeness	1.000								
Duration	0.308	1.000							
Frequency	0.147	-0.099	1.000						
Neighbor	-0.023	-0.063	0.302	1.000					
Co-worker	-0.130	-0.249	-0.056	-0.137	1.000				
Overlap	0.003	-0.033	0.112	0.052	0.099	1.000			
Kinship**	0.116	0.186	0.086	0.036	-0.109	-0.064	1.000		
Prestige difference	0.022	0.050	0.029	0.051	-0.206	-0.073	0.086	1.000	
Educational difference	-0.031	-0.022	0.014	0.042	-0.082	-0.033	0.119	0.130	1.000
Mean	2.483	0.006	4.013	0.426	0.304	0.237	0.155	10.194	2.380
Std. Dev.	0.591	0.805	1.593	0.495	0.460	0.527	0.362	9.571	2.753
B. Aurora (N = 719)†									
Closeness	1.000								
Duration	0.238	1.000							
Frequency	0.264	-0.099	1.000						
Neighbor	-0.133	-0.030	0.189	1.000					
Co-worker	-0.191	-0.198	0.052	-0.038	1.000				
Overlap	0.053	0.024	0.040	0.163	0.074	1.000			
Kinship	0.208	0.465	0.016	-0.058	-0.180	-0.035	1.000		
Prestige difference	0.093	0.044	-0.027	-0.024	-0.259	-0.036	0.033	1.000	
Mean	2.674	-0.003	3.768	0.348	0.173	0.138	0.225	14.935	
Std. Dev.	0.520	0.978	1.215	0.477	0.379	0.410	0.417	14.912	

	Closeness	Duration	Frequency	Topics	Confiding	Neighbor	Co-worker	Kinship	Difference
				C. Altneustadt (N = 895)‡					
Closeness	1.000								
Duration	0.298	1.000							
Frequency	0.099	-0.119	1.000						
Topics	0.281	0.078	0.153	1.000					
Confiding	0.277	0.092	0.178	0.332	1.000				
Neighbor	-0.095	-0.174	0.445	0.015	0.002	1.000			
Co-worker	-0.133	-0.165	0.006	0.069	0.056	0.018	1.000		
Kinship	0.306	0.448	-0.012	0.087	0.018	-0.182	-0.153	1.000	
Prestige difference	0.007	0.006	-0.065	0.024	0.031	0.014	-0.121	0.047	1.000
Mean	2.187	-0.022	3.582	2.125	1.183	0.605	0.117	0.229	11.236
Std. Dev.	0.737	0.873	1.177	1.456	1.169	0.489	0.322	0.420	10.813

*Correlation matrices reported contain a mixture of Pearson, polyserial, and polychoric correlations (see Ollson; Ollson et al.). In computing these correlations, all predictor variables were treated as metric variables, whether measured in categories or not. Indicator variables Closeness, Frequency, Topics, and confiding were treated as ordered categorical variables.

**Correlations involving kinship for Detroit are based only on cases for which there was no revision in the list of friends (see note 1).

***No measure of Topics or Confiding is available in the Detroit data.

†No measure of Topics, Confiding, or Educational Difference is available in the Aurora data.

‡No measure of Overlap or Educational Difference is available in the Altneustadt data.

spent in a tie; and (in the Altneustadt study) measures of the breadth of topics discussed by friends and the extent of mutual confiding are used to represent intimacy. Unfortunately, no measure is available in any of the three surveys for Granovetter's fourth dimension, the provision of reciprocal support services (but see Wellman).

Predictors are aspects of relationships that are related to, but not components of, tie strength. Several of the predictors of tie strength used in this research reflect Feld's hypothesis that ties are formed in the context of joint activities organized, or focused, around elements of the social environment. Kinship, neighbor and co-worker statuses, and overlapping organizational memberships are predictors of tie strength which represent foci on which a tie may be centered. Other predictors used are indices of the social distance bridged by a tie; our motivation in including these is the notion that weak ties should cover considerable social distance, while strong ones should connect socially homogeneous persons (Granovetter, c; Lin and Dumin). As measures of social distance or (lack of) social homogeneity, we have used respondent-friend absolute differences in occupational prestige and (in Detroit) years of education. By using these predictors in our measurement models, we obtain the opportunity to construct-validate the measures of tie strength on the basis of direct indicators of strength; we can also inquire whether the indicators, as measures of strength, are contaminated by the predictors.

Closeness is measured as a trichotomy in all three studies; respondents indicated whether each friend named was an acquaintance (coded 1), a good friend (2), or a very close friend (3). Two measures of the *amount of time spent in the relationship were available in these studies:* frequency of contact outside of work and duration. Frequency of contact is measured in five or six ordered categories, with possible responses ranging from "rarely" to "more than once a week." We have postulated that returns (in terms of tie strength) to increased duration of a relationship decline with increasing length of acquaintance; for this reason, we used the natural logarithm of years of acquaintance to index duration. Also, there are obvious constraints on opportunities to have lengthy relationships that result from age differences among respondents and friends (i.e., age places an upper bound on the potential duration of friendships). To control for these, we used residuals from the regression of the logarithm of duration on the logarithms of respondent's and friend's ages as our measure of duration.

Two other indicators of tie strength are available only in the Altneustadt data. One is a measure of the breadth of discussions that occur between respondent and friend. This was formed by summing reports of whether each of six topics (family, friends, politics, local events, work, and leisure) was discussed in a relationship. Work and leisure were the most commonly discussed of the six topics, so this measure tends to take high

values when the more intimate and less commonly discussed matters of friends, family, and politics were covered by a friendship pair. The final measure of strength in Altneustadt refers to mutual confiding. Respondents were asked to indicate the friends they confided in about personal problems as well as those who confided in them, and also to report the friends they consulted for advice about voting as well as those who consulted them on this matter. High scores on the confiding measure are given to those pairs in which there was mutual consultation concerning both personal problems and voting.

Three of the predictor variables used were measured as dichotomous variables: kinship, co-worker, and neighbor statuses (in all three cases, a code of "1" indicates that the named friend held the status under consideration, while a code of "0" means that the status is not a potential focus for the relationship). The questions eliciting information regarding kinship were quite similar;[1] information about co-worker status was comparable across all three surveys. In Altneustadt, respondents were asked whether the named friend lived in Altneustadt, its near environs, or far away; there was no possible "in the neighborhood" response as in the Aurora and Detroit surveys. This discrepancy in question wording is not particularly problematic, in that Altneustadt was a city of only 20,000, comparable in size to many urban neighborhoods. It is therefore plausible to treat, as we have, any friend living in Altneustadt as a "neighbor."

Another focus for the organization of social ties, suggested by Feld, is membership in voluntary organizations. For the Detroit and Aurora respondents and friends, information on membership in voluntary organizations was available on 15 and 42 types of organizations, respectively. Our measure of overlapping membership is simply the number of organizations in which both the respondent and the named friend were members. No data on memberships of friends were available from the Altneustadt survey, so we were unable to construct a measure of overlapping memberships there.

Our measures of social distance are absolute difference scores involving respondent's and friend's occupational prestige and (in Detroit) years of education. For Detroit and Aurora, we used the Hodge, Siegel, and Rossi scale of occupational prestige (see Ornstein), while for Altneustadt we assigned scores from Treiman's Standard International Occupational Prestige Scale.[2]

Table 1 contains the correlations, means, and standard deviations for all measures used in each of the three data sets. Respondents who could not name any friends were excluded entirely, as were those who did not know the answer to or who did not respond to any of the pertinent questions. We have treated the ordinal measures of closeness, duration, topics, and confiding as categorical realizations of underlying continuous, normally distributed variables, and computed polychoric and

polyserial correlations (see Olsson; Olsson et al.) as appropriate; the matrices in Table 1 therefore contain mixtures of Pearson, polychoric, and polyserial correlations, as duration and all predictors were treated as metric variables.[3]

The Measurement Model

Our initial model for measuring tie strength posits that strength is a unidimensional unobserved concept or "point variable" intervening between its predictors (neighbor, co-worker, and kinship statuses, overlapping organizational memberships, and measures of social distance), and its indicators (closeness, duration, frequency, breadth of discussion topics, and confiding). Thus, the model asserts that strength is a common factor underlying the indicators, and it partitions the variance in each indicator into a common portion (shared with strength and the remaining indicators) and an indicator-specific portion. The model further asserts that all correlations between the predictors and the indicators are explained by the intervening concept of tie strength.

More formally, the measurement model specifies that each indicator of strength is a linear function of the unobserved concept:

$$\begin{aligned} X_1 &= \lambda_{11}Y_1 + \varepsilon_1 \\ X_2 &= \lambda_{21}Y_1 + \varepsilon_2 \\ X_3 &= \lambda_{31}Y_1 + \varepsilon_3 \\ X_4 &= \lambda_{41}Y_1 + \varepsilon_4 \\ X_5 &= \lambda_{51}Y_1 + \varepsilon_5 \end{aligned} \tag{1}$$

where the $\{\lambda_{i1}\}$, $i = 1, 2, 3, 4, 5$ are regression coefficients of the indicators on strength; X_1 is closeness; X_2 is duration; X_3 is frequency; X_4 is breadth of discussion; X_5 is mutual confiding; Y_1 is tie strength; and the $\{\varepsilon_j\}$, $j = 1, 2, 3, 4, 5$ are indicator-specific portions of the corresponding X-variables. It is assumed that all X- and Y-variables are standardized and that ε-variables have expectations of zero; therefore constants can be suppressed. We begin with the assumption that indicator-specific factors are independent of one another, that is,

$$E[\varepsilon_i\varepsilon_j] = 0,\ i \neq j. \tag{2}$$

In addition to the measurement model of equations (1) and (2), we include a structural equation model for determining strength in terms of its predictors; this model serves to construct-validate the measure Y_1 based on (1) and (2). The structural equation model specifies that strength is a linear function of the predictors that we have measured:

$$Y_1 = \sum_{i=2}^{7} \beta_{1i} Y_i + u_1, \tag{3}$$

where the $\{\beta_{1i}\}$, $i = 2, 3, 4, 5, 6, 7$, are regression parameters; Y_2, Y_3, and Y_5 are neighbor, co-worker, and kinship statuses, respectively; Y_4 is the number of memberships in organizations shared between respondent and friend; Y_6 is the absolute difference in occupational prestige between respondent and friend; Y_7 is the absolute difference in years of education between respondent and friend; and u_1 is a disturbance term assumed to exhibit the usual properties. The initial model asserts that the indicators $\{X_i\}$ are independent of the predictors $\{X_j\}$ given strength, that is,

$$\lambda_{ij} = 0, i = 1, \ldots, 5; j = 2, \ldots, 7. \tag{4}$$

The initial measurement model is depicted diagrammatically in Figure 1A. We expect that all five parameters $\{\lambda_{i1}\}$, for the relationships between strength and its indicators, will be positive. If the measure of strength is a valid one, then we should expect that it will be negatively related to the foci of neighborhood and workplace; therefore we anticipate that β_{12} and β_{13} will be negative. In contrast, we expect that β_{14} and β_{15} will be positive: relationships formed within the context of kinship or those that are accompanied by numerous overlapping memberships in organizations should prove to be comparatively strong ties. If social homogeneity produces stronger ties, then β_{16} and β_{17} should be negative; greater discrepancies in occupational prestige or education should be associated with comparatively weak ties.

The model for measuring tie strength outlined above need not, of course, correspond to the data. Three types of problems seem especially plausible (see Costner and Schoenberg). First, assumption (2) may be violated, implying that specific components of indicators are correlated with one another. This possibility is illustrated in Figure 1B, where θ_{23} represents the covariance of specific components of duration (X_2) and frequency (X_3).

A second possibility is that assumption (4) may be violated; this would imply that indicators of strength are contaminated by predictors. In Figure 1B, the presence of λ_{32} reflects contamination of frequency (X_3) as a measure of strength by neighboring (Y_2). If, for instance, λ_{32} is positive, it is implied that neighboring and frequency of contact are more positively correlated than one would expect on the basis of the indirect effect of neighboring on frequency through strength, and therefore that the intervening variable of strength only partially accounts for the correlation between predictor and indicator.

The most involved failure of the model of equations (1)–(4) occurs when there are two (or more) dimensions of tie strength, rather than only

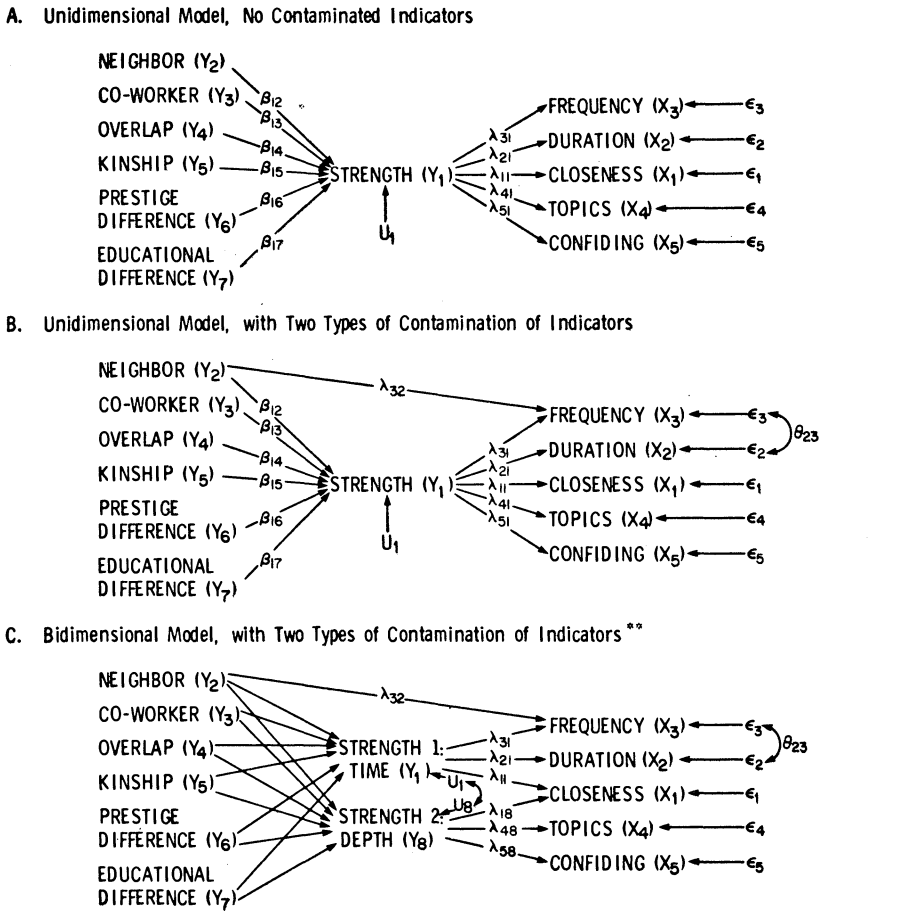

Figure 1. MEASUREMENT MODELS FOR TIE STRENGTH*

*Lines without symbols have fixed coefficients of 1.0. Curved lines symbolizing relationships among predictors are omitted for clarity.

**In this figure, β parameters from predictors to measures of strength have been omitted for clarity.

one. In this case, illustrated in Figure 1C, it is necessary to introduce a second intervening unobserved variable, here symbolized Y_8. Some indicators of strength (e.g., duration, frequency, topics, confiding) may depend directly on only one of the intervening variables, while others (e.g., closeness) may depend on both. It is necessary to include an equation like (3) for relationships between the predictors and additional dimensions of strength. The dimensions of strength may be correlated, as the association of u_1 and u_2 in Figure 1C indicates. Of course, the first two failures of the model—regarding inaccuracy of assumptions (2) and (4)—may also occur

in a model with multiple dimensions of strength, and Figure 1C illustrates these possibilities.

Results

Through inspection of the correlation matrices in Table 1, it immediately becomes apparent that the model defined by equations (1)–(4) will not fit the data without modification. To see this, note that for the model to be adequate, two conditions must be fulfilled (see Burt, a). First, the indicators (X_1–X_5) of strength must be positively related to one another. Second, the indicators of strength must exhibit proportional correlations with the predictors. Moreover, the correlations of indicators with predictors must generally be smaller than the correlations of indicators with one another; otherwise, we run the risk of confounding the interpretation of the unobserved variable for strength (Burt, a).

Clearly, these conditions are not fulfilled by the correlation matrices in Table 1. Note first that the indicators duration (X_2) and frequency (X_3) are negatively correlated in all three samples. This suggests that the indicator-specific components of these variables are negatively correlated (i.e., $\theta_{32} < 0$); that is, net of strength, long friendships tend to involve less frequent contacts between persons. Next, note that neighboring (a predictor) and frequency of contact exhibit a moderate positive correlation in all three cities, while we would have anticipated a negative one on the basis of our expectations that neighbors tend to be weakly tied ($\beta_{12} < 0$) and that frequency is an indicator of strength ($\lambda_{31} > 0$). The positive correlation of neighboring and frequency, in fact, is larger than many of the intercorrelations of measures of strength. These results imply that frequency, as a measure of strength, is contaminated by neighboring (i.e., $\lambda_{32} > 0$); that is, that net of strength, neighbors tend to see one another more frequently than non-neighbors. Similar observations lead to a conclusion that duration is contaminated by kinship in the Aurora and Altneustadt samples; the correlations of kinship and duration exceed all interindicator correlations there. This means that, net of strength, relationships focused by kinship tend to be longer ones (i.e., $\lambda_{25} > 0$).

In formulating our final measurement models, we took these and other (sample-specific) sources of lack of fit of the original model into account. For example, we found that in Altneustadt, the indicator-specific portions of frequency and breadth of discussion were positively related (i.e., $\theta_{43} > 0$); this is not surprising in that the measure of discussion is based in part on reports of the frequency with which friends converse about the different topics.

With the Altneustadt data, where there are five indicators of strength rather than three, our efforts to isolate a unidimensional measure

of strength failed, even after numerous violations of assumptions (2) and (4) were taken into account. Inspection of the data suggested that, for this city, two empirically distinguishable dimensions of tie strength are present. The first refers to the time spent in the relationship, and is indicated by duration and frequency; the second refers to the depth of the relationship and is indicated by mutual confiding and the breadth of discussion topics covered by friends. Closeness, the measure of intensity, is a "general" indicator in that it is directly related to both dimensions of tie strength, as diagrammed in Figure 1C.

Using the matrices of correlations in Table 1 as input, several models were estimated by the maximum likelihood routine implemented in LISREL V (Jöreskog and Sörbom). The estimates obtained for the final models are presented in Table 2. These models correspond closely to the data; the associated X^2 statistics are: for Detroit, 3.54 with 8 degrees of freedom; for Aurora, 2.44 with 6. d.f.; and for Altneustadt, 13.14 with 9 d.f.[4]

The $\{\lambda_{i1}\}$and $\{\lambda_{i8}\}$ parameters reported in panel A of Table 2 allow us to assess the relative importance of the indicators as measures of strength. These parameters give the results of the regressions of the indicators on tie strength, controlling for relevant predictors. As expected, all the indicators are positively related to tie strength. In the Detroit data, duration is by far the strongest indicator of strength ($\hat{\lambda}_{21} = 0.744$), while frequency and closeness bear similar relationships to the unobserved construct ($\hat{\lambda}_{31} = 0.382$; $\hat{\lambda}_{11} = 0.420$). In Aurora, closeness has by far the strongest relationship to tie strength ($\hat{\lambda}_{11} = 1.0$).[5] Frequency is the second strongest indicator in the data for that city ($\hat{\lambda}_{31} = 0.319$).

As mentioned above, two dimensions of strength appear in Altneustadt. The first dimension resembles the measures of strength located for Detroit and Aurora, in that it involves measures of intensity (closeness) and time spent (duration and frequency) in a relationship. We have termed this a "time" dimension of strength. Closeness is most strongly related to this construct ($\hat{\lambda}_{11} = 0.518$), followed by duration and frequency. The second dimension of strength is associated with both intimacy ($\hat{\lambda}_{18} = 0.296$) and measures of mutual confiding ($\hat{\lambda}_{48} = 0.577$; $\hat{\lambda}_{58} = 0.569$); we have termed this a "depth" dimension of strength.[6]

Inspection of the Θ matrices presented in panel B of Table 2 and further examination of the Λ matrices in panel A provide additional insights into the quality of the indicators. The results for Detroit show that duration, there the strongest indicator of tie strength, is contaminated in that the indicator-specific portion of its variance covaries strongly with that of frequency ($\theta_{32} = -0.333$). Frequency is contaminated by three predictors there ($\lambda_{32} = 0.340$; $\lambda_{33} = 0.106$; $\lambda_{34} = 0.096$). Closeness, however, is conditionally independent of all predictors, given strength; more-

Table 2. ESTIMATED PARAMETERS FOR MEASUREMENT MODELS OF TIE STRENGTH: DETROIT, AURORA, AND ALTNEUSTADT

A. Standardized coefficients for regression of indicators of tie strength on strength and foci for relationship (λ parameters)

1. Detroit:

	Regressor						
Indicator	Strength	Neighbor	Co-worker	Overlap	Kinship	Prestige Difference	Educational Difference
Closeness	0.420	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Duration	0.744	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Frequency	0.382	0.340	0.106	0.096	0.000*	0.000*	0.000*

2. Aurora:

	Regressor					
Indicator	Strength	Neighbor	Co-worker	Overlap	Kinship	Prestige Difference
Closeness	1.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Duration	0.133	0.000*	-0.097	0.000*	0.418	0.000*
Frequency	0.319	0.237	0.122	0.000*	0.000*	0.000*

3. Altneustadt:

	Regressor					
	Strength					Prestige
Indicator	Time	Depth	Neighbor	Co-worker	Kinship	Difference
Closeness	0.518	0.296	0.000*	0.000*	0.000*	0.000*
Duration	0.385	0.000*	0.000*	0.000*	0.242	0.000*
Frequency	0.187	0.000*	0.486	0.000*	0.000*	-0.070
Topics	0.000*	0.577	0.000*	0.000*	0.000*	0.000*
Confiding	0.000*	0.569	0.000*	0.000*	0.000*	0.000*

B. Variances and covariances of indicator-specific components (θ parameters)

1. Detroit:

	Indicator		
Indicator	Closeness	Duration	Frequency
Closeness	0.824		
Duration	0.000*	0.446	
Frequency	0.000*	-0.333	0.770

2. Aurora:

	Indicator		
Indicator	Closeness	Duration	Frequency
Closeness	0.000*		
Duration	0.000*	0.754	
Frequency	0.000*	-0.138	0.865

3. Altneustadt:

	Indicator				
Indicator	Closeness	Duration	Frequency	Topics	Confiding
Closeness	0.534				
Duration	0.000*	0.693			
Frequency	0.000*	-0.126	0.765		
Topics	0.000*	0.000*	0.092	0.664	
Confiding	0.000*	0.000*	0.132	0.000*	0.673

Table 2. (cont'd)

C. Standardized coefficients for regression of tie strength on foci for relationships (β parameters)

	Regression Coefficient for Strength in...			
Predictor	Detroit	Aurora	Altneustadt	
			Time	Depth
Neighbor	-0.131	-0.144	-0.151	0.047
Co-worker	-0.331	-0.160	-0.230	0.119
Overlap	0.015	0.096	***	***
Kinship	0.227	0.172	0.467	0.123
Prestige difference	0.003	0.046	-0.061	0.056
Educational difference	-0.068	**	***	***
R^2	0.178	0.095	0.351	0.027

*Marks fixed parameter.
**Predictor variable not available in Aurora data.
***Predictor variable not available in Altneustadt data.

over, its indicator-specific component is uncorrelated with those of the other indicators.

Similar conclusions about indicator quality are reached from more detailed consideration of the Θ and Λ matrices from the Aurora and Altneustadt models. Closeness, as an indicator of tie strength, has three desirable characteristics in both of these data sets. First, as noted above, it is the strongest indicator of tie strength in Aurora, and is related to both dimensions of strength in Altneustadt. Second, the indicator-specific factors corresponding to closeness are independent of those for the other indicators (see θ parameters). Finally, closeness is conditionally independent, given strength, of all predictors in both models; that is, all the effects of neighbor, co-worker, and kinship statuses, occupational prestige differences, and (in Aurora) overlapping memberships on closeness are mediated by tie strength.

Duration is contaminated by kinship in both Aurora and Altneustadt, and by co-worker status in Aurora. In both places, frequency is strongly affected, net of strength, by neighboring; it is also contaminated by co-worker status in Aurora and by differences in prestige in Altneustadt. Furthermore, indicator-specific components of frequency are correlated with those of duration in both cities. In fact, in Altneustadt, indicator-specific components of frequency are associated with all other indicator-specific factors *except* that for closeness.

The general conclusion we reach is that while duration has a λ coefficient of greater magnitude than that for closeness in the Detroit data, the contamination of duration and frequency by predictors and by one an-

other casts doubt on the quality of either as an indicator of tie strength. Closeness, on the other hand, is free of contamination in all three data sets, and is the indicator most highly associated with strength in Aurora and the time dimension of strength in Altneustadt. Overall, then, we conclude that closeness (the measure of the emotional intensity of a tie) is the best indicator of tie strength among those available to us. This is a somewhat comforting result, in that (as noted above) closeness measures are those that have most often been used as single indicators of strength in previous research.

Panel C of Table 2 reports the estimates of the β parameters, included in our model for purposes of construct-validating the measure(s) of tie strength. We anticipated that the β parameters linking neighbor and co-worker statuses to strength would be negative; we expected positive estimates for β_{14} and β_{15}, which respectively represent the relationships to tie strength of overlapping memberships and kinship, and negative estimates for β_{16} and β_{17}.

Inspection of panel C reveals that, for the most part, these expectations are confirmed, though discussion of the results is complicated by the presence of the second dimension of strength for Altneustadt. If, however, we examine the results for Detroit, Aurora, and the first Altneustadt dimension, we see that the only results contrary to expectation are the negligible link between overlapping memberships and strength in Detroit, and the negligible coefficients involving occupational prestige differences in Detroit and Aurora. Neighbor and co-worker statuses are consistently negatively related to strength; kinship has a positive relationship; and shared memberships have the expected positive effect in Aurora. These results, together with the consistently positive relationships between tie strength and its indicators, suggest that the measure of strength is indeed a valid one, though some indicators, especially frequency, are quite problematic.

Some comments concerning the second, "depth," dimension of strength are in order. First, this dimension is very poorly predicted; less than 3 percent of its variance is accounted for by the four predictors available in Altneustadt. Second, all predictors bear positive relationships to the depth dimension; this, plausibly enough, means that depth of a relationship increases when foci are shared, but that depth paradoxically rises with differences in occupational prestige. A third point is that the two dimensions of strength are quite distinct empirically: overall, they are correlated at a level of only 0.358.[7] Clearly, this dimension of strength is quite different from the ones found in Detroit and Aurora, and from the first one in Altneustadt; it remains to be seen whether both dimensions will be useful in empirical research.

To summarize the results of our analyses, we present the standardized factor scoring coefficients for the concept of tie strength in Table 3.

Table 3. STANDARDIZED FACTOR SCORING COEFFICIENTS FOR PREDICTING STRENGTH

	Factor Scoring Coefficient in . . .			
			Altneustadt	
Predictor	Detroit	Aurora	Time	Depth
Closeness	0.117	1.000	0.409	0.298
Duration	0.691	-0.000	0.233	0.023
Frequency	0.412	0.000	0.121	-0.088
Topics	*	**	0.042	0.376
Confiding	*	**	0.035	0.373
Neighbor	-0.176	-0.000	-0.168	0.088
Co-worker	-0.136	0.000	-0.175	0.092
Overlap	-0.036	0.000	***	***
Kinship	0.064	0.000	0.239	-0.014
Prestige difference	0.000	0.000	-0.042	0.029
Educational difference	-0.019	**	***	***

*Predictor variable not available in Detroit data.
**Predictor variable not available in Aurora data.
***Predictor variable not available in Altneustadt data.

These coefficients provide weights for constructing a linear combination of all indicators and all predictors that is designed to estimate optimally the values of each unobserved construct, and they therefore provide tentative answers to Granovetter's open question concerning the relative importance of different components of the concept of tie strength. For the most part, differences in the factor scoring coefficients reflect differences in the magnitudes of λ and β parameters that have already been discussed; notable, however, is the point that indicators such as closeness, duration, and discussion are preferable to predictors for purposes of estimating values for tie strength.

Conclusions

The results we have presented lead, as we have mentioned, to one fairly clear conclusion: a measure of "closeness," or the emotional intensity of a relationship, is on balance the best indicator of the concept of tie strength among those available to us. This measure is free of contamination by other indicators and predictors in all three samples. It is the indicator most strongly related to strength in Aurora, and the one most strongly related to the time dimension of strength in Altneustadt—which is the dimension related to predictor variables in the manner anticipated. Moreover, in Alt-

neustadt, closeness is seen to be a general indicator in that it bears a direct relationship to both of the unobserved constructs isolated.

These considerations lead us to recommend that effort be devoted to obtaining better measures of intensity. Future studies should consider using more finely graded measures of intensity than those in the studies analyzed here. Furthermore, multiple measures of the intensity of a tie may prove useful.

We are less optimistic about the other indicators of tie strength examined. Breadth of discussion topics and mutual confiding could be studied only in Altneustadt. We found that, though these indicators are comparatively free of contamination, they are related to a "depth" construct which has little to do with foci and other characteristics of relationships thought to affect tie strength. Moreover, some of these predictors are related to the depth dimension in unanticipated ways. Since measures like topics and confiding have not been employed in empirical research using the tie strength concept, it remains to be seen whether they will prove useful; on the basis of what we know now, we prefer intensity or closeness.

We found that the two measures having to do with the time spent in a relationship—duration and frequency of contact—were badly contaminated by measures of foci around which ties may be organized. In particular, the use of frequency as a measure of strength will tend systematically to overestimate the strength of ties between persons who are neighbors or co-workers, while the use of duration as a measure of strength will overestimate the strength of ties between relatives. For this reason we would suggest that these indicators be avoided in favor of closeness; if this is impossible, we would recommend that they be adjusted for the biases due to foci that we have mentioned before they are used as indices for strength.

Our final point concerns the possibility of using predictors themselves to form a proxy for tie strength. The results given in panel C of Table 2 show that assumptions that kinship-based ties are stronger, while ties to neighbors or co-workers are weaker, are accurate ones. Those results also show, though, that the combined ability of the predictors to account for strength is limited; coefficients of determination (R^2) range from 0.095 (Aurora) to 0.351 (for the first dimension in Altneustadt). This means that while an index of strength based on an intuitive coding of foci for a relationship and other predictors will be positively correlated with strength, such a correlation is unlikely to exceed 0.6, and may be substantially lower than this figure. We are led, then, to argue that such indices should, where possible, be avoided in favor of direct measures of strength—especially closeness.

Notes

1. Some problems, however, are presented by the Detroit data on kinship. The question on kinship for Detroit (Laumann, 264) was followed by instructions to interviewers that any brothers or brothers-in-law were to be excluded from the lists of friends and replaced by additional friends. Thus, the data for Detroit include two sets of kinship information and an indication of whether each list of friends was revised. Both sets of kinship information, however, contain substantial numbers of brothers and brothers-in-law, indicating that many revisions in lists were not made correctly. Moreover, we found that correlations involving kinship based on unrevised lists were substantially different from those based on revised lists; correlations involving variables other than kinship were quite similar for revised and unrevised lists of friends. The correlations from revised lists involving kinship were nearly random. Our conclusion is that, for whatever reasons, revisions in lists of friends were incorrectly recorded. To deal with this problem, we have reported correlations for kinship based on only those cases in which lists of friends were not revised.
2. For respondents lacking occupations (e.g., housewives, retired persons), we used data on the spouse's occupation when available, and assigned a mean value otherwise.
3. We also conducted all analyses using matrices containing Pearson correlations only, and these analyses lead to the same conclusions as those based on analyses of the matrices reported in Table 1.
4. We have not presented probability levels associated with these statistics because of uncertainty as to the actual efficiency of the sampling schemes (see discussion in the text), and also because the standard theory used for assigning probability levels does not apply when a matrix including polychoric and polyserial correlations is analyzed (see Jöreskog and Sörbom). Since, however, the X^2 values reported are close to or less than their associated degrees of freedom, it is clear that the models correspond closely to the data.
5. Initial efforts to fit the Aurora model produced an inadmissible negative variance for ε_1, the indicator-specific portion of closeness. For this reason, we fixed this variance at the extremal value of zero.
6. Edward Laumann suggests to us, in personal communication, that the presence of two dimensions of strength in Altneustadt may reflect the fact that there are two forms of address for friends in German (see Dahrendorf, 56). The *Du* form of address is used with especially close intimates, generally contacts dating from one's childhood, while the *Sie* form of address is used with other persons. Since we lack data on discussion topics and mutual confiding in Aurora and Detroit, we cannot judge at present whether our results are general or culturally specific. For a discussion of meanings of friendship in an American setting, see Fischer.
7. This correlation concerns the conceptual portion of strength only; it does not involve indicator-specific components of indicators or errors of measurement.

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