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Evaluating Social Influence Relations: An Item-Response-Modeling Approach

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Abstract

Subject of this paper is the measurement of social influence in social networks. The theoretical point of departure is twofold. First, focus is on cognitive processing of perceived influence. Second, three distinct dimensions of social influence are considered: persuasion, authority and coercion. Combining these considerations with Item Response Theory methods, questionnaire-type measurement instruments are proposed. These instruments are employed in a closed network case study where applicability is checked by means of network autocorrelation models.

1 Introduction

Measurement of social influence in closed networks has a long tradition which can be traced back to French's "Formal Theory of Social Power" (French, 1956). French and Raven's (1959) considerations on "The Bases of Social Power" in a follow-up paper have become classics in modern social psychology. The question of how to model influence weights was also put forward before the background of network autocorrelation modeling. In this case the answers were prominently based on considerations about structural features of the network in focus (cf. Friedkin, 1998; Leenders, 2002).

In this paper we want to contribute to answering this question by proposing a new device for measuring social influence relations. We will base our causal considerations on theories from the fields of cognitive and social psychology and rely on item response theory as inference structure of the measurement instrument. The latter methods are very popular in educational assessment and have already been successfully applied to the subject of social capital by (van der Gaag and Snijders, 2005).

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Item response methods are well suited for the task of inferring the intensity of latent properties, since they explicitly incorporate assumptions on the difficulty of observed items. This is especially desirable for the case of measures of social influence which may primarily be used to simulate influence propagation in social networks since inaccuracies accumulate during the process of simulation. Our proposed instrument for measuring social influence relations therefore tries to take advantage of a sophisticated combination of causal theory and inference method in order to control and mitigate the associated amount of measurement inaccuracy.

The paper is organized as follows: In the second section, we will discuss and revise the psychological theory which frames our measurement approach. In the third section, we will turn towards operationalization of the theory before the background of the measurement task and discuss the dimensions reflected in the total item pool. In the fourth section, we will discuss the structure of the employed item response measurement models. In the fifth section, we will report our procedure of instrument development. In the sixth section, we will discuss the final scales of the measurement model in detail. In the seventh section, we will apply the measurement model in a closed network setting, using a network autocorrelation model for validation. We will conclude the paper with a brief summary of results and a discussion.

2 Psychological theory

In this section we will discuss the theoretical framework of the measurement instrument. The two core aspects are the cognition of social influence and its causal modes.

2.1 Social influence and cognition

It is a prominent conception to view social influence as being “power in action”. Central to this conception is the idea that power is a more or less persistent relation between individuals, whose potential may be realized in certain situations. In this framework, power is based on the capacity of the powerful person to control the powerless person’s outcomes. However, there is discussion regarding the nature of the outcomes which are relevant for power processes (cf. Emerson, 1981; Festinger, 1950; French and Raven, 1959; Turner, 1991).

Despite the undoubted plausibility of this view, we want to conceptualize social influence in a different way. It seems to us that regardless of how strongly an influence relation is rooted in certain “bases of power”, its appreciation by the target person is a necessary condition for it to be effective. Therefore we would like to understand social influence as an instance of information processing rather than as an activity of “social forces”.

This approach promises several advantages, as compared to the relational model of power. The first advantage is that focusing on cognition allows us to build more elementary models of influence processes which highlight the causal assumptions held for the agents (viz. patients) of the influence system (cf. Schwenk, 2006). The second advantage refers to the fact that attributes of elementary entities are often measured more easily than those of compound entities.

We have discussed a cognitive model of social influence which is based on the idea of ecological rationality (cf. Gigerenzer et al., 1999) in more detail elsewhere (see Schwenk and Reimer, 2007, 2008), and only want to state a central assumption at this point. We assume that dyadic influence relations can be sensibly represented by a certain quantity which is attributed by the target person to the influence source. We expect such a quantity (it may be called the intensity of influence) to be key to the influence target's consideration of the source, respectively for integration of influence-related information provided by several sources. In essence, we will frame social influence as a decision process, based on social cues and their perceived validities.

In this paper we want to discuss a way to provide these ideas with operational content. Summarized, we will focus on measuring subjective evaluations of neighbor attributes in the respondent's network.

2.2 Modes of social influence

Of course it is plausible to assume more than one dimension of influence to be effective. However, before the background of a cognitive model of social influence it might not suffice to just focus on the different bases of power as French and Raven (1959) do in their well-known paper of the same name. The reason is that, in addition to power, we can imagine further neighbor attributes to be relevant for consideration and processing of communicated information.

Concerning the qualities of social influence processes, we will start our attempt to the subject with Turner's (2005) Three Process Theory of Power. Although we hold some reservations regarding this theory, it should be possible to clear them up, resulting in a viable approach to measuring social influence on the basis of a cognitive model.

Turner (2005) names three core "processes" of social influence: *persuasion*, *authority* and *coercion*. In combination, these clearly exceed the concept of power, which can be related to the latter process of coercion. We want to add that Turner is not explicit with regard to the cognitive structure of those processes. On behalf of our purposes, we will proceed by identifying the capability to induce them with our mentioned dimensions of influence sources.

Interestingly, Turner's combination can be seen as joining major traditions of social psychology and sociology. We will discuss this after a short excursion to

Turner's view on power, which presents his admitted motivation to pool the three mentioned "processes".

Turner (2005: 5) argues that traditional research, which defined power as the *potential to exercise influence,* has neglected the fact that power is exerted "through people" and not only "over people". Hereby is obviously meant that power is not only a feature of an exerting agent, but itself needs to be processed "through" compliant persons who, in the end, act upon a given environment. In order to account for varying degrees of voluntary compliance which may be present during the exercise of "power through others", Turner introduces the three mentioned modes of social influence. Obviously, coercion necessitates a lower amount of voluntary compliance, as compared to authority or even persuasion.

In our opinion, Turner's argumentation correctly refers to the aspect of processing of influence, but this could have been done more elegantly. The concept of "power through people" mixes the active and passive aspects of social influence. From the point of view of a cognitive approach, which focuses on consideration and the processing of influence, it is certainly possible to determine the receiving end respectively patient conditions under which an agent can exert influence. This renders a new concept of "power through people" unnecessary.

Furthermore, by replacing the phrase "power through others" with "power over volition and action", we might introduce a concept which also distinguishes between the three modes of influence on the basis of voluntary compliance. In our view, the attractiveness of such a concept would lie in the fact that it is both easily tractable and close to our personal experience.

Despite our criticism regarding the necessity of his new concept of power, we want to emphasize our position that Turner is convincingly right with his choice of what we like to call dimensions of social influence. We will sketch those subsequently with special attention to alternative derivations.

An obvious connection to Turner's previous work is made by referring *persuasion* to the self-categorization-theory of social influence (Turner, 1987). Here, social influence is identified as some kind of informational dependence, which is called "social reality validation". A person is expected to be receptive to influence when she is unable to exert full control over a given task. In such a situation she will tend to socially validate the nature of the task. The degree of receptiveness is assumed to depend on the perceived similarity of the influence source to the person in focus. The linking assumption is that influence sources which are perceived as similar (belonging to the same "*category*") should bear useful information for the task at hand.

It should be noted, that by concentrating on mere individuals we deliberately depart from the standard use of this theory, which focuses directly on group behavior.

Turner (2005: 11) defines *authority* analogous to what French and Raven (1959) call "legitimate power"; namely as "the power to control in-group members because they are persuaded that it is right for a certain person to control them in certain matters". As may be natural for a sociologist, the author would like to refer to Weber's (1984) classical and largely congruent concept of "legitimate order".

Coercion is defined by Turner (2005: 12) as being "the attempt to control a target against their will and self-interest through the deployment of human and material resources to constrain and manipulate their behavior". Again following Weber (1984), we might extend "against the target's will" towards "regardless of the target's will".

As noted before, Turner (2005: 15) identifies coercion as being the "pragmatic power process in standard theory". We basically agree with Turner in this point, but want to note that the degree to which a person may be voluntarily involved obviously depends on the type of outcome controlled by the powerful person.

3 Item wording

The theoretical background had to be operationalized in order to create a working measurement instrument. We attempted to express the above considerations in the form of a questionaire-type instrument. A common idea underlying all item wordings is that they should reflect our cognitive interpretation of Turner's theory and be situationally unspecific, in order to indicate persistent traits and allow broad application.

Evaluation of a contact's ability to persuade the respondent, as understood by self-categorization theory, was handled as an exception. As mentioned above, persuasion has been decomposed into two separate concepts: informational dependence and perceived similarity. Unfortunately the former is strongly situation specific. We therefore developed an IRT-scale only for the situationally unspecific aspect of perceived similarity. In application, its measures can be used as weights for a specially tailored evaluation of task- or situation specific informational dependence. The resulting product should yield a viable estimate of the perceived potential to persuade in the respective situation. In summary, the instruments subscales can be listed as follows:

- *Persuasion* is measured by two subscales:
  - *Perceived similarity* focuses on the perceived helpfulness of a contact person regarding own problem coping.
  - *Informational dependence* is supposed to be measured tailor-made to the application, because of its situational specificity.
- *Authority* focuses on the perception of rational and accepted authority of a contact person.
- *Coercion* focuses on a contact person's use of coercive means in everyday interaction.

During the pretest, the respondents were presented 58 items in total, with approximately a third of them representing the item pool for an individual item set. Items were selected according to the results of a quantitative item analysis. Items were both expected to show an acceptable fit and to form an item set with easily intelligible semantics. The items selected for the three subscales considered are listed in Table 1. Responses were allowed to range on a five point agreement scale

Table 1: English translation of selected items (which were originally presented in German). The mean responses indicate the difficulty structure of the respective item set in the calibration sample. Agreement ranged on a 0-4 scale, with “0” representing “I do not agree.” and “4” representing “I agree.”.

Perceived Similarity		*Mean*	*Std. Dev.*
Item 1	This person has similar habits to me.	2.71	1.03
Item 2	This person is someone who often faces the same problems as me.	2.47	1.11
Item 3	This person knows many people who face the same problems as me.	1.80	1.10
Authority			
Item 1	This person has gained valuable experience.	2.77	1.08
Item 2	This person has accomplished much in her life, one should conform to her.	1.85	0.98
Item 3	I have often conformed to this person.	1.78	1.16
Item 4	It is normal to conform to this person.	1.08	1.03
Coercion			
Item 1	This person starts arguing if you have a different opinion.	1.97	1.30
Item 2	It may have consequences if you have a different opinion to this person.	1.14	1.22
Item 3	This person gets angry if you have a different opinion.	0.59	0.99
Item 4	This person will avoid me if I have a different opinion.	0.38	0.83

4 Measurement model

Since we attempted to measure social influence as a latent variable, it was necessary to specify an appropiate hypothetic relation between observation the latent attribute. In this section we will discuss the stochastic model our instrument is based on.

Summarizing the theoretical discussion, we are interested in measuring the strength of beliefs about another person’s capability to induce influence over the above mentioned dimensions. We decided to employ an Item-Response-Theory (IRT) measurement model (cf. Embretson and Reise, 2000; van der Linden and Hambleton, 1997) for several reasons.

Firstly, IRT models allow the measurement of a latent trait on interval scale (as we assume by focusing on intensities), with only ordinal scaled observations given. This property is known as “conjoint measurement”. Secondly, since the estimation of latent traits is explicitly related to response patterns, scale values can be given a rather “objective” interpretation, as compared to the standard procedure of assigning quantiles in a norm population. A third, and rather obvious advantage, as compared to factor analytic techniques, is that IRT models allow for skewed (and even dichotomous) response distributions.

4.1 The Rasch Model

The IRT’s fundamental principle is exemplified by the well known “Rasch Model” (cf. Embretson and Reise, 2000: 65). Here both item and person are assumed to show differing degrees of intensity of the dimension to be measured. For example, some item could require a certain amount of perceived authority from a person in order to be agreed upon. Conversely, if the person fails to show this amount of authority, the item will not be agreed upon.

In practice, one expresses a probabilistic version of this idea. The Rasch-Model is a member of the logit-family and models a response probability via a logistic function, whose parameters are dependent on the difference in intensity between item and personal trait.

$$P(X_{ij} = 1 | \theta_j, \delta_i) = \frac{\exp(\theta_j)}{1 + \exp(\theta_j - \delta_i)}$$

$P(X_{ij} = 1 | \theta_j, \delta_i)$ is the probability of a positive response $X_{ij} = 1$ of person *j* to item *i*, given the latent person trait parameter θ_j and the latent item parameter δ_i. This probability is dependent on the logit θ_j, which is, as mentioned, simply the difference between those parameters. θ_j is often denoted as the “trait level” or “ability” and δ_i as „item difficulty“.

Essentially, the Rasch-Model has two fundamental assumptions. The first is obviously that the dependence between trait level and response probability can be described by a sigmoid-curve. The second assumption is about the local conditional independence of the items given the latent parameters. This implies that all correlation between the items must possibly be explained by the difference of the latent parameters θ_j and δ_i.

Since in the Rasch-Model the parameters of interest are latent, they have to be inferred abductively. This can be accomplished by the employment of several maximum-likelihood methods (cf. van der Linden/Hambleton, 1996) or the MCMC-simulation of their a-posterori distribution (cf. Gilks *et al.*, 1995).

Assessment of individual persons during application of a calibrated Rasch-Model (or one of it’s derivates) is done by estimation of their trait level with fixed item difficulties. These fixed values of the item parameters have to be obtained beforehand by an appropriate calibration sample.

4.2 Employed Polytomous IRT-Models

Two models have been applied to data in the actual measurement task. Both are extensions of the Rasch-model for polytomous data and share its features and basic interpretation.

The Partial-Credit-Model (PCM)

The "Partial-Credit-Model" focuses on modeling the probability of a response to the particular higher of two adjacent categories. So to speak, an individual Rasch-Model is estimated for every threshold between the neighboring categories of a polytomous item. The Partial-Credit-Model can be written as follows.

$$P(X_{ij} = x \mid \theta_j, \delta_{i1}, ..., \delta_{im}) = \frac{\exp \sum_{k=0}^{x} (\theta_j - \delta_{ik})}{\sum_{h=0}^{m_i} \exp \sum_{k=0}^{h} (\theta_j - \delta_{ik})} \mid x = 0,1,...,m$$

The target quantity is now the probability $P(X_{ij} = x \mid \theta_j, \delta_{i1}, ..., \delta_{im})$ of person j scoring category x to item i, conditional on the person trait level θ_j and the difficulties δ_{ik} of the item i´s m category thresholds. For a more detailed explanation, we would like to refer the reader to Masters and Wright (1997).

The Rating-Scale-Model (RSM)

The Rating-Scale-Model is an important special case of the Partial-Credit-Model, which assumes the same structure of distances between the threshold difficulties δ_{ik} for all items $i \in [1,2,...,s]$. This is usually a reasonable assumption when the item set shares a common response format. The model can be written as follows.

$$P(X_{ij} = x \mid \theta_j, \lambda_i, \delta_1, ..., \delta_m) = \frac{\exp \sum_{j=0}^{x} [\theta_j - (\lambda_i + \delta_k)]}{\sum_{x=0}^{m} \exp \sum_{j=0}^{x} [\theta_j - (\lambda_i + \delta_k)]} \mid x = 0,1,...,m$$

Again, the target quantity is the probability $P(X_{ij} = x \mid \theta_j, \lambda_i, \delta_1, ..., \delta_m)$ of person j scoring category x on item i, but now it is conditional on both the person trait level θ_j, the *common* difficulties δ_k of the item i´s m category thresholds and an additional item-location parameter λ_i. This latter parameter adjusts the common threshold structure to the particular item. For detailed discussion, the reader is referred to (Anderson, 1997).

Due to its restricted threshold structure, the Rating-Scale-Model is not as flexible as the Partial-Credit-Model. This may be a shortcoming if the data indicates considerable threshold variation. On the other hand, it should avoid over-fitting better than its more complex relative.

5 Instrument development

After having set up proposal item wordings and structure of the measurement model, we tried to integrate both in an empirical study consisting of pretest and calibration test. In this section we will report the details of the procedures.

It has been our aim to develop scales for assessment of social influence in closed social networks. It is plausible to assume the existence of nodes with a rather high degree in such a context. In order to facilitate economic data collection, we decided to develop scales which contain only a few items. These would need to be presented repeatedly to the respondents, once for every one of their neighbors.

The eventually small size of the networks in which the measurement instruments should be applied also posed a restriction to our task. It is not likely that such a small network would show enough variance in responses in order to allow the simultaneous estimation of both item- and person parameters. We therefore decided to prepare instruments which can be applied in a stepwise procedure. In a first step, we developed and calibrated the instruments in a survey setting, with an abundance of responses. In a second step, we employed the instruments, with now readily calibrated item parameters, for evaluation of individual responses in a closed network setting.

5.1 Survey setting

Development and calibration of scales in a survey setting necessitated some considerations to allow application in a closed network setting. The critical point is that in a sampled survey, respondents can not be expected to be connected at all. We therefore decided to ask the respondents to evaluate a member of their personal network.

More precisely, the respondents were asked to complete a list with (up to) seven persons that they have contact with outside their family. Then one person from the list was drawn at random, employing a method similar to the familiar „Kish-Selection-Grid“ (Kish, 1965). The items that were subsequently presented then referred to this randomly selected person, measuring in fact their perceived influence on the respondent.

Our consideration concerning the listing of contact persons and subsequent randomized selection, had been to avoid developing a scale of “best friends influence”. We assumed that persons, who are salient in memory are likely to be those assigned with strong and presumably positive emotions. By asking the respondents to name seven contacts, we hoped to trigger sufficient cognitive activity to overcome this tendency.

5.2 Samples

We collected data on two occasions, the first time for pretest and the second time for calibration from the student population at the social science department at a German university.

The pretest data was collected in an advanced statistics class and consisted of 63 cases: 68.3 % of the respondents were female and 31.7 % male.

Calibration data was collected at an inter-department lecture on introductory sociology, which is commonly attended by social science students and students who are studying to become teachers. On this occasion 352 cases were collected with the gender distribution being 73.6 % female and 26.4 % male.

5.3 Instrument Stability

The ordinality structure of selected items remained constant from the pretest to the calibration sample, together with the general structure of item fit.

The only major change was observed in the “coercion” item set. In the calibration sample, mean responses for all its items dropped approximately one agreement-category on a five category scale, indicating a lower total level of reported coercion. We have put this change down to environmental effects. The pretest had been collected after a rather unpopular evening lecture in statistics. However, the calibration sample was collected after the students had been told that the rest of the day’s introductory lecture would be canceled. We believe that these different levels of experienced “coercion” are mirrored in the data.

5.4 Calibration

In this section, we will discuss the properties of our calibrated scales such as threshold structure and item fit. Our considerations will concentrate on the so called "infit mean squares". This value measures the proportion of observed to expected variance, with a value of *1* indicating perfect fit and complete local conditional independence. High infit-values (*> 1.33*) indicate that only an insufficient proportion of variance can be explained by the model. This may suggest that the assumption of local conditional independence is not met, implicating the presence of different data-generating processes. Low infit-values (*< 0.66*) also indicate misfit of the model, namely that items show a higher discriminatory power than expected. Being certainly suboptimal, this kind of lack of fit may however be tolerable.

Furthermore, we computed both Partial-Credit and Rating-Scale models and decided for one alternative according to an analysis of Akaike's (*AIC*) and Schwartz' Information Criteria (*BIC*). Both are aimed at a comparison of nested models while controlling for a tendency of overfitting, which is inherent in models of increasing complexity. This is accomplished by adding a complexity penalty term to the model's deviance, indicating that the model with the lower information criterion is preferable. The complexity penalty of Akaike's Criterion is higher than that of Schwartz' Criterion.

6 Measurement instrument

In this section we will report the calibrated models including item sets, parameters and fit indices. There is a subsection for every theoretical subdimension.

6.1 Scale I: Persuasion / Perceived similarity

The scale on perceived similarity consists of the following items:

- Item 1: „This person has similar habits to me."
- Item 2: „This person is someone who often faces the same problems as me."
- Item 3: „This person knows many people who face the same problems as me."

6.1.1 Model selection

As shown in Table 2, the Likelihood Ratio-Test (*LR=14.21; df=3;* $\alpha < 0.005$) indicates that the Partial Credit Model fits the perceived similarity item set significantly better than the Rating Scale Model. Akaike's Information Criterion (*AIC*) prefers the Partial Credit Model, while Schwartz' Information Criterion (*BIC*) prefers the Rating Scale Model. Since the recommendations of the information criteria are conflicting, we decided to err on the side of simplicity and chose the more parsimonious Rating Scale Model for this item set.

Table 2: Information criteria and Likelihood-Ratio-tests for the competing measurement models, based on calibration sample data. Two stars (**) indicate that the LR-Test is significant on a level (α < .005).

Item Set	*Model 1*	*Model 2*	*AIC(M1)*	*AIC(M2)*	*BIC(M1)*	*BIC(M2)*	*LR*
Perceived Similarity	Rating Scale	Partial Credit	2884.02	2875.82	2903.29	2906.66	14.24**
Authority	Rating Scale	Partial Credit	3742.09	3728.86	3765.10	3771.01	23.27**
Coercion	Rating Scale	Partial Credit	3253.32	3220.75	3276.41	3263.09	42.57**

6.1.2 Scale properties

Table 3 shows the scales threshold structure, whose regularity stems from application of the Rating Scale Model. As can be seen from the infit-values in Table 3, a single item (item 2, "This person is someone who often faces the same problems as me.") shows considerably higher discriminatory power (i.e. lower variance) than expected under the Rating Scale Model. However, for the sake of consistent semantics, we decided to leave the item in the set. The remaining two items show rather good infit values.

Table 3: Rating Scale Model for Perceived Similarity: Item Difficulties & Common Threshold Difficulties.

Item	Estimate	Error	Infit MnSq
1	-0.530	0.045	1.21
2	-0.187	0.044	0.70
3	0.717	-	-
Threshold	*Estimate*	*Error*	*Infit MnSq*
1	-1.122	0.077	1.17
2	-1.158	0.069	1.11
3	0.677	0.072	0.97
4	1.603	-	-

6.2 Scale II: Authority

The scale for Authority consists of the following items:

- Item 1: “This person has gained valuable experience.”
- Item 2: “This person has accomplished much in her life, one should conform to her.”
- Item 3: “I have often conformed to this person.”
- Item 4: “It is normal to conform to this person.”

6.2.1 Model selection

Again the Partial Credit Model fits significantly better than the Rating Scale Model, as indicated by a Likelihood Ratio-Test ($LR=23.27;\ df=5;\ \alpha< 0.00$). However, consultation of the information criteria is again inconclusive, since *AIC* prefers the Partial Credit Model and *BIC* prefers the Rating Scale Model, as is shown in Table 2. For the sake of simplicity, we again decided to employ the Rating Scale Model for the Authority item set.

6.2.2 Scale properties

Table 4 shows thresholds and item fit of the authority scale. The items of the scale can be regarded as well-fitting, since all infit values show only reasonable departure from a perfect fit.

Table 4: Rating Scale Model for Authority: Item Difficulties & Common Threshold Difficulties.

Item	Estimate	Error	Infit MnSq
1	-1.093	0.045	1.22
2	0.012	0.043	0.84
3	0.095	0.043	0.96
4	0.987	-	-
Threshold	*Estimate*	*Error*	*Infit MnSq*
1	-1.307	0.065	1.14
2	-0.714	0.059	1.06
3	0.791	0.074	0.92
4	1.231	-	-

6.3 Scale III: Coercion

Coercion is measured by the following items:

- Item 1: “This person starts arguing, if you have a different opinion.”
- Item 2: “It may have some sort of consequence, if I have a different opinion to that person.”
- Item 3: “This person gets angry, if you have a different opinion.”
- Item 4: “This person will possibly avoid me, if I have a different opinion.”

6.3.1 Model selection

As before, a Likelihood Ratio-Test ($LR=42.57;\ df=5;\ \alpha< 0.005$) shows that the Partial Credit Model fits significantly better than the Rating Scale Model (compare Table 2). Consultation of the information criteria indicates that the Partial Credit Model is indeed preferable, since both *AIC* and *BIC* show a minimum value for this model.

6.3.2 Scale Properties

The threshold structure and item fit of the Coercion scale is given in Table 5. It can be seen that the thresholds of the individual items are contracting with increasing mean difficulty. This decrease of discriminatory power can again be interpreted as corresponding with a decline in the respondent’s willingness (or ability) to provide unbiased responses. Again we assume that the extremity of the items is the reason for the observation of these response patterns in our calibration sample.

Item fit can be regarded as generally good for this scale. All but one of the infit values are in a reasonable range around 1. The third item (“This person gets angry, if you have a different opinion.”) shows a rather low infit value, indicating that its discriminatory power has been underestimated. Being a tolerable feature, we decided to leave the item in the item set of the scale.

Table 5: Partial Credit Model for Coercion: Threshold Difficulties.

Threshold	Estimate	Error	Infit MnSq
Item 1			
1.1	-1.921	0.121	1.05
1.2	-1.210	0.113	1.01
1.3	-0.338	0.144	0.99
1.4	-0.287	-	-
Item 2			
2.1	-0.826	0.114	1.01
2.2	-0.146	0.134	0.95
2.3	0.067	0.192	0.92
2.4	0.293	-	-
Item 3			
3.1	0.323	0.124	0.93
3.2	0.091	0.170	0.91
3.3	0.839	0.301	0.91
3.4	0.287	-	-
Item 4			
4.1	0.823	0.139	0.97
4.2	0.911	0.222	1.03
4.3	-0.005	0.305	1.00
4.4	1.099	-	-

7 Application in a network setting

We conducted a study in order to assess the validity of the instrument, which is crucial point for its confident application. Unfortunately rigorous validation of the scales in the sense of criterion validation of a survey instrument has been infeasible. The reason is that in the case of our subject of social influence, we cannot simply look for features that correlate with our measurements. Instead we need to look for the effects of a composite of influence measures and communication structures, because we assume that individuals employ evaluations of social influence in order to consider and integrate information from a possible array of sources. This clearly implies that the instruments cannot be validated by means other than a closed network study, where there is a known communication structure.

7.1 Network Autocorrelation Model

In order to get information about the joint effect of influences in a closed network setting, we decided to check our scales using a Network Autocorrelation Model

(NACM). This class of regression models originates from spatial statistics (Anselin 1988) and has been discussed with regard to network application by Leenders (2002). For cross-sectional data the model can be written as follows.

$$Y = \rho WY + BX + e$$

Y indicates a dependent attribute vector and WY the so called "network autocorrelation term", where the vector of the dependent attribute Y is multiplied by a matrix of influence weights W. The scalar ρ and the elements of the vector B are the regression coefficients of the model which estimate the relative impact of the network autocorrelation term and the matrix of exogenous predictors X. e represents the stochastic error term of the model.

Applied to our problem, ρ indicates the effect of a social influence structure, as evaluated by our proposed measurement instruments, on a particular attitude variable. Analysis of such a model in a case study, with special attention to explained variance and fit, should lead to valuable conclusions regarding the applicability of our instruments.

Unfortunately we can not rule out a possible bias towards validity, namely that evaluations of communication partners are themselves subject to social influence. We abstained from constructing NACMs to explain neighbor evaluations, since this seemed unpromising in terms of the expected data base. It would have been necessary to set up a particular NACM for every person in the network, each based only on the probably small number of her direct neighbors.

7.2 Case study

We collected data from a group of professors and assistants at two German universities who collaborated in order to apply for a grant from the German Science Foundation. The subject of their application was the field of "Evidence Based Policy".

The core group, who both officially applied for the grant and actively participated in internal communication, consisted of 13 persons. Obvious features were distributed as follows over the group:

- Ten persons worked at one university (subsequently called "University A") and three persons at the other (subsequently called "University B").
- Eleven persons were male and two were female.
- Eleven persons were professors and two were assistants (including the project coordinator).
- Six persons were social scientists, five psychologists and two business economists.

In order to collect data from this group, we invited its members to participate in an online survey. In this survey, respondents were asked about their attitudes towards various aspects of the project, as well as their communication pattern and their evaluation of their contacts according to our social influence scales. After a field time of five weeks we were able to gather data from eleven of the 13 group members.

7.3 Measurements

We decided to employ the respondent's evaluation of qualitative methods (with regard to their utility for evidence-based policy) as the dependent variable (DV) of the model, since it showed considerable variance. We furthermore chose a single predictor variable (IV), the respondent's evaluation of structural equation modeling (again with regard to their utility for evidence-based policy). This variable had been chosen because of its good correlation ($r=0.308$) with the dependent variable. Both variables had been measured by a single item on a seven point scale ("1" representing "negative" and "7" representing "positive").

- DV item: "How do you evaluate *qualitative methods* with regard to their utility for evidence-based policy and practice?" ($\bar{x}=5.73$, $sd=1.49$, $n=11$)
- IV item: „How do you evaluate *structural equation modeling* with regard to it"s utility for evidence based policy and practice?" ($\bar{x}=5.73$, $sd=1.35$, $n=11$)

In order get a context specific measure of informational dependence, respondents were asked about their familiarity with qualitative methods, the attitude object of the dependent variable in focus. This variable was also measured by a single item on a seven point scale ("1" representing "I do not feel familiar." and "7" representing "I do feel familiar.").

- Informational dependence item: "How familiar do you feel with *qualitative methods*?" ($\bar{x}=4.27$, $sd=2.28$, $n=11$)

The evaluations of interaction partners was collected using our three proposed measurement instruments. The inferred trait parameters were allowed to vary between -*6* and *6* logits and were subsequently standardized for application. The values for persuasion were calculated by multiplication of the standardized trait parameters of perceived similarity with the standardized measurements of informational dependence. By this we tried to express the conditionality inherent to self categorization theory. (Perceived similarity only makes a difference if people need to depend on others in a task.) Altogether, the following measurements have been made on social influence.

- Persuasion scale ($\bar{x}=0.26$, $sd=0.03$, $n_{evaluations}=37$)
- Authority scale ($\bar{x}=0.62$, $sd=0.15$, $n_{evaluations}=37$)
- Coercion scale ($\bar{x}=0.36$, $sd=0.05$, $n_{evaluations}=37$)

7.4 Influence networks

Our measurements of evaluation of interaction partners yielded the directed networks given in Tables 6 – 9 and Figure 1). In order to provide the network autocorrelation model with appropriate input, the adjacency matrices have been transposed, thus converting subjective evaluations into properly directed influences. We furthermore set the diagonal of the adjacency matrices to unity in order to allow for maximum "self influence".

Table 6: Observed adjacency matrix, values set to unity.

	1 Psychologist	2 Sociologist (Uni B)	3 Sociologist	4 Business Economist (Ass.)	5 Business Economist	6 Sociologist (Uni B)	7 Sociologist	8 Sociologist	9 Psychologist	10 Sociologist (Ass.)	11 Psychologist (Uni B)
1 Psychologist	1	0	0	0	0	0	0	1	1	0	0
2 Sociolo-gist (Uni B)	0	1	0	0	0	0	0	1	0	1	1
3 Sociologist	0	0	1	0	0	0	0	1	0	0	0
4 Business Econ. (Ass.)	0	0	0	1	1	0	0	0	0	0	0
5 Business Economist	0	0	0	1	1	0	1	1	0	0	0
6 Socio-log. (Uni B)	0	1	1	0	0	1	1	1	0	1	1
7 Sociologist	0	0	1	0	1	0	1	1	0	0	0
8 Sociologist	1	1	1	0	1	0	1	1	1	1	1
9 Psychologist	1	0	0	0	0	0	0	1	1	0	0
10 Sociolo-gist (Ass.)	1	0	1	1	1	0	0	1	0	1	0
11Psycholo-gist (Uni B)	1	1	0	0	0	0	0	1	1	0	1

Table 7: Observed adjacency matrix, values as measured by persuasion instrument, receiving agent in columns/.

	1 Psychologist	2 Sociologist (Uni B)	3 Sociologist	4 Business Economist (Ass.)	5 Business Economist	6 Sociologist (Uni B)	7 Sociologist	8 Sociologist	9 Psychologist	10 Sociologist (Ass.)	11 Psychologist (Uni B)
1 Psychologist	1	0	0	0	0	0	0	0.188	0.463	0	0
2 Socio-log.(UniB)	0	1	0	0	0	0	0	0.167	0	0.029	0.519
3 Sociologist	0	0	1	0	0	0	0	0.188	0	0	0
4 Bus. Econ. (Ass.)	0	0	0	1	0.143	0	0	0	0	0	0
5 Business Economist	0	0	0	0.210	1	0	0.383	0.188	0	0	0
6 Sociolo-gist (Uni B)	0	0.049	0.098	0	0	1	0.357	0.167	0	0.029	0.451
7 Sociologist	0	0	0.087	0	0.203	0	1	0.167	0	0	0
8 Sociologist	0.670	0.049	0.098	0	0.264	0	0.322	1	0.558	0.024	0.483
9 Psychologist	0.341	0	0	0	0	0	0	0.127	1	0	0
10 Sociolo-gist (Ass.)	0.410	0	0.078	0.196	0.203	0	0	0.188	0	1	0
11 Psycho-logist(UniB)	0.4103	0.049	0	0	0	0	0	0.208	0.524	0	1

Table 8: Observed adjacency matrix, values as measured by authority instrument, receiving agent in columns.

	1 Psychologist	2 Sociologist (Uni B)	3 Sociologist	4 Business Economist (Ass.)	5 Business Economist	6 Sociologist (Uni B)	7 Sociologist	8 Sociologist	9 Psychologist	10 Sociologist (Ass.)	11 Psychologist (Uni B)
1 Psychologist	1	0	0	0	0	0	0	0.653	0.440	0	0
2 Sociolo-gist (Uni B)	0	1	0	0	0	0	0	0.653	0	0.999	0.882
3 Sociologist	0	0	1	0	0	0	0	0.653	0	0	0
4 Bus.Econ. (Ass.)	0	0	0	1	0.403	0	0	0	0	0	0
5 Business Economist	0	0	0	0.488	1	0	0.0005	0.569	0	0	0
6 Sociolo-gist (Uni B)	0	0.871	0.941	0	0	1	0.502	0.653	0	0.999	0.882
7 Sociologist	0	0	0.788	0	0.713	0	1	0.760	0	0	0
8 Sociologist	0.999	0.0005	0.941	0	0.784	0	0.219	1	0.765	0.999	0.991
9 Psychologist	0.536	0	0	0	0	0	0	0.653	1	0	0
10 Sociolo-gist (Ass.)	0.0005	0	0.732	0.488	0.4957	0	0	0.760	0	1	0
11 Psycho-logist(UniB)	0.536	0.0005	0	0	0	0	0	0.993	0.634	0	1

Table 9: Observed adjacency matrix, values as measured by coercion instrument, receiving agent in columns.

	1 Psychologist	2 Sociologist (Uni B)	3 Sociologist	4 Business Economist (Ass.)	5 Business Economist	6 Sociologist (Uni B)	7 Sociologist	8 Sociologist	9 Psychologist	10 Sociologist (Ass.)	11 Psychologist (Uni B)
1 Psychologist	1	0	0	0	0	0	0	0.442	0.309	0	0
2 Sociologist (Uni B)	0	1	0	0	0	0	0	0.419	0	0.217	0.0005
3 Sociologist	0	0	1	0	0	0	0	0.361	0	0	0
4 Bus.Econ. (Ass.)	0	0	0	1	0.501	0	0	0	0	0	0
5 Business Economist	0	0	0	0.578	1	0	0.464	0.442	0	0	0
6 Sociologist	0	0.368	0.557	0	0	1	0.501	0.442	0	0.310	0.0005
7 Sociologist	0	0	0.557	0	0.420	0	1	0.462	0	0	0
8 Sociologist	0.222	0.309	0.538	0	0.394	0	0.443	1	0.216	0.310	0.0005
9 Psychologist	0.465	0	0	0	0	0	0	0.419	1	0	0
10 Sociologist (Ass.)	0.501	0	0.519	0.395	0.361	0	0	0.394	0	1	0
11 Psychologist(UniB)	0.366	0.217	0	0	0	0	0	0.419	0.216	0	1

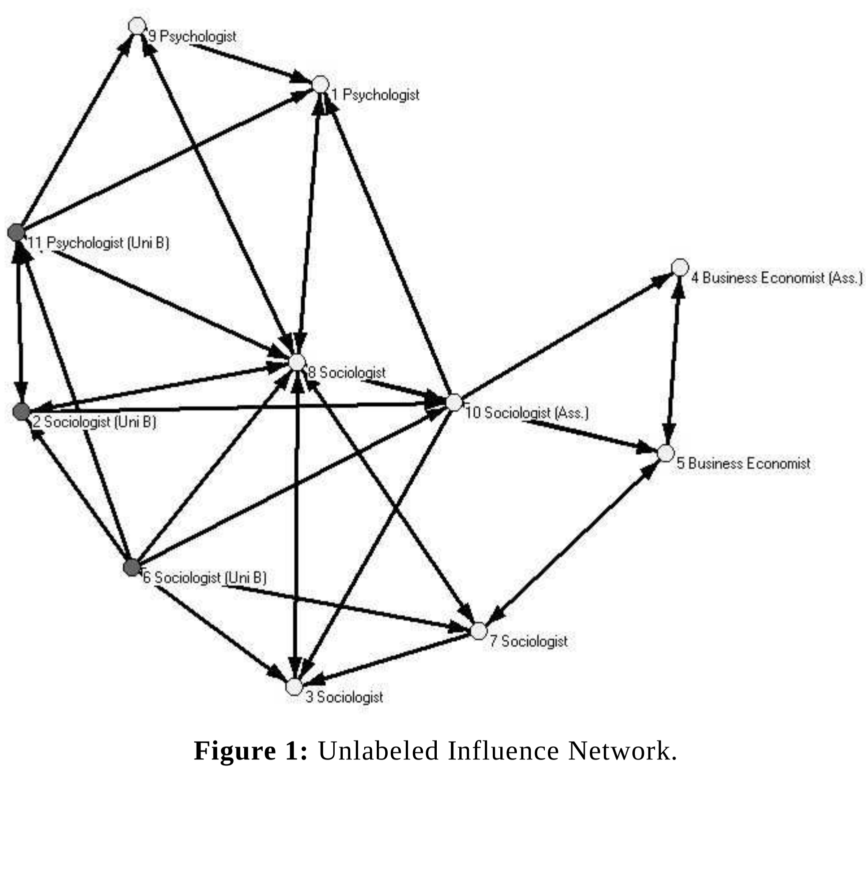

Figure 1: Unlabeled Influence Network.

7.5 Model results

We fitted several models to the data, using maximum likelihood estimation. All models had the evaluation of qualitative methods as their dependent variable. The baseline model was an ordinary bivariate regression model with the evaluation of structural equation modeling as its independent variable. Our extended models contained an additional network autocorrelation term, each model with a differently valued adjacency matrix. A first model contained the surveyed adjacency matrix with values set to unity. Three further models contained the surveyed adjacency matrix, each with values measured by the instruments on persuasion, authority, and coercion. A last model contained a complete adjacency matrix with values set to unity. Estimations are given in Table 10.

Table 10: Fitted network autocorrelation models, dependent variable is evaluation of qualitative methods.

Model	**IV**	*AC Matrix*	*Network Effect* ρ	*Sig.* ρ	*IV Effect* β	*Sig.* β	R^2	*LL*	*LR(to Basel)*	*Sig LR*
Baseline	SEM	-	-	-	0.969	0.000	0.382	-20,67	-	-
Unity	SEM	Unity	0.068	0.012	0.676	0.000	0.454	-18.34	4.66	< 0.050
Persusasion	SEM	Persuasion	0.283	0.003	0.486	0.05	0.484	-17.46	6.42	< 0.010
Authority	SEM	Authority	0.097	0.006	0.681	0.000	0.468	-18.02	5.30	< 0.025
Coercion	SEM	Coercion	0.194	0.003	0.546	0.000	0.4147	-19.49	2.36	> 0.1

The baseline model shows a strong effect of evaluation of structural equation modeling on the evaluation of qualitative methods, and a considerable proportion of explained variance. When the surveyed adjacency matrix, with values set to unity, was entered into the equation, we observed a small effect of network autocorrelation. The effect of structural equation modeling dropped considerably, while the proportion of explained variance rose by over *0.08*.

When the surveyed adjacency matrix with values measured by the persuasion instrument was entered for the autocorrelation term, we observed a much stronger network effect, an even weaker effect of evaluation of structural equation modeling and a proportion of explained variance which exceeded the one of the baseline model by over *0.1*.

Compared to the model containing the observed adjacency matrix set to unity, the model containing the authority matrix showed similar behavior. The network autocorrelation effect was weak, the effect of the evaluation of the structural equation model was considerably lower and the proportion of explained variance was considerably higher than in the baseline model. However, knowledge of the distribution of perceived authority did not yield improved results, as compared to the case, when only the barren structure of communication was known.

The model containing measured evaluations of coercive behavior showed a considerable network effect and an accordingly lower effect of evaluation of structural equation modeling. Although its proportion of explained variance exceeded the baseline model by approx. 0.03, it was approx. 0.04 lower than in the model with the adjacency matrix values set to unity. Furthermore, a likelihood ratio test indicated no significantly improved fit as compared to the baseline model.

All other models containing a network autocorrelation term, but the coercion model, were superior compared to the baseline model, as indicated by likelihood ratio tests.

7.6 Implications for validity

Summarized, our estimations show improved predictions for the case of the persuasion instrument. The instrument on authority did not improve predictive performance in our case study, while the coercion instrument yielded new predictions but did not fit well. This clearly suggests the validity of the persuasion instrument. However, the result does not necessarily strip the other two instruments of potential validity.

The reason is that in a setting of professors it is quite plausible to assume persuasion to be more important than authority and coercion not fitting well. Given the small size and specific culture of our network, the small effect and inferior fit of the latter measurements can not necessarily be generalized. It should make sense to expect different patterns under different circumstances.

8 Conclusion

In this section we will summarize the results and breifly discuss their implications and value.

Taken together, we developed three instruments to measure the subjective evaluations of a communication partner’s potential to induce influence. Following a cognitive reinterpretation of Turner’s Three Process Theory of Power, we proposed persuasion, authority and coercion to be the relevant dimensions of social influence. We decided to employ IRT-methods in the form of partial-credit and rating-scale models as measurement rationale. In order to yield readily calibrated item parameters for application of the instruments in a closed network setting we developed scales in a survey setting. The calibrated models were then applied in a closed network study about communication and attitudes in an academic setting. The application of a network autocorrelation model to the case study’s data showed a substantive predictive gain for the case of the persuasion measures, but only negligible predictive gain in the case of the authority measures and inferior fit in the case of the coercion measures. This supports our claim of validity for the persuasion scale. Although this claim has not been supported for the other scales, it can, however, not be refuted by the case study. It is plausible to assume that authority and coercion should have only minor effects in an academic setting. Investigation on these scales should therefore proceed using data from a different area.

Central finding is that assessment of the model fit supports our hypotheses of cognitive representation of social influence and three core influence processes. The first is important since it justifies the measurement of social influence as an psychological attribute with common survey type questionaires. Secondly, the obviously feasible assumption of an array of influence modes allows a more detailed view on the influence processes taking place in a network. This is a crucial point for both simulation modeling of social networks and planning of interventions.

Maybe the most significant scientific value of the instrument is the following: It shows that network measurement can be enriched with both substantial causal assumptions and a rigorous method of statistical inference. The expected results of a structural approach augmented this way are better prediction and higher control over the specific inferences made.

References

[1] Anderson, E.B. (1997): The Rating Scale Model. In van der Linden, W. and Hambleton, R. (Eds.): *Handbook of Modern Item Response Theory*. New York: Springer.

[2] Anselin, L. (1988): *Spatial Econometrics: Methods and Models.* Dordrecht: Kluwer Academic Publishers.

[3] Embretson, S.E. and Reise, S.P. (2000): *Item Response Theory For Psychologists.* New Jersey: Lawrence Erlbaum Associates, Mahwah.

[4] Emerson, R.M. (1981): Social exchange theory. In Rosenberg, M. and Turner, R.H. (Eds.): *Social Psychology: Sociological Perspectives,* New York.

[5] Festinger, L. (1950): Informal social communication. *Psychological Review,* **57**, 271-282

[6] French, J.R.P. (1956): A formal theory of social power. *Psychological Review*, **63**, 181-194.

[7] French, J.R.P. and Raven, B. (1959): The bases of social power. In Cartwright, D. (Ed): *Studies in Social Power,* Ann Arbor: University of Michigan.

[8] Friedkin, N.E. (1998): *A Structural Theory of Social Infuence*. Cambridge: Cambridge University Press.

[9] Gigerenzer, G., Todd, P.M., and the ABC Research Group (1999): *Simple Heuristics That Make us smart*. New York: Oxford University Press.

[10] Gilks, W.R., Richardson, S., and Spiegelhalter, D.J. (1995): *Markov Chain Monte Carlo in Practice.* Boca Raton: CRC Press.

[11] Kish, L. (1965): *Survey Sampling*. New York: Springer.

[12] Leenders, R. (2002): Modeling social influence through network autocorrelation: constructing the weight matrix, *Social Networks*, **24**, 21-47.

[13] Masters, G.N. and Wright B.D. (1997): The Partial Credit Model. In van der Linden, W. and Hambleton, R. (Eds.): *Handbook of Modern Item Response Theory*, New York: Springer.

[14] Schwenk, G. (2006): Interlevel relations and manipulative causality. *Journal for General Philosophy of Science*, **37**, 99-110.

[15] Schwenk, G., and Reimer, T. (2007): Social influence and bounded rationality: Heuristic decision making in complex networks. In McNamara, D.S., and Trafton, G. (Eds.): *Proceedings of the Twenty-Ninth Annual Conference of the Cognitive Science Society*. New York: Taylor & Francis.

[16] Schwenk, G. and Reimer, T. (2008): Simple heuristics in complex networks: Models of social influence. *Journal of Artificial Societies and Social Simulation*,**11**. http://jasss.soc.surrey.ac.uk/11/3/4.html

[17] Turner, J.C. (1987): *Rediscovering the Social Group: A Self-Categorization Theory*, Basil Blackwell: New York.

[18] Turner, J.C. (1991): *Social Influence.* Maidenhead Philadelphia: Open University Press.

[19] Turner, J.C. (2005): Explaining the nature of power: A three-process theory, *European Journal of Social Psychology*, **35**, 1-22.

[20] van der Gaag, M. and Snijders, T.A.B. (2005): The resource generator: Social capital quantification with concrete items. *Social Networks*, **27**, 1-29.

[21] van der Linden, W. and Hambleton, R. (1997): *Handbook of Modern Item Response, Theory*, New York: Springer.

[22] Weber, M. (1984): *Soziologische Grundbegriffe*. 6th edition, Tuebingen: Mohr.