Classifying social roles by network structures

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Abstract Network Analysis is employed as methodological approach to classify social roles. With this aim, we measure sociometric status by the direct observation of pre-school children behaviours. The data have been collected by a longitudinal observational study. We follow the children in seven waves for two months. In this study, we measure relational skills of subjects applying three procedures. Namely, the regular equivalence is used to detect similar positions within the network, the lambda sets to observe the ability to be intermediary and the cliques to assess the propensity to belong to a group. Concerning each analytic dimension, the results show an increase of relational competence and an association with ego-network measures.

KEYWORDS: Sociometric status; Role profiles' classification; Structural equivalence; Lambda sets; Cliques.

1 Introduction

This paper concerns Network Analysis (NA) methods employed to classify role profiles based on the measurement and the specification of linking structures among pupils in infant school. In NA approach, the notion of social role depends conceptually, theoretically and formally on peculiar relationships established among subjects and their positions across the network. Our study analyses the capability of pre-school children (3-5 years old) to relate with peers in building behaviour patterns consistent over time up to shape social roles. We monitored the relational behaviour of 42 pupils aged from 3 to 5 years, obtaining a panel survey repeated for seven waves, during two months (October and December) by directly observing the pupils’ behaviours in their school setting, with the aim to measure sociometric status in order to classify social roles.

2 Theoretical Framework

Children in pre-school age already have significant relational skills. This issue has also been evaluated in the psychosocial field. Many studies classify sociometric status of children in the following profiles: popular (altruistic children), rejected (with little or no contact), controversial (aggressive children defining themselves as popular), average (average propensity to communicate with others) and neglected
The most part of these studies concerns 5-12 aged children, investigated by interview (Newcomb and Bukowski, 1983; Coie et al., 1990; Patterson et al., 1990; Newcomb et al., 1993). Since at pre-school age the gap between verbal and relational competence is too large to achieve reliable measurements, in this study we propose to classify 3-5 aged children, measuring sociometric status by direct observation of relational behaviours.

3 Material and methods

Firstly, we record children relational behaviours in seven weighted and directed matrices (one for each week). Then, in order to specify the role of each child, we employ three NA tools: structural equivalence lambda sets and cliques. Specifically, as structural equivalence method, we apply the regular equivalence (REGE algorithm), that is the most flexible measure to identify general social roles (Faust, 1988; Borgatti and Everett, 1993). According to White and Reitz (1983), regular equivalence for single relation networks is defined as follows:

- If \( G = (P, R) \) and \( \equiv \) is an equivalence relation on \( P \), then \( \equiv \) is a regular equivalence if and only if for all \( a, b, c \in P \),
  - \( a \equiv b \) involves that:
    1. \( aRc \) implies there exists \( d \in P \) such that \( bRd \) and \( d \equiv c \)
    2. \( cRa \) implies there exists \( d \in P \) such that \( dRb \) and \( d \equiv c \).

REGE is an iterative algorithm. Within each iteration, a search is implemented to optimize a matching function between nodes or vertices \( i \) and \( j \). As a consequence, for each \( k \) in \( i \)'s neighbourhood the procedure searches for an \( m \) in \( j \)'s neighbourhood of similar value. A measure of similar values, based upon the absolute difference among sizes of ties, is weighted and optimized by the degree of equivalence between \( k \) and \( m \) at the previous iteration. This is summed for all members of \( i \)'s neighbourhood over all relations and normalized to provide the current iteration measure of equivalence between \( i \) and \( j \) obtaining a similarity matrix. On this matrix, then, the single link routine is employed for hierarchical clustering (White and Reitz, 1983).

Furthermore, we apply lambda set, used to identify the subjective tendency to assume roles as mediators or intermediaries. Given a graph \( G (V, E) \), a lambda set \( S \) represents the edge-connectivity of two vertices \( a \) and \( b \) in the graph. It is a subset of \( V \) such that for all:

- \( a, b, c \in S \) and \( d \in V - S \), then \( \lambda(a, b) > \lambda(c, d) \).

We obtain, thus, a matrix of partitions in which a value of \( K \) in an \( i \)-column and in a \( j \)-row indicates that the node \( j \) is in the \( k \)-partition and the other members of the partition form a lambda set with minimum edge-connectivity. On this basis, we can derive a permutation of the nodes used in a particular hierarchical clustering of roles in a net (Borgatti et al., 1990). This technique, then, is here adapted to draw
homogeneous sub-groups based on the ability of subjects to be intermediaries. By means of this tool, we are able to establish a ranking of the most important links of the network, in relation to the ability of members to act as ‘bridges’. Removing nodes with a high score, the structure of the network substantially changes. By contrast, although the nodes or subjects with an intermediate score have the ability to act as ‘intermediaries’, their role does not affect the shape of the network. These latter nodes manage the relational dynamics between two or more subjects or subgroups of small sizes.

Finally, we employ cliques as a maximal subset of nodes in which each node is directly connected with each other. Specifically, a clique $S$ of a graph $G (V, E)$ is a maximal subset of $V$ such that for all:

$$s \in S, \alpha(s, S) = | S | - 1.$$ 

By means of cliques, we identify the structure of the cohesive partitions within the networks, allowing to observe the propensity of each node to be part of a group. Indeed, the same node or set of nodes may belong to different, also overlapped, cliques with a score as high as the number of occurrences in a clique (Bron and Kerbosch, 1973).

### 4 Results

Firstly, the October data are classified in 4 profiles of children: isolated (similar to the ‘rejected’), invisible (similar to the ‘neglected’), average (with a high index of aggressiveness), popular (with the same tendency to contact and to be contacted).

Then, the structure of December data allow to use the criterion of regular equivalence, obtaining cluster of children in a structural equivalent position. By REGE algorithm, the data are classified in three types of node: sinks (with only incoming links), repeaters (with both incoming and outgoing ties) and sources (with only outgoing links). The 93% of the average becomes repeaters in December while populars in October become sources or sinks in December. Most children become more sociable in December and, as a consequence, the few isolated and invisible are merged in a cluster.

Furthermore, we classify children into three clusters through lambda sets taking into account the intermediary role, namely: connectors (supporting the structure of the network), bridges (intermediaries among sub-groups) and marginal (no strategic function). In December we notice an increase in the number of bridges, a weak decrease of connectors and a notable decrease of marginal nodes.

Finally, employing cliques in October only 17 nodes show relational competence while this ability increases in December. The structure, indeed, becomes more complex identifying three groups: embedded (within the most part of cliques), integrated (able to belong at least to a triad, not necessarily with multiple links) and marginals (with weak capacity to belong to a group).

As the last step, we study the association between individual characteristics and social roles. What does it mean, for example, to be popular in October? To answer
this question, we use the Kruskal-Wallis test, introducing three blocks of variables: structural variables, indicators of sociability and ego-measures. The attributes significantly associated with the definition of roles are the presence of positive or negative relationships, indices of social impact and social preference. Therefore, ego-measures related to the roles are: ego-network efficiency, size, betweenness, density and the α-parameter, as an estimation of individual sociability of each node. During the second step of our study, in December, we notice a different structure of roles, more oriented towards friendliness and with the widespread presence of subjects who are reference points for others. Moreover, the relational profiles of October are not associated with any attributes of the subjects, while in December the number of positive and negative occurrences are significantly associated with the social roles. Overall, from October to December, the number of significant indices decreases for the indicator of sociability (social impact, preferences, aggressiveness) and increases looking at ego-network measures. As a consequence, the structure of the individual relationships changes over the time.

References


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