

Network Analysis Methods to Measure Sociometric Status

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Abstract This paper proposes an innovative methodological approach to measure sociometric status in small groups of pupils. Although it uses indirect data collected by interview, in this study the sociometric status is analysed by direct observation. This method is specifically suitable when the target population concerns pre-school children. Their cognitive competence, in fact, is not as well developed as their relational abilities. Hence, the indicators constructed are more reliable than the measures derived by the subjective perception of interviewed pupils. The Network Analysis methods allow for the definition of sociometric status by means of regular equivalence. Employing lambda sets and cliques, then, we specify further roles into distinctive small groups. The results show that sociometric status can be revealed by regular equivalence. Besides, the Network Analysis approach allows for the observation of further relational skills, not strictly associated with traditional social roles, detectable only through lambda sets and cliques.

Keywords Sociometric Status, Role Classification, Structural Equivalence, Lambda Sets, Cliques

Nowadays, infant behaviour cannot simply be studied in relation to adults. Parents continue to play central roles in the construction of the child's identity but the child's world becomes progressively more polycentric. Relationships with peers, therefore, are as important as those with parents. On the basis of this assumption, our study explores the capability of pre-school 3-5 years children to relate with peers in the construction of social roles.

The concept of role suggests a structure of relationships among the subjects in a network. In a NA approach, the notion of social role depends conceptually, theoretically and formally on the specific relationships that link the set of actors and their positions across the network.

Our research was carried out in an infant school, observing 42 pupils aged from 3 to 5 years during the whole month of October and the first three weeks of December. The collected data refers to seven waves. In each wave, the teachers observed and recorded the pupils' behaviour on Saturday when the same pupils all play together in a common space with no difference in class or age. Finally, it was possible to compare children who continuously occupy the same subgroup, maintaining the same sociometric status, as well as children who change their relational behaviour.

1. Introduction

This paper describes and analyses relational patterns among pupils at an infant school, in order to classify roles into distinctive groups by means of Network Analysis (NA) measures.

Several studies have shown that peer relationships have significant effects on language development, learning abilities and empathetic capabilities [1, 2]. To contextualize the research, a recent study [3] characterises selection and socialization aspects of school-age children and adolescent peer groups. Using nearest neighbour observations, affiliative subgroups are identified. Secondly, additional behavioural observations and sociometric data are used to show that high mutual proximity subgroups reflect friendship relations, whereas low mutual proximity subgroups reflect common social goals without subgroup dyadic ties.

2. Theoretical Framework

In our hypothesis, children in pre-school age (3-5 years old) have relational skills that are sufficiently developed to allow for the analysis of social roles [4, 5]. In addition, the paper proposes a parallelism between analysis of social roles and sociometric status, implementing this through NA. Following NA approach, the concept of role is defined in terms of equivalence between the actors within a network. Individuals play the same role if they are similar, taking into account the number and type of relationships they have with others. The concept of sociometric status refers to the degree to which the children like or do not like the other children of their groups. That is to say, it refers to the level of satisfaction in the peer group. Sociometric tests are usually applied to measure the attraction and repulsion between persons. Attraction and repulsion are considered orthogonal processes in social relations, sociometric status then affect both how individuals perceive others and how

roles for all significant indices, followed by *average*, *invisible* and *isolated* pupils. In December, *repeaters* have the highest values, followed by *sources* and *sinks*.

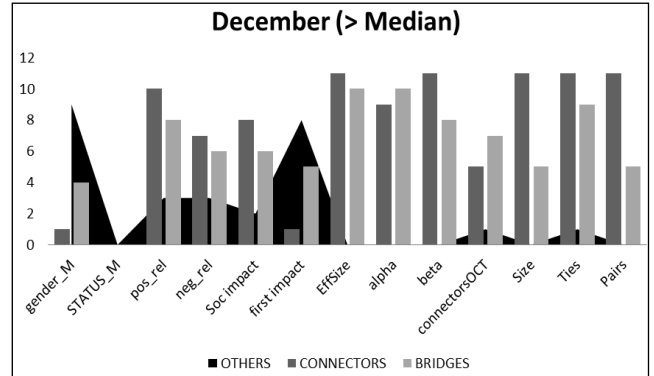
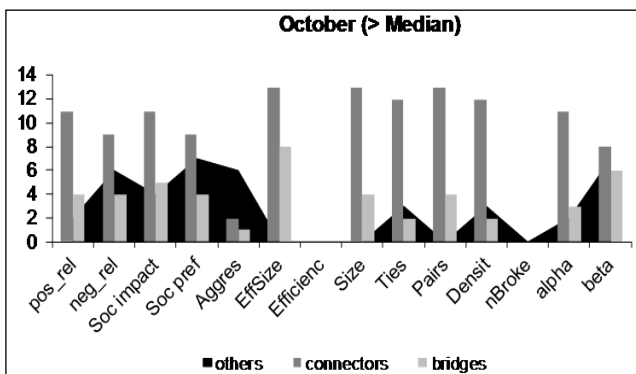
The underlying dynamics involved represent an especially significant aspect of our study. The *repeaters* of December, in fact, are mostly *average* children in October. Besides, from October to December, pupils improve their ability as intermediaries at least within their own *ego-networks*, whereas it is more difficult to play this role if the network is considered as a whole.

4.3. Relational Dynamics and Brokerage

The *lambda set* procedure draws clusters of pupils focusing on the ability to act as brokers. Three groups of children are observed, namely:

1. *connectors*, supporters of the structure of the network
2. *bridges*, intermediaries between groups or individuals
3. *marginal nodes*.

In December, the number of *bridges* increases while *marginal* pupils decrease much more than *connectors* do. By means of the Kruskal-Wallis test (Table 3), the main differences are in the sociability indicators. Compared with October, in December, aggressiveness and a larger number of positive contacts rather than negative are not associated with the ability to act as intermediary. However, both positive and negative relationships are equally associated with the broker ability. Besides, the most of *ego-measures* are significant in October but only few are still significant in December: only *ego-measures* showing the subjective ability to relate to others (*Size*, *Ties*, *Pairs*, *Ego-Betweenness*) retain their significance.



* The figure shows only the significant values according to the Median test

Figure 5. Median test: weights of significant measures related to the roles (*lambda sets*)*.

Finally, most of October's *connectors* become *bridges* or keep their role in December. Individual sociability, measured by α -parameter, and attractiveness, by β -parameter, show really impressive trends from the first to the other month (Figure 5).

Summing-up, in October *bridges* and others have quite similar *ego-network* values. *Connectors*, instead, show the highest values for most of indices and, in particular, they are both the most sociable and attractive pupils. The dynamics of December are different. Namely, *connectors* are the most attractive (β -parameter) and *bridges* are the most sociable (α -parameter).

4.4. Relational Dynamics and the Ability to belong to Subgroups

The ability to build group relationships is analysed by means of *cliques*, which focuses on the presence of groups among children. This dynamic is certainly the most influenced by time. The difference is so great that, while in October it is possible to find only 17 children belonging to a group, in December we distinguish two clusters: *embedded* and *integrated*.

Analysing the values of the measures (Table 4), the presence of positive relationships and indices of preference and aggressiveness are relevant in October, while in December there is a positive association with social impact and first school entrance and also with the values of α - and β -parameters. Focusing on the *ego-networks* measures - *Size*, *Ties*, *Pairs*, *Density*, *Efficiency* and *Nbroker* - are significantly associated with the unique group drawn in October, while in December the significance holds only for the *Efficiency*.

Table 3. Kruskal-Wallis test: role of 'broker' by (*lambda sets*).

Roles by lambda sets	October χ^2	December χ^2
Age3	0,55	2,28
Age4	1,23	2,11
Age5	1,54	0,2
GenderM	0,72	8,91**
Brother0	0,4	0,58
Brother1	1,22	1,23
Brother2	2,1	2,31
Cry	1,49	2,11
StatusLow	4,39	3,44
StatusMedium	3,14	5,55
StatusHigh	0,52	1,86
Pos_rel	18,45***	12,35**
Neg_rel	2,82	9,01*
Index_Social impact	11,17**	15,32***
Index_Social preference	6,27*	0,771
Index_Social aggressiveness	6,27*	0,771
First_impact	2,46	5,51
EffSize	33,57***	34,96***
Efficiency	15,02**	0
Size	34,15***	36,68***
Ties	24,04***	26,09***
Ordered pairs	34,15***	36,68***
Density	10,02**	1,18
nBroker	9,45**	1,47
nEgoBe	0,264	6,43*
Alpha	16,346***	21,39***
Beta	10,214**	23,53***
Isolated Oct		1,88
Invisible Oct		0,991
Average Oct		0,888
Popular Oct		3,221
Lambda: Connectors Oct		6,29*
Lambda: Bridges Oct		2,68
Cliques Oct		0,49

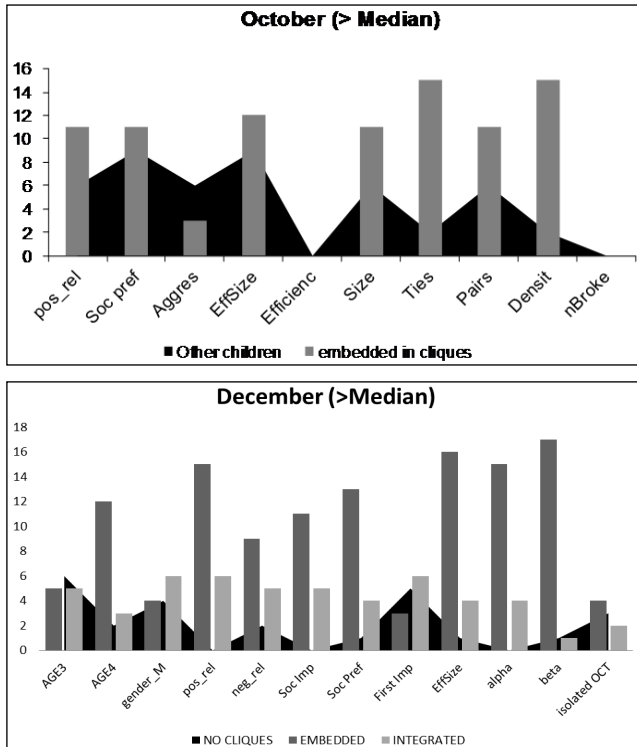
* significant for $\alpha=0.05$; ** significant for $\alpha=0.01$; *** significant for $\alpha=0.001$.

Table 4. Kruskal-Wallis test: measures by *cliques*.

Roles by cliques	October χ^2	December χ^2
Age3	0,112	4,01
Age4	0,006	4,84
Age5	0,24	0,3
GenderM	0,003	6,81*
Brother0	0,004	0,04
Brother1	0,19	1,61
Brother2	0,26	2,14
Cry	0,067	0,36
StatusLow	0,073	3,45
StatusMedium	0,617	2,57
StatusHigh	0,898	2,899
Pos_rel	6,689*	20,78***
Neg_rel	0,228	7,31
Index_Social impact	3,16	16,74***
Index_Social preference	4,96*	4,17
Index_Social aggressiveness	4,96*	4,17
First_impact	0,05	6,74*
EffSize	5,27*	17,87***
Efficiency	25,04***	0
Size	7,18*	0
Ties	22,75***	0
Ordered pairs	7,18*	0
Density	25,71***	0
nBroker	26,5***	0
nEgoBe	0,018	0
Alpha	3,03	18,096***
Beta	0,914	18,209***
Isolated Oct		0,562
Invisible Oct		1,45
Average Oct		3,83
Popular Oct		1,831
Lambda: Connectors Oct		2,642
Lambda: Bridges Oct		1,066
Cliques Oct		2,63

* significant for $\alpha=0.05$; ** significant for $\alpha=0.01$; *** significant for $\alpha=0.001$.

In October the members of *cliques* show a particularly high propensity to build positive ties, while the relevance of *Size*, *Ties*, *Pairs*, *Density*, *EffSize*, as well as the low aggressiveness, highlights the relevant social competence of this group (Figure 6).



* The figure shows only the significant values according to the Median test.
Figure 6. Median test: weights of significant measures related to the roles (*cliques*)*

In December, moreover, a difference between *embedded* and *integrated* children arises. The *embedded* are those who have a strong propensity to belong to groups. These pupils have the highest values for almost all computed measures. They build many positive relationships rather than negative ones. They are reference points (β -parameter) for others and are also sociable (α -parameter). They, indeed, contact other pupils but are also often contacted by others. The *integrated* pupils have quite equal positive and negative ties. Furthermore, they have a higher propensity to sociability α -parameter rather than to be reference points β -parameter.

5. Conclusions

In this paper the development of social roles among children, focusing on peer-to-peer relationships, is analysed by means of NA methodology. The aim is both to detect the presence of social roles and explore the structure of the relationships among children. We carried out our research employing the method of direct observation since at this age there is a considerable gap between verbal and relational competence.

In our findings, even if the networks of October and

December are really different, we detect a coherent evolution in the relational structure and role building. The network of December shows an increasing relevance of *brokers*' and *reference points* or *popular* children. We notice only few *isolated* children and high levels of interaction among pupils. This implies an increasing specialization in the individual roles even among children aged 3-5.

NA methods, notably *lambda sets* and *cliques*, allows detecting suggestive relational dynamics, not necessarily similar to the traditional sociometric status. Only the *regular* equivalence procedure, instead, provides similar results to those already known in literature.

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