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Original Article

Study of network process in children during cooperation games

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Abstract
While playing, the child progresses in reasoning ability, develops thinking and other skills, creates social relations, understands the environment, develops knowledge and creativity, and satisfies desires (Dallabona& Mendes, 2004). Thus, playing "increases their independence, stimulates their visual and auditory sensibility, values their popular culture, develops motor skills, exercises their imagination, their creativity, socializes, interacts, rebalances, recycles their emotions, their need to know and reinvent, and thus builds their knowledge" (Dallabona& Mendes, 2004, p.4). However, the interaction with a medium that is still unknown requires the child to explore new spaces, new situations, and new contexts, watching for visible behavioral changes, acquiring patterns of communication and interaction with each other (Martins, Clemente,& Mendes, 2015), all of which is essential for the child's development.The aim of the present study was to analyze the variance between groups of different sizes in different playful games of cooperation. The groups were randomly formed and consisted of groups of 5 (G5) or 10 (G10) members.In the results obtained, it was possible to verify that there are no significant differences in the groups of 5 and 10 children in the values of proximity prestige, whereas in centroid value statistically significant differences were found in the comparison between groups of 5 and those of 10 children, regarding interaction in the cooperation games.
Key-words: adjacency matrices; graph theory; network;cooperation;playful activities; games

Introduction

The game/play is one of the most common behaviors in a child (Neto, 2007), allowing one to know his/her body, to explore his/her surroundings, to identify social roles, and to acquire new motor skills (Dias & Mendes, 2012). In the game, children manifest wants and desires (Souza, 2013) and learn to live together, to know how to do things and how to be. Play encourages curiosity, self-confidence, and independence. It also provides the development of thought, concentration, and language, including moral and cultural values, preparing them to face the social environment that surrounds them (Melo & Silva, 2012).

The progress of the relationship with the other occurs simultaneously with the development of cognitive, physical, social, and linguistic capacities, making interactions more complex (Williams, Mastergeorge, & Ontai, 2010). Thus, the experience of cooperative situations helps the child to relate positively to games at school and in the family (Mendes, Paiano, & Filgueiras, 2009).

In cooperative games, children play to overcome challenges and obstacles, not to win or lose. They play for pleasure and satisfaction, seeking interaction with others and participation of all (Brotto, 2006). When playing in groups, the child learns to live with the other and develops some feelings, such as respect and affection (Melo & Silva, 2012).

In turn, play and playful activity allow the child to have freedom of action and to feel satisfaction in performing tasks. It involves the child in the activities, since the act of playing is an inherent practice in the child: it is children's form of reflecting, of working, and of discovering the world that surrounds them (Dallabona & Mendes, 2004). Thus, playful activities enable children to communicate with themselves and with each other, establishing social relationships and building knowledge. Through the discoveries and experiences of creativity, children can observe, express, evaluate, and transform reality (Dallabona & Mendes, 2004). To maintain balance with the world, children need to play, to create, and to invent (Dallabona & Mendes, 2004).

Silva (2014) conducted a study with 24 children, of ages between 4 and 6, 7 girls and 17 boys. The study focused on the construction of puzzles in group, in different sessions, where it was possible to verify that puzzle construction in group can be a strategy that allows the development of cooperation of children in

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preschool ages. The results achieved in the experimental groups showed positive changes in the cooperation behaviors between the first session (pre-test) of building puzzles in group and the last (post-test). However, it should be noted that, as the sessions progressed, the groups improved the times of achievement and consequently became more effective in performing them. The limitation of that study was the absence of data that measured cooperative play among preschool children, which would allow for comparisons (Silva, 2014).

Oliveira, Clemente, and Martins (2016) conducted a study with 10 children, 5 girls and 5 boys, of a preschool. The study focused on the interactions that occurred in the playground, with interaction defined as all time spent in play, in conversation, or in other situations of being face-to-face with peer(s). All observations were made on the playground for three weeks, on the same day of the week, using two cameras. In the results of this study, it was verified that the boys were more social during the activities in the playground, presenting higher levels of centrality. The boys were found to be more likely to play in groups were more apt to be recruited to play, while girls were more intimate with their friends (Oliveira, Clemente, & Martins, 2016). The limitation of that study was that the sample was small and might have compromised the results obtained.

There is currently no clear identification of the influence recreational play has on children of these ages, especially with regard to the size of the group and the ability to induce children to interact amongst themselves, hence the need for the present study. The present study analyzes the variance between groups, with different number of elements, in the different playful games of cooperation, through Social Network Analysis.

Material & methods

Participants

The group consisted of 10 children, 5 girls and 5 boys (boys: n = 5, 5.8 ± 0.4 years old of age, 117.8 ± 6.1cm of height, 21.6 ± 4.8 kg of body mass index) (girls: n = 5, 5.6 ± 0.5 years old of age, 116.8 ± 3.1 cm in height, 19.3 ± 2.1 kg of body mass index) who attend weekly a physical and motor expression class at the Coimbra Education School.

In order to be able to carry out the study with the children, the caregivers were informed in advance, signing an informed consent, knowing what was intended to be done with their students. The present study followed the international recommendations for the study in humans in accordance with the Declaration of Helsinki.

Procedures

This study focused on child interaction in cooperative games, in groups with different numbers of elements. The cooperative games used were chosen and planned according to the target audience and study objective. There were four games – “Don't let it fall”; “Hugh me”; “The more gifts the better” and “Free Game”– Each of the games ended as soon as they were timed 5 minutes. The game "Don't let it fall" consisted in the children passing the ball to someone, without the ball falling. Every time a child received the ball, they would catch it and pass it to a colleague randomly and moved to the place of the colleague to whom they passed the ball. Being that the one that received the ball, stayed in its place until passing the ball to somebody and only then does he go to the place of the colleague who passed the ball. In the game of "Hug me" the children run freely through a space and as soon as they heard the sound of a whistle, they stopped running and looked for a colleague of their choice to hug and so on. The game "The more gifts the better" consisted of children placing their cards in the arches of their colleagues. There were 10 cards of different colors, there being 30 cards of each color. Each child corresponded to a color and that same color corresponded to the color of the card they would place in the arches of their colleagues, thus placing as many cards as they could. It is worth mentioning that the cards would all be together in one box in the middle of the field, where each child had to move to the box to take the card that corresponded to their color. They could only take one card at a time. Lastly, it´s worth mentioning that "Free Game" consisted in allowing children to play freely, without rules or orientations. In the field there was a sponge ball at the disposal, being able to use it how they see fit. All the children participated in the activity.

The games were held with Groups of 5 (G5) elements and groups of 10 (G10) elements. Each game was held twice, once with the group of 10 elements and another with two groups of 5 playing simultaneously - one group is in one half of the field and the other in the other half. Thus, it is possible to verify the interactions of the children, considering the number of elements of each group.It'sworth mentioning that the groups were formed randomly, considering the groups was placed the same number of boys and girls were dividedby group not allowing the existenceof gender differences.

However, before starting the study, a class was used to familiarize the children with the games and with the two cameras so that they could be environmentally friendly and contact with what they did not know, not conditioning the study. Twocameras were used in two different angles of the field, so that children and games could be filmed with more need and in a broader way.

The study was carried out for four weeks, one day a week, in the classes of physical and motor expression, held at the Coimbra Education School.

Network analysis

We recorded in weighted adjacency matrices the interactions between colleagues, codified as number of passes. In this study we classified weighted graphs and weighted digraphs. The network measurements have

been processed with the Social Network Visualizer (SocNetV, version 1.9.) that is a software that allow to visualize the graphs and compute the network measurements (Kalamaras, 2014; Oliveira, Clemente & Martins, 2016). Proximity prestige was used to check how close are all the other teammates to a specific player. The notion of the distance between two nodes is considered the geodesic distance. Centroid value was used to test the probability of a player to be functionally capable of organizing clusters in the team. The games "Don't let it fall", "The more gifts the better" and "Free Game" are analysed with weighted digraph formulas. The game "Hugh me" is the only one who use weighted graph formulas to be analysed.

Proximity Prestige

Proximity prestige represents the child more recruited by the peers and is usually the closest one that can establish relationships with the other. It allows to identify the importance that the player has in a team and allows to identify the children who are closer to their peers.

Definition 1. (Schramm 2012; Clemente, Martins & Mendes 2016) Let n_i be a vertex of unweighted digraph G with n vertices. The proximity prestige index, $P_p(n_i)$, of the vertex n_i, is the proportion of vertices who can reach n_i to the average distance these vertices are from n_i,and is determined by

$$P_p(n_i) = \frac{\frac{I_i}{n-1}}{\frac{\sum_{\substack{j=1 \\ j\neq i}}^{n} d(n_j, n_i)}{I_i}}$$

where I_i is the number the vertices that are either directly or indirectly connected to n_i and $d(n_j, n_i)$ is the shortest path between vertices $n_j$and n_i.

Remark: In weighted digraph the proximity prestige index is determined the similar form that unweighteddigraphs, considering $d^w(n_j, n_i)$.

Centroid value

Centroid value is the child who is most likely to interact with peers, being better positioned to be considered more important during games. Thus, a child with a high centroid value compared to the centroid mean value will be more involved in the games.

Definition 2. (Scardoni & Laudanna 2012; Clemente, Martins & Mendes 2016)Given one G unweighted graph with n vertices. The centroid value$C_{Ce}(n_i)$, of a vertex n_i is determined by

$$C_{Ce}(n_i) = \min\left\{f(n_i, n_j) : n_j \in V - \{n_i\}\right\}$$

where $f(n_i, n_j) = \gamma_{n_i}(n_j) - \gamma_{n_j}(n_i)$, and $\gamma_{n_i}(n_j)$ is the number of vertex closer to n_i than to n_j, i.e. $\gamma_{n_i}(n_j) = \left|\{n_k \in V: d(n_i, n_k) < d(n_j, n_k)\}\right|$.

Remark: (Scardoni & Laudanna 2012; Clemente, Martins & Mendes 2016)The centroid value is applied the similar weighted graphs and weighted digraphs.

Statistical procedures

The number of elements of group (group of 5 and group of 10 elements) was defined as factor for the analysis of differences between G5 and G10. Proximity prestige in the weighted digraph situation and Centroid value in the weighted graph and digraph situations were the dependent variables. Independent-samples t-test was applied to compare the proximity prestige scores for G5 and G10. Preliminary analysis was performed to ensure no violation of the assumptions of normality and Levene's test for equality of variances (Pallant, 2011). The effect size (ES) to independent t-test, Cohen's d was executed as ES measure using the follow criteria: small effect ($d \leq 0.2$); moderate effect ($0.2 < d \leq 0.8$); and large effect ($d > 0.8$).

Mann-Whitney Test was applied to compare the Centroid value for G5 and G10. For the case of non-parametric tests is obtained (Pallant, 2011): $\frac{|z|}{\sqrt{N}}$where N is the total sample and the value of z that is reported after apply the Mann-Whitney test. The classification of effect size is obtained by using of the follow criteria (Pallant, 2011): very small ($r < 0.1$); small effect ($0.1 \leq r < 0.3$); medium effect ($0.3 \leq r < 0.5$); and large effect ($r \geq 0.5$).

SPSS software (version 24.0, Chicago, Illinois, USA) was used to compute the statistical procedures. A Statistical Package for Social Sciences(SPSS) significance of 5% was defined.

Data collection and analysis/Statistical analysis

An observer training occurred to avoid mistakes and to improve the reliability of the data. The reliability of the results represents the degree of confidence or accuracy that can be obtained in the information collected (Fink, 1995). Thus, in order to record the interactions between children, a careful and accurate analysis of each of the videos was necessary. In order to be able to know its truth and meet the required conditions, inter-observer validation was realized, with an 81%, using Cohen's Kappa, being one of the most used indexes(Fonseca, Silva & Silva, 2007).The interactions were verified through the videos and it is considered an interaction when one child passed the ball to another, when they hugged the colleague or when they placed their cards in the arches of their colleagues.

Social Network Analysis was used in the construction of matrices of adjacency for each game and for each group (G5 and G10). A number is distributed to each child to be identified by the same number in all games, thus allowing its construction.

Results

The comparison of proximity prestige scores between G5 (M= 0.34; SD=0.181) and G10 (M=0.379 and SD=0.153) showed no significant statistical differences (t(58)=-0.906, p-value= 0.369, d=0.234,moderate effect size).

For the case of the comparison of centroid values between G5 (Md=-2.5) and G10 (Md= -3.5) showed significant statistical differences (MW= 464.5, z=-3.301, p-value= 0.001, r= 0.369, medium effect size).

Discussion

The different groups were analyzed through the proximity prestige and centroid value metrics, so that it was possible to verify if there were differences according to the variance of the number of elements per group (G5 and G10) in relation to the interactions in the cooperation games.

No significant statistical differences were observed between the group of 5 (G5) and the group of 10 (G10) at the level of the proximity prestige; that is, no differences were found between the number of members per group and the nature of their interactions while the games were running, thus being balanced.

However, the same did not happen at the centroid value level. There, significant statistical differences were found regarding the size of the different groups and the children's interactions with each other. These results are in line with Hanish and Fabes (2014), who found boys and girls having lots of time to play with children of the same gender, thus sparing little time to play with other children of the opposite gender. In turn, both boys and girls acquire different experiences, learn and develop skills and interests in interaction with children of the same gender. It should be noted that over time these preferences among peers of the same gender tend to become stronger (Hanish & Fabes, 2014). The present study presents some limitations in relation to the size of the sample and the size of the different groups, and may compromise the data obtained.

Conclusions

The present study found no significant statistical differences in the proximity prestige comparison between the 5and 10child groups, showing no differences in the size and variance of both groups and in the interactions in the long cooperation games. However, at the centroid value level significant statistical differences were found in the comparison of the groups of 5 versus 10 children with regard to the interactions in the different games. Thus, future studies should consider a larger sample and a larger number of groups.

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