FACULTY OF SPORT AND EDUCATION

Advanced Modelling of Ludomotor Games

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Abstract

Pierre Parlebas is a French professor in sport sociology, mathematician, psychologist, but above everything, a physical education (PE) teacher. He pursues the study of society from the structures of the games. He proposes the Motor Praxiology in order to study the motor action, which is oriented by a logic of a specific situation. As a good scientist he started looking for objective measurable variables, elements that could lead to the understanding of the effects of the internal logic of the situations.

Parlebas understands the PE as the education of the motor conduct which is created by a motor action and its meaning. According to him, the situations of the sporting games orient the motor conduct of the players, and consequently, their motor action.

The curiosity as a PE teacher to understand sporting games, due to their power to orientate the motor conducts, pushed him to build mathematical models of ludomotor games, that is, models of the objective structures of the internal logic of games which took the name of universals. A model is a simplified representation of a given reality which is generally designed to study, explain or predict phenomena. Universals were models proposed by Pierre Parlebas, maybe, the specific knowledge that PE teachers need in order to carry out their job: educate the motor conduct.

As a future PE teacher,I also feel the same curiosity as Parlebas did. If I want to be a good PE teacher, should not I understand the logic of the situations of the games?. Knowing that the motor action represents the common denominator of all the physical practises and confers its own identity to the PE, I consider necessary to know all the possibilities, effects and functioning of the sporting games.

In this project we are going to continue with the modelling activity suggested by Parlebas but using modern computational resources, in other words, we are going to make advanced modelling of the ludomotor games. For that, we are going to analyse a game called 4 corners, a game easy to model and already modelled by Parlebas in 1973. Our proposal covers two main elements: 1) the study of the mathematical analysis of the 4 corners game and its integration. 2) a new approach for the observation and utilization of computational tools to do that analysis.

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1 Introduction

It can be said that the modelling of ludomotor games can be the scientific knowledge that the physical education (PE) teachers need in order to carry out their job: educate the motor conduct. Moreover, the models of games contain the specific knowledge of the PE field, since they are the resource that defines the basis of every single motor action. A model is an abstract and simplified representation of a given reality (game, society). As simulations, models are generally designed to study and explain observed phenomena or to predict future phenomena (Bandini et al., 2009).

Ludomotor Universals are mathematical models suggested by Pierre Parlebas in order to develop a scientific mathematical framework for the study of the internal logic of sporting games. Pierre is a French professor in sport sociology, mathematician and psychologist. He was named professor in the ENSEP (L'École normale d'Éducation physique, 1965-1975) and later in the INSEP (Institut national du sport et de l'Éducation physique 1975-1987) (Martínez-Santos, 2014). Although he has reached the highest positions at university and studied many degrees, we can not forget that above everything, Parlebas is a PE teacher. He suggests the study of society from the structures of games, which are analysed mathematically using graphs. For that, he proposes the Motor Praxiology in order to study the motor action, which is oriented by the internal logic of a specific situation (Parlebas, 2010).

A sporting game is a motor situation of codified confrontation called game or sport by social instances. Each sports game is defined by a rule system that determines its intern logic (Parlebas, 2012b, p. 276). However, the internal logic is just an abstract concept that has not any importance if we do not contextualise it properly. The motor action as a characteristic of a game, consists in the process of producing the motor conduct of the players. That is, the result of the emotions and whims of the player. But as we have said before, the internal logic of a game has the capacity to orient the action (Parlebas, 2010), which means that the internal logic is able to intervene in the action of the players. Consequently, games can create favourable conditions for reaching our objectives, for instance, cause new and unexpected interactions between the players (Parlebas, 1996).

In this way, we are more interested in the characteristics of the game than in the player's ones. The obligations of the internal logic derived from the rules establish filters that channel the action of the players (Parlebas, 1996). Therefore, games must be analysed in order to know what are the limits and possibilities that each of them offers to the players. Games have a real pedagogic power (Parlebas, 1996) that can help with learning transfer, one of the main priorities of any PE teacher or educator (Parlebas, 2012b, p. 460).

But the effects of the transfer are not only limited to a biomechanical, physiological, technical environment, but they can intervene in the behaviours of the students, semiotor attitudes, affective and relational facts and basically, in the motor decision conducts (Parlebas, 2012b, p. 460). In other words, the learning transfer will help students to face their future problems and situations as they are going to have the capacity to face them thanks to their past behaviours and action: the best adaptation to the present is in the past behaviours (Parlebas, 2012b, p. 460). Without that influence, every past experience would be for nothing. There would not be learning, nor education.

After all this, can we consider models of games helpful resources to be better PE teachers? The modelling of the universals can allow us to analyse the objective structures that the internal logic of the game contains, that is, the elements that can be objectively identified in all games, in this case, from a mathematical frame. In other words, there are some structures that are specifically held in some games, but there are other ones that can be found in most of them: universals (Parlebas, 2003, p. 154).

In this case, we are not dealing with etnomotricity. We could think that if every game is in essence equal, there are not cultural differences between different societies since the games that reflect their culture are basically identical. Every motor conduct is related to a cultural sense and the internal logic of the games is bounded to the culture of a society. When children play games, they are learning about their society, and reflecting their culture (Parlebas, 2003, p. 157).

Universals represent broad categories and not exact and rigid elements that can accept so many different structures, that is, the cultural, ethical and political characteristics of a society do not disturb the concept of universals, but they reinforce the fact that despite the differences of societies, universals can be identified in the games of every culture (Parlebas, 2003, p. 160).

2 Towards a Praxiological Physical Education

"Physical education is an intervention practise that influences the motor conducts of the participants according to the implicit or explicit education rules. That regulated influence provokes a transformation of the motor conducts, a process that places the learning transfer in the centre of the concerns of the PE teacher" (Parlebas, 2012b, p. 172).

PE can have a deep effect in the personality and development of the children (Parlebas, 2009) since the motor conduct involves all the dimensions of the pupil: biological, affective, cognitive and relational. That is the reason why games play a primary role in the socialization process of children and adolescents. So, it is important to expose their characteristics and functioning mechanisms (Parlebas, 2012a).

Any ludomotor activity has some components that must be quoted and described in order to understand their effect in the motor action.

2.1 Internal Logic: the essence of the game

In the world of arts, the intern logic of a work of art is the framework that defines the limits of the reality in which the work is exhibited, and it lasts from the beginning until the end of the story.

The internal logic of games is somehow the same. Parlebas (2012b) defines it as a system of relevant features of a motor situation, and the consequences that it involves for the realization of the corresponding motor action. In other words, the intern logic is a system of obligations, a kind of framework that limits the action of the players during the game.

The rules of a game reflect the characteristics of its internal logic. There are three important components of the internal logic that help us have a better understanding of games themselves: interaction of motor cooperation, interaction of motor opposition and spatial uncertainty (Parlebas, 2009). Motor cooperation refers to a intervention of help or support, for instance between two team mates or two climbers. Instead, motor opposition corresponds to the antagonistic actions between volleyball or tennis adversaries.

Cooperation and/or Opposition interactions
There are games that do not require any partners or adversaries. They are called psychomotor games (pole vault, juggling, weightlifting). On the other hand, there are games that need to be played with partners, adversaries or both. These games are called sociomotor games (4 corners, handball). Sociomotor games require interaction of cooperation and/or opposition. The action of the other players become an element to consider in the game.

Players have to be able to foresee the adversary's movements and cooperate with their partners without showing their intentions. For instance, in the 4 corner game, each player has to be constantly observing other player's behaviour in order to make the right decision and do not loose the game.

Spatial Uncertainty

Games can be developed in certain or uncertain spaces. The certain environments instead, do not require to process information from the environment, as the space has been prepared for that activity (athletics). But the uncertain ones require to constantly observe the environment and make decisions based on that observations (nature sports). These decisions are going to be reflected in the player's motor conduct.

When there is a lack of uncertainty, the motor conduct will always be the same, for instance, the long jumper will always do the same acceleration, the same jump and the same landing. The player does not have to face the lack of foresight or take different and new decisions and he/she is going to be able to develop automatisms (Parlebas, 2009).

However, when there is uncertainty, the player has to choose what is the best motor conduct for him or her. That is, when the environment is constantly changing or is unknown the player has to be always ready to receive and process information from the outside elements in order to be able to redirect and transform that informations into motor conducts (Parlebas, 2009).

Classification of the sporting games

The combination of the mentioned 3 components of the internal logic define the groups that classify every sporting game. The letter C refers to a motor action of cooperation, the letter A to a motor action of opposition, and the letter I to the spatial uncertainty. The absence of any of the components will be symbolised with an underlined corresponding letter. For instance, $\underline{C}A\underline{I}$ represents absence of team mate and uncertainty, and presence of adversary: boxing, tennis or judo 1.

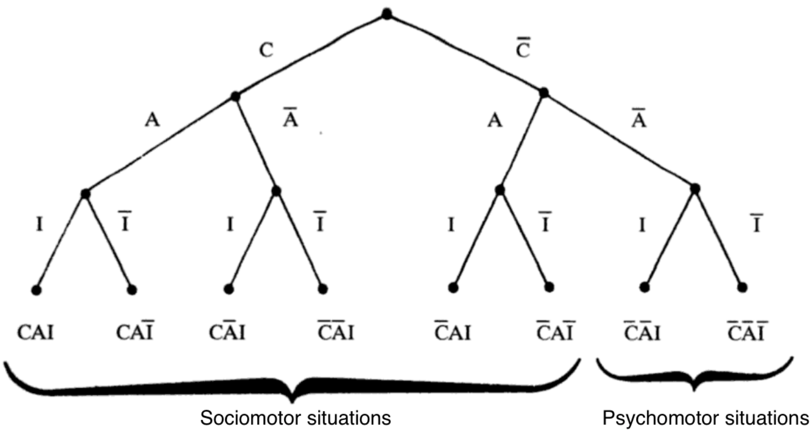

Figure 1: Classification of the motor situations (Parlebas, 2012b, p. 61)

2.2 External Logic: an individual logic

Each person, each social group can interpret the activities according to their motivations and feelings. That is, the internal logic of the games can be reinterpreted from outside by an external logic that give new meanings to it. Each individual perception is faced by the players according to their cognitive capacities (Parlebas, 2012b, p. 307). In other words, the external logic of the game is the group of characteristics of the player that affect the way of playing, that is, the motor conduct. Values, culture, personality and gender are examples of external logic elements.

So, it can be said that the internal logic and the external logic of games kind of orientate the motor conduct of the players. Both logics play the role of a filter, that based on the rules of the game, limit the conducts of the players. Expressed differently, it can be said that the internal and external logics distribute the probabilities of the action of the players, operating as the conduct control system that Ferreira et al. (2009) mention in their text.

The action of the players during a game can look disordered and anarchical, but behind them there is an organization that gives the game an internal coherence: under the superficial disorder, there is a deep order (Parlebas, 1970).

So, are the behaviours of the players predictable before the game? Can we know how is going to play each player? Perhaps. It can be thought that the conduct of the player is already established before the game, but it is not really like that. The conducts of the players come from schemas, most of the time improvised at the moment by the player, that are objectively predefined (Parlebas, 2003, p. 153). Each player has its own identity, autonomy and

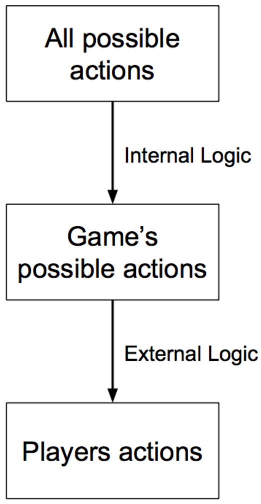

Figure 2: The impact of the external and internal logic in the action of the players

capacity to decide, but the action is channelled by an internal logic that orientates the action (Parlebas, 2010).

The play action is not random since from the beginning of the game it is being limited by the rules of that game. However, something that is not random does not have to be determined. The motor conduct is unpredictable because we are immersed in an ocean full of wish and choice (Martínez-Santos, 2014).

2.3 Universals

Are then games pure mathematical probabilistic distributions? Based on the previous analysis of the internal and external logic, it can be said that there are two main filters that distribute the probabilities. The first filter is the internal logic and the second one the external logic. However, in this case, we are going to put aside the second one and we are going to focus on the first one.

The internal logic of a game is related to the rules of that game. Among all the relevant characteristics of the internal logic, there is a little group of objective structures that have been mathematically formalised in models (Parlebas, 2003, p. 151).

Those models are called universals, operational models that represent the basic structures of the functioning of any sporting game and that include its internal logic (Parlebas, 2012b, p. 463).

The aim of the modellization of universals is to describe the functioning mechanism of the sporting games and predict some of their consequences. Once we understand the functioning of a situation, we can intervene more profitably and effectively both during and in its results (Parlebas, 2012a).

That models are called universals, "operational models that represent the basic structures of the functioning of any sporting game and that include its internal logic" (Parlebas, 2012b, p. 463). Parlebas distinguishes 7 universals whose characteristics are summarized in the table 1:

Table 1: Relevant characteristics of the motor universals (Martínez-Santos, 2007)

	notional nucleus	**formalisation**	**ruled**
Motor comunication network	direct interactions	graph	yes
Mark interaction network	direct interactions	graph	yes
Pointing system	direct interactions	graph	yes
Sociomotor role change network	motor action units	graph	yes
Sociomotor subrole change network	motor action units	graph	yes
Gestemic code	indirect interactions	code	no
Praxemic code	indirect interactions	code	no

Parlebas wanted to build a single model for each game, but finally he could not find a way to do it, so he had to make use of various systems that each of them represented a specific characteristic of the ludomotor situation: motor communication network, punctuation graph, role system (Parlebas, 2003). This relevant characteristics of the sporting games are not obstructed by each other, but they are related and organized in coherent systems that create the ludomotor universals (Parlebas, 1990).

However, there is a significant characteristic that divides the first 5 universals and the last 2 in different groups. That difference is the origin of the universal, which means that the first 4 universals are originated in the rule system and the last 2 by the motor action. The universal that is remaining can be considered to be in the middle of both groups, but we will talk about it in another case.

The universals originated in the rules can be easier to model as the rules give us all the information about them. Moreover, we do not need to observe players because their interactions and decisions do not affect those universals. We could call them static universals since they do not never change and provoke artificial actions that can be logically predicted thanks to the rule system.

Instead, the last two universals, which are originated in the motor action, are constantly affected by the players, their interactions and decisions. In this case, they should be called dynamic universals as they are build during the game and provoke difficultly unpredictable actions by the rules. In this case, it is obvious that if we want to model these two universals, we have to observe real games and make use of that data in order to build dynamic models and actually understand them.

In conclusion, both types of universals can be useful for understanding the functioning of the internal logic. The analysis of the first type of universals represents an easier task since all the information resides in the rules, whereas the second group challenges us to make use of advanced computational resources that were not available at the time that universals were discovered in order to model them.

3 Objectives of the study

There are two main objectives in this study. First of all, we are going to study the mathematical analysis of the 4 corners game that Parlebas did in 1973 and its possibilities of integration in a computational environment. Secondly, we are going to propose a new approach for the observation and utilization of modern computational tools to do that analysis. In other words, we want to build an informatics tool for the processing of real data from the game and use that tool in a real observation case. Furthermore, the aim is to present and manage empirical data from the real observations of the 4 corners game.

4 Perspectives of modelling

4.1 Why model?

Modelling can be the key for understanding games as it is said to be the most effective resource for the approach of complex systems such as games. Consequently, researchers take advantage of complementary resources such as informatics and programming to analyse that kind of complex systems. In fact, computer simulation uses computational models in order to gain additional insight of systems behaviour (e.g. biological, social). Moreover, these resources make easier to evaluate elements, as they can be observed without bringing them in the real world (Bandini et al., 2009).

A computer simulation uses a computational model to gain additional insight into a complex system (social systems, games). Generally, computer simulations are used as predictive or exploratory instruments (Gilbert and Troitzsch, 2005) as it can be seen in the description of the figure 3.

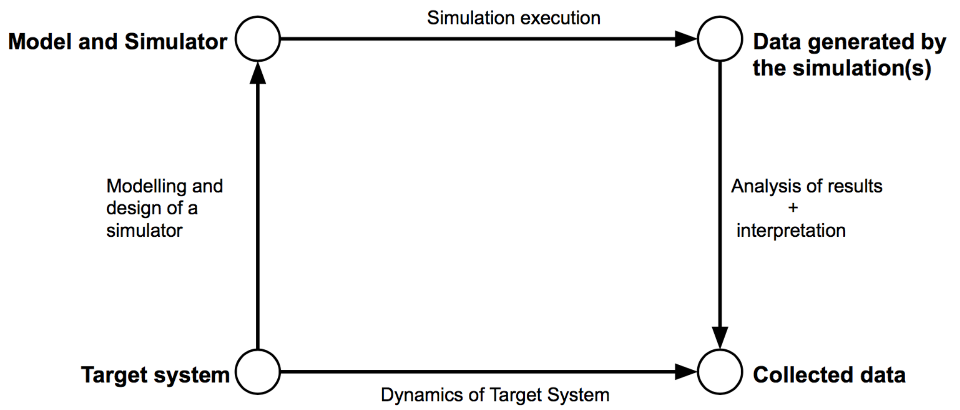

Figure 3: A general diagram describing the usage of simulation as a predictive or explanatory instrument.

However, there is a tendency to think that the aim of modelling is only prediction. Prediction can be a goal but there are many other reasons to build a model (Epstein, 2008).

- Explain
- Guide data collection
- Suggest analogies
- Discover new questions
- Reveal the apparently simple (complex) to be complex (simple)

There is growing interest in extending complex systems approaches to the social sciences (Marion, 1999). This interest is reflected in the literature and journals of social sciences that are adopting multi-agent simulation in research (Goldspink, 2000). Moreover, many traditional methods of research adopt linear concepts of causality and consequently fail to attempt or even obscure complex sources of order. That is why it is being increasingly argued that agent based simulation offers one path forward (Gilbert and Conte, 1995; Axelrod, 1997; Troitzsch, 1997).

Parlebas proposed models of ludomotor games in order to understand better logics of the situations. That models are mathematical representations of ludomotor games based on action and interaction systems, that is summaries of a examined situation (Parlebas, 2012a).

Technology has dramatically developed during the last decades, and today, we have the opportunity to design more advanced models of ludomotor games. This means that we can include variables that when Parlebas designed his models in 1973 were difficult to make use of, for instance, the observed interactions between real players during a game.

Therefore, we are going to propose an approach of the models suggested by Parlebas but using modern computational resources, in other words, we are going to make advanced models of ludomotor games. For that, we are going to analyse the 4 corners game, a game easy to model and already modelled by Parlebas in 1973. The analysis of modelling the interactions of the players during the 4 corners game. For that, he had to model the type of interaction that the 4 corner has, that is, the spatial displacements of the players.

4.2 A model of a ludomotor game: 4 corners

Pierre Parlebas analysed the logical-mathematical structures of the traditional game 4 coins (Parlebas, 1973, 1974) in order to bring out the richness of the logical system of the game. With this he started an interdisciplinary connection between mathematics and physical education, between mathematics and the science of the motor action (Parlebas, 1973).

The analysis was divided in 3 parts: the search of a model, the group structure and equivalence classes between the substitution groups (Parlebas, 1973).

The search of a model

In the 4 corner game, the playing court has a specific organisation. There are 4 posts plus the intermediate post, which is located at the centre of the rectangle that the 4 main posts create. The 5 players of the game have to fight for the conquest of the privileged 4 post in order to avoid staying in the centre post. So, the space is crucial since winning or loosing depends on where the player is located, a polarized space that will cause territorial behaviours in the players.

There are two ways of playing the game: the strict modality and the free modality. In the strict modality all the players have to abandon their corner in each play. That is, when the player of the central post says "Now!", all the players have to move to a different corner. With reference to the free modality, each player can move whenever he/she wants. That is, the plays are not controlled by the player of the central post, but any of the players can move among the posts.

In order to represent these ludic dispositions in a diagram, the 4 corners are associated with tags (A, B, C, D) and the central post with the letter Z. The graph represents the spatial changes that the players of each corner have made. For instance, John, who was in the corner A, moved to the corner B; Lisa was in the corner B and she moved to the corner D; Maria was in the corner D and moved to the corner A; Jack, who was in the central post moved to the corner C. Finally, Peter who was in the corner C could not find any free corners, so he had to move to the central post Z.

In the diagram 4 we can distinguish 5 different individual displacements of each player. Each individual displacement is associated with 2 posts: the leaving post and the arrival post. For example, the displacement of John is associated with the posts A (leaving) and B (arrival).

The 5 individual displacements of each player create what Parlebas calls the

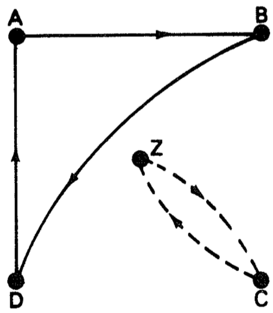

Figure 4: Graph of a collective displacement.

collective displacement and it represents one play of the game. Figure 4 represents one collective displacement in the form of a graph. This graph is associated with a matrix (table 2) whose cells indicate the couples that are related to the collective displacement: if there is a 1 in the cell, that interaction between players is associated with the collective displacement; if there is a 0 there is not relationship with that displacement.

Table 2: Matrix associated to the graph of the figure 4.

	A	B	C	D	Z
A	0	1	0	0	0
B	0	0	0	1	0
C	0	0	0	0	1
D	1	0	0	0	0
Z	0	0	1	0	0

So, the arches represent a summary of the route that each player does, they do not actually show the real displacement of the players. These arches are determinant for the study of the motor conduct of the players since the graph does not show the association level between the leaving post and the arrival post, but the reason that lead to move from one post to another.

Group structure

A collective displacement corresponds to a bijection, which in the mathematical language is called permutation. The concept of permutation is ambiguous:

- A permutation is a state, in this case, a distribution of the players among the posts.

- A permutation is a substitution (transformation) a passage from one state to another, in this case, a collective displacement.

Each substitution represents a game unit in the case of the 4 corner game, which means that the plays of the game are based on the transformations (collective displacements). Once having the game unit, is possible to calculate the combinatory evidence of the transformations. Firstly, we have to enumerate all the possible transformations that can be done during the game: the number of possible substitutions is equal to the effect factor, in our case, the number 5. So, the number of possible substitutions is 120. The 120 substitutions have an internal binary composition. This chaining operation is associative as there is a neutral element. These properties define a characteristic algebraic structure: the structure of the group.

In conclusion, the observations during the the show that during the 4 corner game a mathematical structure is updated: the structure of the group. Moreover, the use of graphs in the 4 corner game lead to the conclusion that the motor conducts of the players are actually related to spatial trajectories.

Equivalence classes between the substitution groups

As we have seen, there are 120 possible substitutions starting from a reference permutation. These substitutions can be organised in families of equivalence, that is, in types. The possibility to organize all the possible substitutions in types, allows calculating their theoretical frequency. In this way, we get a control value and we can compare the random frequencies with frequencies observed during a real 4 corner game.

Going backwards to the graph (figure 4), if we observe the displacements we can see that some displacements trace a track that ends in the leaving point. It is a circular track called circuit (or cycle in the permutations language). For instance, the substitutions of the figure 4 create 2 circuits: one of them has 3 vertices and 3 arches, so, it is a circuit of degree 3. The other circuit is a circuit of degree 2 since there are 2 vertices and 2 arches.

In relation to the circuits, there is a general rule that is applicable to every possible permutation of the 4 corner game: all the substitutions can be split up in separated circuits from degree 1 to 5. These circuits are crucial for the analysis of the motor conduct since they reflect the interactions between the players, the loses and wins in the motor communication the motor dialogues etc. For example, a circuit of degree 2 between 2 players of any corner represent a motor communication of cooperation. Instead, a circuit that concerns the player of the central post represent a case of motor counter-communication.

In conclusion, the main characteristic of the substitutions is the number of circuits of the graph and their degree. So, based on these circuits we can classify the circuits in families as it can be seen in the table 3.

Table 3: Cyclic equivalence classes that correspond to the 120 collective displacements of the 4 corners game.

Classes	Les différents partages de 5	Classes d'équivalence cycliques correspondantes	Effectifs des classes
C_1	5= 1+1+1+1+1	(5, 0, 0, 0, 0)	1
C_2	1+1+1+2	(3, 1, 0, 0, 0)	10
C_3	1+2+2	(1, 2, 0, 0, 0)	15
C_4	1+1+3	(2, 0, 1, 0, 0)	20
C_5	1+4	(1, 0, 0, 1, 0)	30
C_6	2+3	(0, 1, 1, 0, 0)	20
C_7	5	(0, 0, 0, 0, 1)	24
			120

4.3 Advanced modelling: Agent Based Models (ABM)

Games are social systems. Agent-based models are particularly used to study and analyse topics like decision-making, local-global interactions and effects of heterogeneity (emotions, gender, sport practice) in the system (Bandini & Vizzari 2009). Therefore, the use of agent-based simulations allows researchers or teachers to create advanced models of ludomotor games, representing a huge improvement in Physical Education.

Agent based models for simulation are characterized by the presence of agents performing some kind of behaviour in a shared environment. This approach is increasingly pursued since it is ideally suited to exploration of the implications of non-linearity in system behaviour.

There are various types of models: mathematical models, conceptual models and physical models. The mathematical model is based on variables and mathematical functions that describe the elements and their relations. Instead, the conceptual models make use of concepts to indicate the elements and linking arrows in order to establish and describe the relations. Finally, in a physical model, there are physical objects and the spatial arrangements between them (Peters et al., 1998).

Agent Based Models can be considered models of complex systems and this approach considers that simple and complex phenomena can be the result of interactions between autonomous and independent entities (agents, players) which operate with different modes of interaction (Bandini et al., 2009). So, the basic elements of a model are: agents, the environment and the mechanisms of interaction.

Agents

Agents are defined as real or abstract entities that are able to act on themselves and their environment. Agents can communicate with other agents and their behaviour is a result of their observations, knowledge and interactions with other agents (Ferber, 1999, p. 249). If we compare this with a player of a ludomotor game, we can consider the player as an entity that acts on itself and its environment. The player can communicate with other agents and its motor conduct is a result of its observations, knowledge and interactions with other agents.

Environment

In the specific context of simulation, the environment is responsible for (Weyns et al., 2007):

- Reflecting/managing the structure of the physical/social arrangements of the system
- Maintaining internal dynamics
- Defining/enforcing rules

Transforming this into praxiology, the environment of a game is the combination between the rules and the intern logic of that game. The intern logic of a game defines the interactions between the players (social arrangements) and the spatial environment (physical arrangements). Apart from that, the rule system defines the rules of a specific games.

Interaction

Interaction is a key aspect in ABM. Most of the definitions of agents emphasize the fact that agents should be able to interact with their environment and other agents in order to solve problems or simply reach their goals. Moreover, the essence of an ABM is the fact that global system dynamics emerges from the local behaviours and interactions (Bandini et al., 2009). In other words, complex system such as games are based on the interactions and behaviours of the player, so, if we want to understand the game we have to understand the players.

As mentioned in the previous paragraphs, the elements of a model fix perfectly with the ones of the games, obviously, because games are complex systems based on player interactions. In conclusion, modelling, particularly agent based modelling can help in the way to understanding games and consequently, players.

5 Advanced modelling of the 4 corners game

5.1 Modelling with NetLogo

NetLogo is a multi-agent programmable modelling environment. Today, it is used by tens of thousands of students, teachers and researchers worldwide. It is a dialect of the Logo language, specifically designed for modelling phenomena characterized by a decentralized, interconnected nature (Bandini et al., 2009). NetLogo creates simulations that consist in a cycle which chooses and performs an action for every agent (turtles in Netlogo environment), considering its current situation and state (Bandini et al., 2009).

In our case, after learning how to program with this environment, NetLogo v5.2.1 was used to create two different models of the 4 corners game: a random model and a real model. The random model did not use the collected data as the collective displacements were performed randomly. In the case of the real model, the collected data was imported into the model, so the turtles of the model illustrated the real displacement of the players.

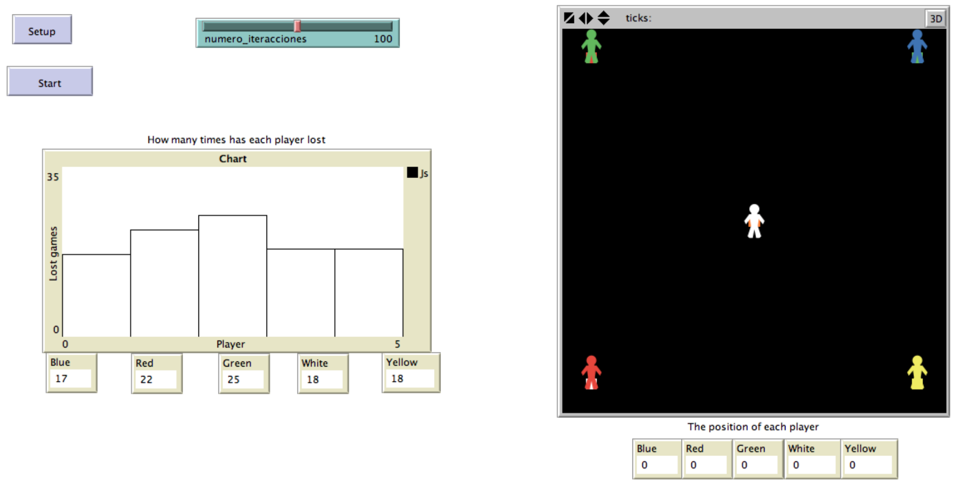

Figure 5: The random model of the 4 corner game in NetLogo.

As it can be seen in the figure 5, the models consist of 2 main elements: the animation (right side) and the statistical chart (left side). The animation aimed to show in a visual way the collective displacements and the statistical chart showed how many time each player lost a game, that is, moved to the central post.

It has to be said, that the developed models are available for everyone as any user can download the NetLogo program, copy the code (click here) and run both models. This allows any PE teacher to be able to do the same observation with his/her students and import the data to the models we have designed. The only thing it has to be done is copy the code and import the data collected.

However, NetLogo does not offer the optimal resources in order to model universals. It is a brilliant way of visualising the observed real games and an interesting tool for taking the first steps towards the modelling of games. In our case, we wanted to go further, in search of a effective tool that could really mathematically formalise the 4 corner game in an advanced model: R.

5.2 Modelling with R

R is a programming language an environment for statistical computing and graphics. It provides a wide variety of statistical (linear and non-linear modelling, classical statistical tests, time-series analysis, classification, clustering...) and graphical (well-designed publication-quality plots) techniques, and it is highly extensible. Many users think that R is just another statistical system like SPSS. However, R developers prefer to consider it as an environment where statistical techniques are implemented. R is available as Free Software in source code form and it runs on every platform and system. Moreover, there are thousands of packages that can extend the functions and utilities of R (The R Foundation).

The main advantage that R offers compared to SPSS for example, is that apart from containing all the statistical tools that SPSS has, it offers the creation of your own functions and automatise operation. With that, once you have designed a function or a set of statistical operations, you can share the code and anyone in the world can run the same function with only copying the shared code.

R offers more freedom and flexibility when dealing with big data and bigger statistical problems, and that is the reason why I have chosen this tool to build advanced models of ludomotor games.

The main objective of the analysis with R was to be able to import real game data and start getting statistical information of the observed rounds. For that R Studio v0.99.486 was used, a special R software interface for running the R code. The analysis structure consisted of 2 main functions. The first function was designed in order to analyse the game round data, particularly, the permutations (collective displacement). This function gives information about a specific game round, the characteristics of the players, the number of plays and the ID of each play (permutation) and some illustrations that show the interactions between the posts and the permutations during that game round.

Instead, the second function was designed focused on the players. This function gives information about the players of a specific game round: their statistics, personal characteristics, performed permutations etc. But apart from the statistical processing that this analysis structure offers for analysing real games, one of the most important characteristics of this system is the fact that it can be performed by anyone in the world. The use of programming code allows anyone in the world to copy the pieces of code that we have designed and repeat the same statistical analysis with different observations. That is, the R model that we have designed is easily reproducible by any other scientist or PE teacher since they only have to copy the code and import their observed games.

5.2.1 Data collection

The observations for the data collection were made in the Faculty of Sport and Education of the University of the Basque Country. A total amount of 60 subjects were observed during the observations. Each subject performed a mean of 4 ± 1 game rounds of 15 ± 5 plays lasting for 1 min and resting 1 min between the rounds. While subjects were resting, they were asked to observe and write down the data of the players that were playing at that moment.

The data collection was based on writing down the spatial changes among the posts that each player was doing during the game rounds. The observation was done in a specific observation sheet provided by us. The subjects that were observing had only to write down in the observation sheet the number of the post that the player was moving to. As it can be seen in the figure X, the posts were marked with a number, so the observers only had to write down the number of the post where the player they were observing had moved to.

Apart from the observation sheet, each subject was given an informed consent in order to be able to analyse and record them during the game and have some information about their characteristics. The questioner contained the following questions:

- Birth date
- Gender
- Do you practise any sport? If so, what sport do you practise?
- Have you ever played to the 4 corner game?
- What is your average mark at university/high school/school?

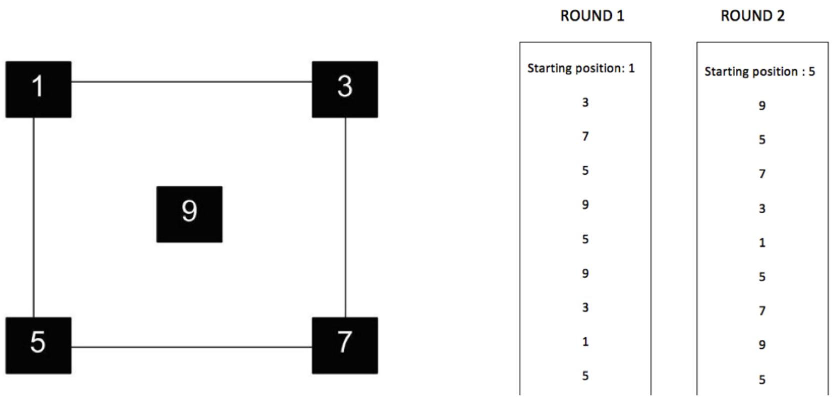

Figure 6: An ilustration of the field during the observations (left) and a part of an observation sheet (right).

Both documents had to be identified with an ID number, so the observation could be joined with the subjects characteristics.

In relation to the organization of the place and the material, some considerations were made in order to collect objective and exact data:

- The distance between the 4 corners had to be of 7.5 meters.
- Each corner had a rug with the corresponding identification number.
- There was one field per two groups.
- Each member of a group had to have an observer from the other group.
- A person recorded the game rounds using a Smartphone with a HD camera.

Regarding to the explanation, it was explained how was the 4 corner game played and what were the different ways of playing it. Afterwards, the questionnaire containing the informed consent and the data collection sheet were distributed. Additionally, a complete explanation about the following concepts was given: the informed consent, the questions and the observation procedure.

5.2.2 Data pre-processing

Once having the data collected, we pre-processed it in 3 different Excel documents. One of the document contained all the data of the plays performed during the game rounds: number of round, number of play and the spatial displacements of each subject. Another document included information about each game round: ID of the round, field, percentage of men-women, percentage of psychomotor-sociomotor sport players, mean age and the ID of each player. The third document included specific information about all the observed subject: ID of the subject, gender, sport practised and age. The merger element of the 3 documents were the ID of the game round and the ID of the subject. With those 2 ID all the collected data could be related.

Now we are going to see the analysis performed we are going to see the outputs that the difference functions offer. Due to the large amount of code involved in the data processing operations and functions, we are only going to see the output of each function. The source code of the function can be found in the appendix.

5.2.3 Analysis with R

First of all, we imported the collected and processed data (Excel documents) into R Studio. For that, we only had to call to the documents from inside the software and assign a name to each file. The file that contained information about the game rounds was called (infpart), the file that had information about the plays of the round was called (partidas) and the file that contained information about the players was named (jugadores). Each of the imported data sets can be seen in the following tables 4, 5 and 6.

Table 4: The data set named: infpart.

```
##   id ambito_practica sexo_grupo dep_grupo edad_grupo id_jugadorA
## 1  1      secundaria        0.4       0.8         13  jonsanchez
## 2  2      secundaria        0.6       0.6         15   josurruti
##   id_jugadorB id_jugadorC  id_jugadorD id_jugadorZ
## 1  anderortiz    mariaopo    saragarin susanamonte
## 2   jonagirre   andersoto alaznegoitia  luciaortiz
```

As it can be seen in the table 4, 2 game rounds have been imported. The first game round is from university students, 2 men and 3 women, 4 of them practise a psychomotor sport and 1 a sociomotor sport. The mean age is 20 ± 1 and each player has an ID. The second game round is also from university students. There are 3 men and 2 women, 4 of them practise a psychomotor sport and 2 of them a sociomotor sport. The mean age is 20 ± 1 and each player has an ID.

In the case of the table 5, it shows the plays that were performed during the two imported game rounds. During the first round 14 plays were performed and the spatial displacement in each play were observed.The ID of

Table 5: The data set named: partidas.

```
##    partida id jugada A B C D Z
## 1        1 NA      0 1 2 3 4 5
## 2        1 NA      1 3 4 5 2 1
## 3        1 NA      2 1 2 3 5 4
## 4        1 NA      3 5 3 1 4 2
## 5        1 NA      4 3 1 2 5 4
## 6        1 NA      5 2 4 3 1 5
## 7        1 NA      6 5 3 1 4 2
## 8        1 NA      7 3 4 5 2 1
## 9        1 NA      8 1 2 3 4 5
## 10       1 NA      9 5 3 2 1 4
## 11       1 NA     10 1 2 3 4 5
## 12       1 NA     11 3 5 4 2 1
## 13       1 NA     12 5 3 1 4 2
## 14       1 NA     13 1 4 2 3 5
## 15       2 NA      0 1 2 3 4 5
## 16       2 NA      1 5 3 2 1 4
## 17       2 NA      2 1 4 3 2 5
## 18       2 NA      3 5 3 1 4 2
## 19       2 NA      4 4 2 3 1 5
## 20       2 NA      5 3 5 4 2 1
## 21       2 NA      6 1 2 3 5 4
## 22       2 NA      7 3 5 2 4 1
## 23       2 NA      8 1 2 3 5 4
## 24       2 NA      9 5 3 1 4 2
## 25       2 NA     10 1 2 3 5 4
## 26       2 NA     11 5 3 2 1 4
## 27       2 NA     12 1 2 3 4 5
```

the permutations was not completed since it is going to be filled using an R function. In the second round 14 plays were performed and the spatial displacement of the players were also observed and written down.

Table 6: The data set named: jugadores.

```
##               id sexo   deporte edad
## 1   jonshanchez    h atletismo   12
## 2    anderortiz    h     esqui   12
## 3      mariaopo    m  escalada   12
## 4     saragarin    m atletismo   14
## 5   susanamonte    m    futbol   14
## 6     josurruti    h balonmano   14
## 7     jonagirre    h     tenis   14
## 8     andersoto    h     tenis   16
## 9  alaznegoitia    m    futbol   16
## 10   luciaortiz    m    futbol   16
```

In relation to the table 6, it shows the data set jugadores, where the characteristics of the player are stored. Each player's ID, gender, sport practise and age was stored in the data set.

Once having imported the data, the observed collective displacements were illustrated in frequency charts as it can be seen in the figure 7.

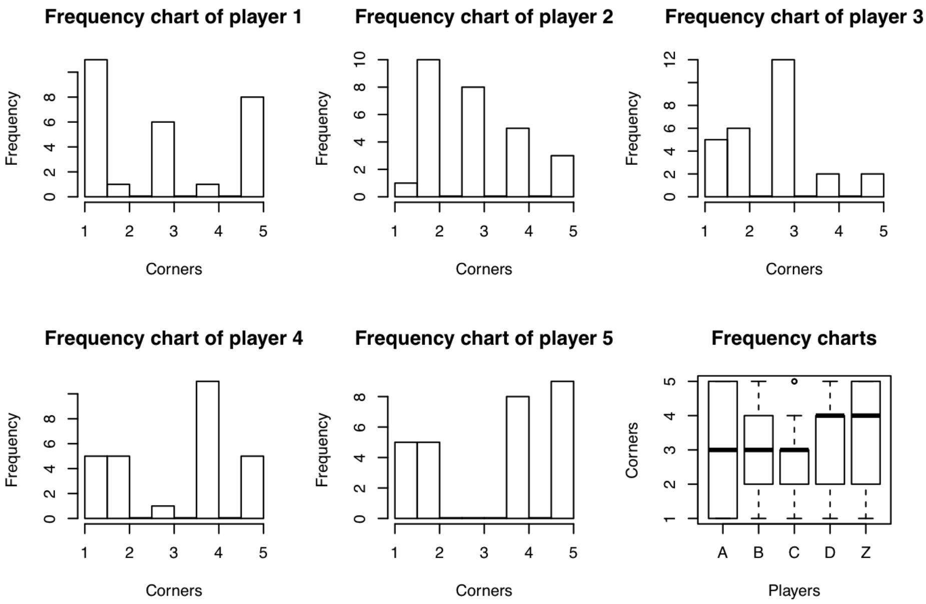

Figure 7: Frequency charts of the players of the game round 1.

Afterwards, we had to get a very important variable that was missing in the data set, which was the permutation's ID. For that, we built an specific function that automatically recognises the registered permutations with its corresponding ID.

As table 7 shows, the id column that was empty when we imported the data, is automatically filled thanks to the recognising function. Now our data set is complete for the analysis. The analysis of the 4 corners game was done designing two main R functions. The first function was focused on the permutations (collective displacements) and the second one on the players.

The function of the permutations aimed to show in a visual and organised way, the statistic data of each game round. To give an example of this, we can see the statistics of the game round 1 that can be seen in the figure 8. The output of the function is a list containing 5 elements:

1 General information of the game round: it contains the same informations that the infpart variable has.

Table 7: The data set partidas before (left) and after (right) applying the recogniser function

```
##    partida id jugada A B C D Z
## 1        1 NA      0 1 2 3 4 5
## 2        1 NA      1 3 4 5 2 1
## 3        1 NA      2 1 2 3 5 4
## 4        1 NA      3 5 3 1 4 2
## 5        1 NA      4 3 1 2 5 4
## 6        1 NA      5 2 4 3 1 5
## 7        1 NA      6 5 3 1 4 2
## 8        1 NA      7 3 4 5 2 1
## 9        1 NA      8 1 2 3 4 5
## 10       1 NA      9 5 3 2 1 4
## 11       1 NA     10 1 2 3 4 5
## 12       1 NA     11 3 5 4 2 1
## 13       1 NA     12 5 3 1 4 2
## 14       1 NA     13 1 4 2 3 5
## 15       2 NA      0 1 2 3 4 5
## 16       2 NA      1 5 3 2 1 4
## 17       2 NA      2 1 4 3 2 5
## 18       2 NA      3 5 3 1 4 2
## 19       2 NA      4 4 2 3 1 5
## 20       2 NA      5 3 5 4 2 1
## 21       2 NA      6 1 2 3 5 4
## 22       2 NA      7 3 5 2 4 1
## 23       2 NA      8 1 2 3 5 4
## 24       2 NA      9 5 3 1 4 2
## 25       2 NA     10 1 2 3 5 4
## 26       2 NA     11 5 3 2 1 4
## 27       2 NA     12 1 2 3 4 5
```

```
##    partida   id jugada A B C D Z
## 1        1 G010      0 1 2 3 4 5
## 2        1 G192      1 3 4 5 2 1
## 3        1 G041      2 1 2 3 5 4
## 4        1 G154      3 5 3 1 4 2
## 5        1 G207      4 3 1 2 5 4
## 6        1 G093      5 2 4 3 1 5
## 7        1 G154      6 5 3 1 4 2
## 8        1 G192      7 3 4 5 2 1
## 9        1 G010      8 1 2 3 4 5
## 10       1 G187      9 5 3 2 1 4
## 11       1 G010     10 1 2 3 4 5
## 12       1 G217     11 3 5 4 2 1
## 13       1 G154     12 5 3 1 4 2
## 14       1 G097     13 1 4 2 3 5
## 15       2 G010      0 1 2 3 4 5
## 16       2 G187      1 5 3 2 1 4
## 17       2 G031      2 1 4 3 2 5
## 18       2 G154      3 5 3 1 4 2
## 19       2 G022      4 4 2 3 1 5
## 20       2 G217      5 3 5 4 2 1
## 21       2 G041      6 1 2 3 5 4
## 22       2 G164      7 3 5 2 4 1
## 23       2 G041      8 1 2 3 5 4
## 24       2 G154      9 5 3 1 4 2
## 25       2 G041     10 1 2 3 5 4
## 26       2 G187     11 5 3 2 1 4
## 27       2 G010     12 1 2 3 4 5
```

2 Frequency of the permutations: it shows the permutations that have been done and their frequency during the selected round.

3 Adjacency matrix of the permutations: it shows the relationships between the different permutations that have been done in the selected round.

4 Adjacency matrix of the players: it shows the relationships between the 5 posts in the selection round.

5 Adjacency matrix between the players (J) and the corners (E): it shows the relationships between the players and the 5 posts.

Apart from the statistical data, the function shows 3 illustrations: 2 graphs that illustrate the interactions among the posts and the permutations, and 1 frequency chart of the players of that round.

If we observe the figure 9, we can see that the left graph shows the interac-

```
## [[1]]
##   id ambito_practica sexo_grupo dep_grupo edad_grupo id_jugadorA
## 1  1      secundaria        0.4       0.8         13  jonsanchez
##   id_jugadorB id_jugadorC id_jugadorD id_jugadorZ
## 1  anderortiz    mariaopo   saragarin susanamonte
##
## [[2]]
##
## G010 G041 G093 G097 G154 G187 G192 G207 G217
##    3    1    1    1    3    1    2    1    1
##
## [[3]]
##      G010 G192 G041 G154 G207 G093 G187 G217 G097
## G010    0    1    0    0    0    0    1    1    0
## G192    1    0    1    0    0    0    0    0    0
## G041    0    0    0    1    0    0    0    0    0
## G154    0    1    0    0    1    0    0    0    1
## G207    0    0    0    0    0    1    0    0    0
## G093    0    0    0    1    0    0    0    0    0
## G187    1    0    0    0    0    0    0    0    0
## G217    0    0    0    1    0    0    0    0    0
## G097    0    0    0    0    0    0    0    0    0
##
## [[4]]
##   1 2 3 4 5
## 1 0 3 2 4 4
## 2 1 0 4 4 4
## 3 5 3 0 3 2
## 4 2 6 2 0 3
## 5 5 1 5 2 0
##
## [[5]]
##     J_A J_B J_C J_D J_Z
## E_1   5   1   3   2   3
## E_2   1   4   3   3   3
## E_3   4   4   5   1   3
## E_4   4   4   1   6   5
## E_5  NA   1   2   2  NA
```

Figure 8: Output list of the function of the permutations.

tions between the posts during that specific game round. The central graph shows the same interactions, but in this case among the permutations that have been performed during that game round. Finally, the right chart shows the frequencies that each player among the posts.

Apart from the main two functions, a special matrix was build in order to store the frequencies of permutations of more than 1 game round. With this, a big data set of game round permutation frequencies could be stored and analysed as it can be seen in the figure 8 .

As figure 8 shows, the first column indicates the ID of the game round and the rest of the columns are permutations that have been performed at that round. The numbers of the columns are the number of times that each permutation has been performed at that round. In this case, we only tried

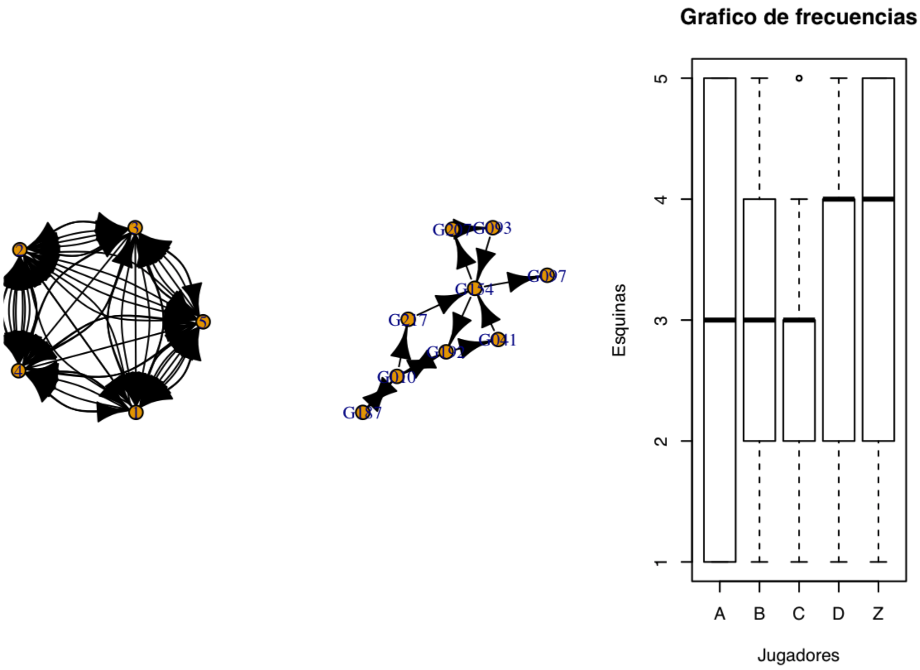

Figure 9: The ilustrations of the permutations function

Table 8: The frequencies of permutations of game rounds 1 and 2.

```
##
##     G010 G022 G031 G041 G093 G097 G154 G164 G187 G192 G207 G217
##   1    3    0    0    1    1    1    3    0    1    2    1    1
##   2    2    1    1    3    0    0    2    1    2    0    0    1
```

the analysis with two game rounds, but this matrix can store thousands of game rounds.

The second main function of the analysis with R is specifically related to the players. In this case, the outputs are 5 lists, each one corresponding to one player. Each list has a sub-list with the following elements:

1 Characteristics of the player: id, gender, sport practised and age.

2 Frequencies of the posts: the posts that the player has used and their frequencies.

3 Adjacency matrix of the interactions among the posts during that game round.

Apart from the lists and sub-lists, the function also can show graphically the frequencies of each player in the posts using a graph and a frequency chart.

Table 9: The list of player 1 from the output of the function

```
## [[1]]
## [[1]][[1]]
##            id sexo   deporte edad
## 1 jonshanchez    h atletismo   12
##
## [[1]][[2]]
## data_stat
## 1 2 3 5
## 8 2 8 8
##
## [[1]][[3]]
##   1 3 5 2
## 1 0 2 2 0
## 3 2 0 1 1
## 5 2 2 0 0
## 2 0 0 1 0
```

All the code of the analysis can be found in the appendix. Anyone that has installed the R Studio software can perform the same analysis since the code can be copied and pasted any time and anywhere.

6 Results and Discussion

A total amount of 3 groups of 5 subjects were used for the analysis. Each subject performed a total amount of 4 rounds. The performed rounds contained 15 $\pm$ 8 plays and had a duration of 1 min. In relation to the permutations, the players performed 80 different permutations. None of them was repeated in all the observed 12 rounds. The most repeated permutation was repeated 13 times and the less repeated one 1 time.

Table 10: General characteristics of the observed rounds

Number of rounds	4
Number of plays	15 $\pm$ 8
Duration of the rounds	1min
Rest between rounds	1min
Performed different permutations	80
Most repeated permutation	13 times
Less repeated permutations	1 time

Table 11: Permutations of the observed rounds

	Round 1	Round 2	Round 3	Round 4
Different permutations	35	33	30	25
Most repeated	4	3	3	3
Less repeated	1	1	1	1

As table 11 shows, 35 different permutations were done in the first rounds, 33 in the second rounds, 30 in the third ones and 25 in the last rounds.

Table 12: General characteristics of the observed groups

	Group 1	Group 2	Group 3
Different permutations	42	43	30
Most repeated	5	4	4
Less repeated	1	1	1

In relation to the groups (table 12), the first group did a total amount of 42 different permutations, the second group 43 and the third group 30. The most repeated permutation was done 5 times in the case of the first group and 4 times in the rest two groups. The less repeated permutations were performed only once.

In relation to the preferred posts of the players (figure 10), in the case of the group 1, player A, B, C and D generally preferred posts 1, 2 and 3, whereas player Z moved through posts 2, 3, 4 and 5 more frequently. In the case of

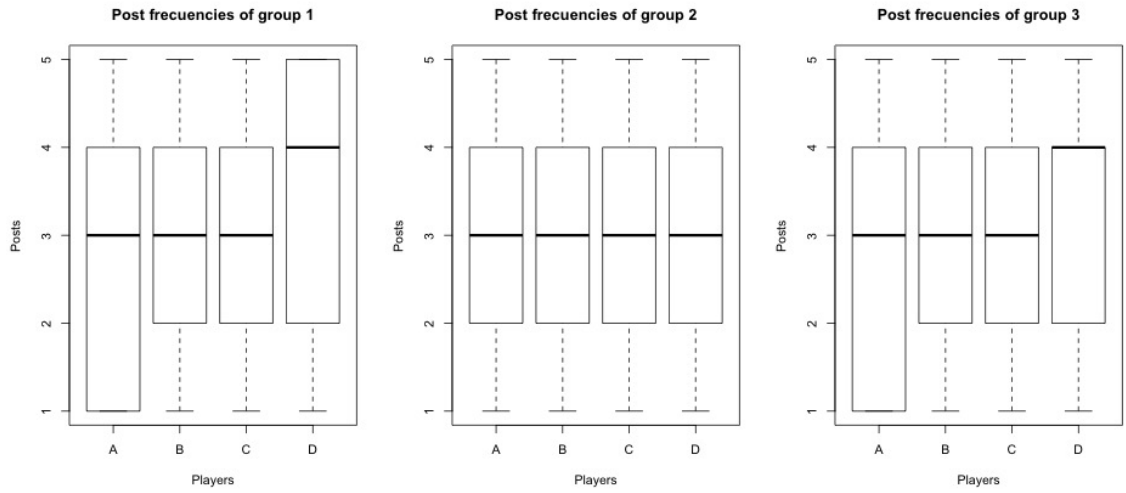

Figure 10: Post frequencies of the 3 observed groups

the second group, all the players moved through the same posts and finally in the third group, players B and C preferred the posts 2, 3 and 4; player A moved generally through posts 1, 2, 3 and 4; and player D generally moved through posts 2,3 and 4.

If we compare the differences between the rounds of all groups, we can say that as long as the rounds are played, the number of different permutations decrease, that is, the more the players play, the less the variability of the permutations is. This decrease in the diversity of permutations could be due to the fact that the players acquire experience and they know which are the most effective permutations, so they only perform the ones that prevent them from loosing the game.

If we go back to the theoretical part of the internal logic, we said that above the characteristics of the players, their values, wishes and culture, there is an internal logic that orientates the motor action of the players. As Parlebas said, the first time we see some players playing a game, we are going to see so many different actions, strategies and decision makings. But, if we keep observing, we will realise that suddenly, the same action starts to be repeated by different players and the motor action that was totally different and unique at first, starts being similar in all the players (Parlebas, 2003, 2012b).

So, the decrease in the diversity of permutations could be due to the learning process of the players. As long as they play, they learn, acquire experience and they know which is the most effective way to play.

Regarding the differences between the groups, the first group performed a total amount of 42 different permutations, the second group 43 and the third group 30. This differences in the amount of difference permutations, could be simply due to the different characteristics of the players like for instance: sport practised, gender, playing experience etc. Provided that the conclusion of the previous paragraph would be correct, that is, if the experience would be related with a decrease in the use of different permutations, the group 3 would be the group with the most experienced players and group 1 and 2 the less experienced ones.

However, the fact that only 3 groups were correctly observed, limited us to know which characteristics affect more to the diversity of the permutations. More groups should be observed and analysed in order to start differentiating the different playing styles in relation to the external logic of the players. Moreover,the relationship between the playing experience and the use of different permutations could be verified by analysing a bigger amount of players and groups.

7 Conclusions

After learning to program in more than 2 programming languages, getting into the statistical world and increasing my knowledge of physical education and motor praxiology, I can say that I am prepared to continue with the advanced modelling of the ludomotor games.

With regard to the scientific part, as Galileo Galilei said we have "measured what was measurable, and made measurable what it was not so." We have made an empirical research in the physical education field, a scientific study that could yield to the creation of a whole new scientific base for the education of the motor conduct.

This project has been just the introduction, a demonstration of the power of models. It has been a modest progress in the line of research of the models, but it will probably yield to start making more use o computational technologies and artificial intelligence. There is still a long way off...

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R Code for the 4 corners game

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June, 2016

R Studio was used in order to analyse and treat the collected data. In order to explain better how the analysis was done, we are going to show the pieces of code that allowed analysing the data.

First of all we imported all the observed data into R. For that, we saved the data in three different .csv files: player information, game information and plays information. Each user that wants to do the same analysis, has to import the files from his working directory and name them with the same names as it is done now.

```
# It is a package that is going to be used for the ilustrations
library(igraph)
```

```
##
## Attaching package: 'igraph'
##
## The following objects are masked from 'package:stats':
##
##     decompose, spectrum
##
## The following object is masked from 'package:base':
##
##     union
```

```
# General information
infpart <- read.csv("~/Documents/IVEF/Praxiologia/TFG/Excel/infpart.csv", sep=";")
```

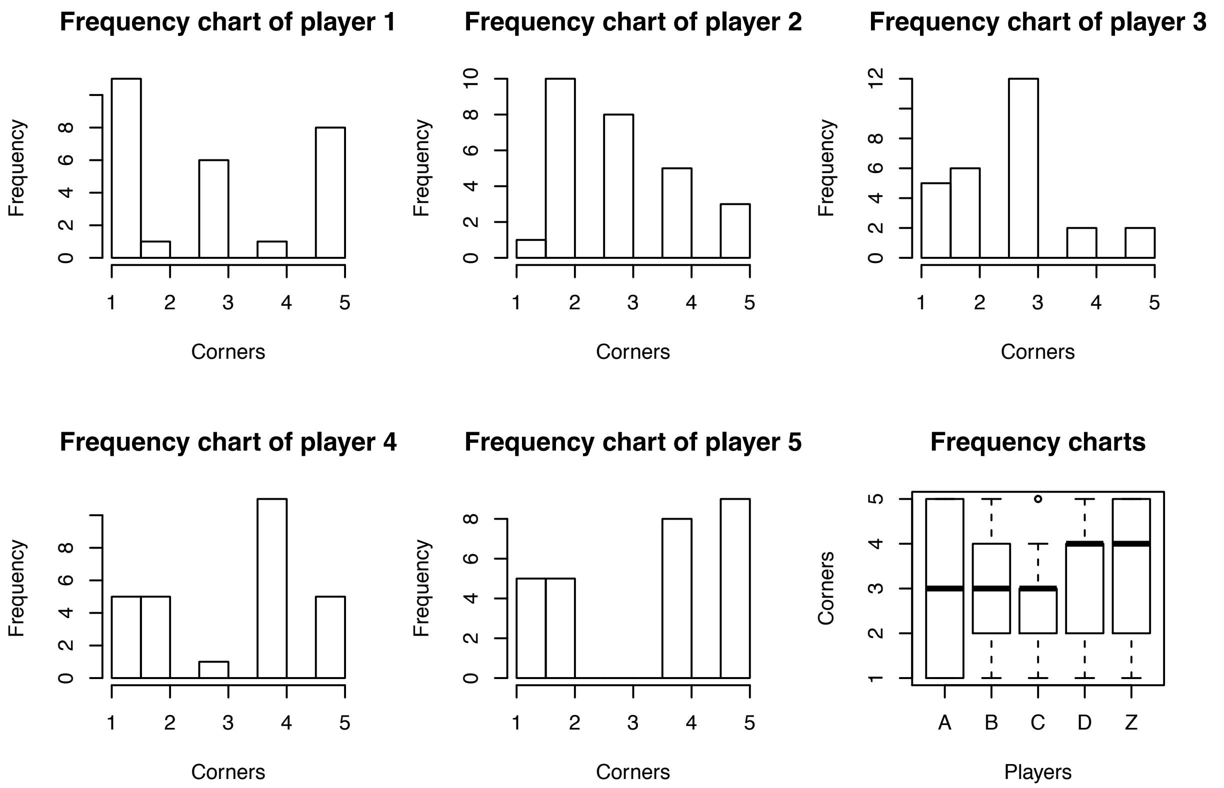
```
## Warning in read.table(file = file, header = header, sep = sep, quote =
## quote, : incomplete final line found by readTableHeader on '~/Documents/
## IVEF/Praxiologia/TFG/Excel/infpart.csv'
```

```
# Player data
jugadores <- read.csv("~/Documents/IVEF/Praxiologia/TFG/Excel/exceljug.csv", sep=";")

# Game data
partidas <- read.csv("~/Documents/IVEF/Praxiologia/TFG/Excel/partidas.csv", sep=";")
```

Once having the data in the R environment, the first thing we are going to do is to create some charts to visualize the data. There are frequency charts for each player's movements and a general graph that shows the interactions between the corners.

```
graphics <- function(x) {

  par(mfrow=c(2,3))
  hist(x$A, main = "Frequency chart of player 1", xlab = "Corners", ylab = "Frequency")

  hist(x$B, main = "Frequency chart of player 2", xlab = "Corners", ylab = "Frequency")
```

```
  hist(x$C, main = "Frequency chart of player 3", xlab = "Corners", ylab = "Frequency")

  hist(x$D, main = "Frequency chart of player 4", xlab = "Corners", ylab = "Frequency")

  hist(x$Z, main = "Frequency chart of player 5", xlab = "Corners", ylab = "Frequency")

  boxplot(x[,4:8], main = "Frequency charts", xlab = "Players", ylab = "Corners")

}

graphics(partidas)
```



Then we are going to recognise the ID of each permutation based on the analysis of Parlebas. For that we are going to use this function that automatically recognises every registered play. The output of the function is the same data frame of the game data, but with the identification number of each play.

```
recogn <- function(x){
      x[which(x$A== 1 & x$B== 2 & x$C == 3 & x$D == 4 & x$Z==5), "id"] <- "G010"
      x[which(x$A== 1 & x$B== 2 & x$C == 4 & x$D == 3 & x$Z==5), "id"] <- "G021"
      x[which(x$A== 4 & x$B== 2 & x$C == 3 & x$D == 1 & x$Z==5), "id"] <- "G022"
      x[which(x$A== 2 & x$B== 1 & x$C == 3 & x$D == 4 & x$Z==5), "id"] <- "G023"
      x[which(x$A== 1 & x$B== 3 & x$C == 2 & x$D == 4 & x$Z==5), "id"] <- "G024"
      x[which(x$A== 1 & x$B== 4 & x$C == 3 & x$D == 2 & x$Z==5), "id"] <- "G031"
      x[which(x$A== 3 & x$B== 2 & x$C == 1 & x$D == 4 & x$Z==5), "id"] <- "G032"
      x[which(x$A== 1 & x$B== 2 & x$C == 3 & x$D == 5 & x$Z==4), "id"] <- "G041"
      x[which(x$A== 5 & x$B== 2 & x$C == 3 & x$D == 4 & x$Z==1), "id"] <- "G042"
      x[which(x$A== 1 & x$B== 5 & x$C == 3 & x$D == 4 & x$Z==2), "id"] <- "G043"
      x[which(x$A== 1 & x$B== 2 & x$C == 5 & x$D == 4 & x$Z==3), "id"] <- "G044"
```

```
x[which(x$A== 2 & x$B== 1 & x$C == 4 & x$D == 3 & x$Z==5), "id"] <- "G051"
x[which(x$A== 4 & x$B== 3 & x$C == 2 & x$D == 1 & x$Z==5), "id"] <- "G052"
x[which(x$A== 3 & x$B== 4 & x$C == 1 & x$D == 2 & x$Z==5), "id"] <- "G061"
x[which(x$A== 1 & x$B== 5 & x$C == 4 & x$D == 3 & x$Z==2), "id"] <- "G071"
x[which(x$A== 4 & x$B== 2 & x$C == 5 & x$D == 1 & x$Z==3), "id"] <- "G072"
x[which(x$A== 2 & x$B== 1 & x$C == 3 & x$D == 5 & x$Z==4), "id"] <- "G073"
x[which(x$A== 5 & x$B== 3 & x$C == 2 & x$D == 4 & x$Z==1), "id"] <- "G074"
x[which(x$A== 5 & x$B== 2 & x$C == 4 & x$D == 3 & x$Z==1), "id"] <- "G075"
x[which(x$A== 4 & x$B== 2 & x$C == 5 & x$D == 1 & x$Z==3), "id"] <- "G076"
x[which(x$A== 2 & x$B== 1 & x$C == 5 & x$D == 4 & x$Z==3), "id"] <- "G077"
x[which(x$A== 1 & x$B== 3 & x$C == 2 & x$D == 5 & x$Z==4), "id"] <- "G078"
x[which(x$A== 1 & x$B== 4 & x$C == 5 & x$D == 2 & x$Z==3), "id"] <- "G081"
x[which(x$A== 3 & x$B== 2 & x$C == 1 & x$D == 5 & x$Z==4), "id"] <- "G082"
x[which(x$A== 5 & x$B== 4 & x$C == 3 & x$D == 2 & x$Z==1), "id"] <- "G083"
x[which(x$A== 3 & x$B== 5 & x$C == 1 & x$D == 4 & x$Z==2), "id"] <- "G084"
x[which(x$A== 1 & x$B== 3 & x$C == 4 & x$D == 2 & x$Z==5), "id"] <- "G091"
x[which(x$A== 3 & x$B== 2 & x$C == 4 & x$D == 1 & x$Z==5), "id"] <- "G092"
x[which(x$A== 2 & x$B== 4 & x$C == 3 & x$D == 1 & x$Z==5), "id"] <- "G093"
x[which(x$A== 2 & x$B== 3 & x$C == 1 & x$D == 4 & x$Z==5), "id"] <- "G094"
x[which(x$A== 4 & x$B== 1 & x$C == 3 & x$D == 2 & x$Z==5), "id"] <- "G095"
x[which(x$A== 3 & x$B== 1 & x$C == 2 & x$D == 4 & x$Z==5), "id"] <- "G096"
x[which(x$A== 1 & x$B== 4 & x$C == 2 & x$D == 3 & x$Z==5), "id"] <- "G097"
x[which(x$A== 4 & x$B== 2 & x$C == 1 & x$D == 3 & x$Z==5), "id"] <- "G098"
x[which(x$A== 1 & x$B== 5 & x$C == 3 & x$D == 2 & x$Z==4), "id"] <- "G101"
x[which(x$A== 3 & x$B== 2 & x$C == 5 & x$D == 4 & x$Z==1), "id"] <- "G102"
x[which(x$A== 1 & x$B== 4 & x$C == 3 & x$D == 5 & x$Z==2), "id"] <- "G103"
x[which(x$A== 5 & x$B== 2 & x$C == 1 & x$D == 4 & x$Z==3), "id"] <- "G104"
x[which(x$A== 1 & x$B== 4 & x$C == 5 & x$D == 3 & x$Z==2), "id"] <- "G111"
x[which(x$A== 4 & x$B== 2 & x$C == 3 & x$D == 5 & x$Z==1), "id"] <- "G112"
x[which(x$A== 5 & x$B== 1 & x$C == 3 & x$D == 4 & x$Z==2), "id"] <- "G113"
x[which(x$A== 1 & x$B== 5 & x$C == 2 & x$D == 4 & x$Z==3), "id"] <- "G114"
x[which(x$A== 1 & x$B== 2 & x$C == 4 & x$D == 5 & x$Z==3), "id"] <- "G115"
x[which(x$A== 5 & x$B== 2 & x$C == 3 & x$D == 1 & x$Z==4), "id"] <- "G116"
x[which(x$A== 2 & x$B== 5 & x$C == 3 & x$D == 4 & x$Z==1), "id"] <- "G117"
x[which(x$A== 1 & x$B== 3 & x$C == 5 & x$D == 4 & x$Z==2), "id"] <- "G118"
x[which(x$A== 4 & x$B== 1 & x$C == 2 & x$D == 3 & x$Z==5), "id"] <- "G121"
x[which(x$A== 2 & x$B== 3 & x$C == 4 & x$D == 1 & x$Z==5), "id"] <- "G122"
x[which(x$A== 3 & x$B== 1 & x$C == 4 & x$D == 2 & x$Z==5), "id"] <- "G131"
x[which(x$A== 3 & x$B== 4 & x$C == 2 & x$D == 2 & x$Z==1), "id"] <- "G132"
x[which(x$A== 2 & x$B== 4 & x$C == 1 & x$D == 1 & x$Z==3), "id"] <- "G133"
x[which(x$A== 4 & x$B== 2 & x$C == 1 & x$D == 1 & x$Z==3), "id"] <- "G134"
x[which(x$A== 1 & x$B== 3 & x$C == 4 & x$D == 4 & x$Z==5), "id"] <- "G141"
x[which(x$A== 5 & x$B== 2 & x$C == 4 & x$D == 4 & x$Z==1), "id"] <- "G142"
x[which(x$A== 2 & x$B== 5 & x$C == 3 & x$D == 3 & x$Z==1), "id"] <- "G143"
x[which(x$A== 5 & x$B== 1 & x$C == 2 & x$D == 2 & x$Z==4), "id"] <- "G144"
x[which(x$A== 4 & x$B== 1 & x$C == 3 & x$D == 3 & x$Z==5), "id"] <- "G145"
x[which(x$A== 5 & x$B== 1 & x$C == 2 & x$D == 2 & x$Z==4), "id"] <- "G146"
x[which(x$A== 1 & x$B== 5 & x$C == 2 & x$D == 2 & x$Z==3), "id"] <- "G147"
x[which(x$A== 4 & x$B== 2 & x$C == 5 & x$D == 5 & x$Z==3), "id"] <- "G148"
x[which(x$A== 1 & x$B== 5 & x$C == 4 & x$D == 4 & x$Z==2), "id"] <- "G151"
x[which(x$A== 3 & x$B== 2 & x$C == 5 & x$D == 5 & x$Z==1), "id"] <- "G152"
x[which(x$A== 2 & x$B== 4 & x$C == 3 & x$D == 3 & x$Z==5), "id"] <- "G153"
x[which(x$A== 5 & x$B== 3 & x$C == 1 & x$D == 4 & x$Z==2), "id"] <- "G154"
```

```
x[which(x$A== 4 & x$B== 5 & x$C == 3 & x$D == 2 & x$Z==1), "id"] <- "G155"
x[which(x$A== 3 & x$B== 1 & x$C == 5 & x$D == 4 & x$Z==2), "id"] <- "G156"
x[which(x$A== 1 & x$B== 4 & x$C == 2 & x$D == 5 & x$Z==3), "id"] <- "G157"
x[which(x$A== 5 & x$B== 2 & x$C == 1 & x$D == 3 & x$Z==4), "id"] <- "G158"
x[which(x$A== 1 & x$B== 4 & x$C == 5 & x$D == 3 & x$Z==2), "id"] <- "G161"
x[which(x$A== 4 & x$B== 2 & x$C == 1 & x$D == 5 & x$Z==3), "id"] <- "G162"
x[which(x$A== 5 & x$B== 1 & x$C == 3 & x$D == 2 & x$Z==4), "id"] <- "G163"
x[which(x$A== 3 & x$B== 5 & x$C == 2 & x$D == 4 & x$Z==1), "id"] <- "G164"
x[which(x$A== 5 & x$B== 4 & x$C == 3 & x$D == 1 & x$Z==2), "id"] <- "G165"
x[which(x$A== 2 & x$B== 5 & x$C == 1 & x$D == 4 & x$Z==3), "id"] <- "G166"
x[which(x$A== 1 & x$B== 3 & x$C == 5 & x$D == 2 & x$Z==4), "id"] <- "G167"
x[which(x$A== 3 & x$B== 2 & x$C == 4 & x$D == 5 & x$Z==1), "id"] <- "G168"
x[which(x$A== 3 & x$B== 5 & x$C == 4 & x$D == 1 & x$Z==2), "id"] <- "G171"
x[which(x$A== 2 & x$B== 4 & x$C == 5 & x$D == 1 & x$Z==3), "id"] <- "G172"
x[which(x$A== 2 & x$B== 3 & x$C == 1 & x$D == 5 & x$Z==4), "id"] <- "173"
x[which(x$A== 5 & x$B== 3 & x$C == 4 & x$D == 2 & x$Z==1), "id"] <- "G174"
x[which(x$A== 3 & x$B== 1 & x$C == 2 & x$D == 5 & x$Z==4), "id"] <- "G175"
x[which(x$A== 5 & x$B== 4 & x$C == 2 & x$D == 3 & x$Z==1), "id"] <- "G176"
x[which(x$A== 4 & x$B== 5 & x$C == 1 & x$D == 3 & x$Z==2), "id"] <- "G177"
x[which(x$A== 4 & x$B== 1 & x$C == 5 & x$D == 2 & x$Z==3), "id"] <- "G178"
x[which(x$A== 5 & x$B== 1 & x$C == 4 & x$D == 3 & x$Z==2), "id"] <- "G181"
x[which(x$A== 4 & x$B== 5 & x$C == 2 & x$D == 1 & x$Z==3), "id"] <- "G182"
x[which(x$A== 2 & x$B== 1 & x$C == 5 & x$D == 3 & x$Z==4), "id"] <- "G183"
x[which(x$A== 4 & x$B== 3 & x$C == 2 & x$D == 5 & x$Z==1), "id"] <- "G184"
x[which(x$A== 4 & x$B== 3 & x$C == 5 & x$D == 1 & x$Z==2), "id"] <- "G185"
x[which(x$A== 2 & x$B== 1 & x$C == 4 & x$D == 5 & x$Z==3), "id"] <- "G186"
x[which(x$A== 5 & x$B== 3 & x$C == 2 & x$D == 1 & x$Z==4), "id"] <- "G187"
x[which(x$A== 2 & x$B== 5 & x$C == 4 & x$D == 3 & x$Z==1), "id"] <- "G188"
x[which(x$A== 3 & x$B== 5 & x$C == 1 & x$D == 2 & x$Z==4), "id"] <- "G181"
x[which(x$A== 3 & x$B== 4 & x$C == 5 & x$D == 2 & x$Z==1), "id"] <- "G192"
x[which(x$A== 3 & x$B== 4 & x$C == 1 & x$D == 5 & x$Z==2), "id"] <- "G193"
x[which(x$A== 5 & x$B== 4 & x$C == 1 & x$D == 2 & x$Z==3), "id"] <- "G194"
x[which(x$A== 4 & x$B== 3 & x$C == 1 & x$D == 5 & x$Z==2), "id"] <- "G201"
x[which(x$A== 5 & x$B== 1 & x$C == 4 & x$D == 2 & x$Z==3), "id"] <- "G202"
x[which(x$A== 3 & x$B== 5 & x$C == 1 & x$D == 2 & x$Z==4), "id"] <- "G203"
x[which(x$A== 2 & x$B== 4 & x$C == 5 & x$D == 3 & x$Z==1), "id"] <- "G204"
x[which(x$A== 4 & x$B== 5 & x$C == 1 & x$D == 3 & x$Z==2), "id"] <- "G205"
x[which(x$A== 4 & x$B== 1 & x$C == 5 & x$D == 2 & x$Z==3), "id"] <- "G206"
x[which(x$A== 3 & x$B== 1 & x$C == 2 & x$D == 5 & x$Z==4), "id"] <- "G207"
x[which(x$A== 3 & x$B== 4 & x$C == 2 & x$D == 5 & x$Z==1), "id"] <- "G208"
x[which(x$A== 5 & x$B== 4 & x$C == 1 & x$D == 3 & x$Z==2), "id"] <- "G211"
x[which(x$A== 4 & x$B== 5 & x$C == 2 & x$D == 1 & x$Z==3), "id"] <- "G212"
x[which(x$A== 3 & x$B== 1 & x$C == 5 & x$D == 2 & x$Z==4), "id"] <- "G213"
x[which(x$A== 4 & x$B== 3 & x$C == 2 & x$D == 5 & x$Z==1), "id"] <- "G214"
x[which(x$A== 2 & x$B== 4 & x$C == 1 & x$D == 5 & x$Z==3), "id"] <- "G215"
x[which(x$A== 5 & x$B== 3 & x$C == 1 & x$D == 2 & x$Z==4), "id"] <- "G216"
x[which(x$A== 3 & x$B== 5 & x$C == 4 & x$D == 2 & x$Z==1), "id"] <- "G217"
x[which(x$A== 3 & x$B== 4 & x$C == 5 & x$D == 1 & x$Z==2), "id"] <- "G218"
x[which(x$A== 5 & x$B== 3 & x$C == 4 & x$D == 1 & x$Z==2), "id"] <- "G221"
x[which(x$A== 2 & x$B== 5 & x$C == 4 & x$D == 1 & x$Z==3), "id"] <- "G222"
x[which(x$A== 2 & x$B== 3 & x$C == 5 & x$D == 1 & x$Z==4), "id"] <- "G223"
x[which(x$A== 2 & x$B== 3 & x$C == 4 & x$D == 5 & x$Z==1), "id"] <- "G224"
x[which(x$A== 4 & x$B== 5 & x$C == 2 & x$D == 3 & x$Z==1), "id"] <- "G225"
```

```
      x[which(x$A== 4 & x$B== 1 & x$C == 5 & x$D == 4 & x$Z==2), "id"] <- "G226"
      x[which(x$A== 4 & x$B== 1 & x$C == 2 & x$D == 5 & x$Z==3), "id"] <- "G227"
      x[which(x$A== 5 & x$B== 1 & x$C == 2 & x$D == 3 & x$Z==4), "id"] <- "G228"

      return (x)}

partidas <- recogn(partidas)
```

After indentifying the permutations, our game data will be completed.

```
partidas
```

```
##    partida   id jugada A B C D Z
## 1        1 G010      0 1 2 3 4 5
## 2        1 G192      1 3 4 5 2 1
## 3        1 G041      2 1 2 3 5 4
## 4        1 G154      3 5 3 1 4 2
## 5        1 G207      4 3 1 2 5 4
## 6        1 G093      5 2 4 3 1 5
## 7        1 G154      6 5 3 1 4 2
## 8        1 G192      7 3 4 5 2 1
## 9        1 G010      8 1 2 3 4 5
## 10       1 G187      9 5 3 2 1 4
## 11       1 G010     10 1 2 3 4 5
## 12       1 G217     11 3 5 4 2 1
## 13       1 G154     12 5 3 1 4 2
## 14       1 G097     13 1 4 2 3 5
## 15       2 G010      0 1 2 3 4 5
## 16       2 G187      1 5 3 2 1 4
## 17       2 G031      2 1 4 3 2 5
## 18       2 G154      3 5 3 1 4 2
## 19       2 G022      4 4 2 3 1 5
## 20       2 G217      5 3 5 4 2 1
## 21       2 G041      6 1 2 3 5 4
## 22       2 G164      7 3 5 2 4 1
## 23       2 G041      8 1 2 3 5 4
## 24       2 G154      9 5 3 1 4 2
## 25       2 G041     10 1 2 3 5 4
## 26       2 G187     11 5 3 2 1 4
## 27       2 G010     12 1 2 3 4 5
```

Once having all the data, we are going to start with the analysis. The analysis has 2 main functions.

The first function gives us information about each round that was performed. The outputs of the first function are 2 charts and 1 graph about the game round and list that containes the following elements:

1 General information about the game round 2 Frequency of the permutations 3 Adjacency matrix of the permutations 4 Adjacency matrix of the corners 5 Corner frequency of each player

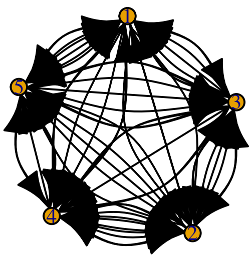
```
datos_partida <- function(x) {

  # Selecting the game round
  infpartx <- subset(infpart, id == x)
```

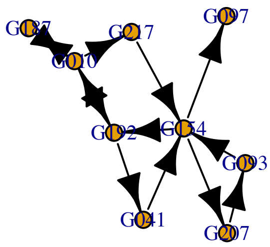
```r
partidax <- subset (partidas, partida == x)

matriz <- matrix(rbind(partidax$A, partidax$B, partidax$C, partidax$D, partidax$Z), ncol=1)

vertice <- matriz[1: (length(matriz)-5)]

node <- matriz[6: length(matriz)]

data <- cbind(vertice, node)

# Graph
g <- graph.data.frame(data, directed=TRUE)

# Adjacency matrix
adj <- as.matrix(get.adjacency(g))

# Frequency of the permutations
frecper <- table(partidax$id)

#  Graph and adjacency matrix of the permutations

vertice_per <- partidax$id[1:length(partidax$id)-1]
node_per <- partidax$id[2:length(partidax$id)]

data_stat_per <- cbind(vertice_per, node_per)

g_per <- graph.data.frame(data_stat_per, directed=TRUE)

adj_per <- as.matrix(get.adjacency(g_per))

# Corner frequency of each player

a <- as.matrix(table(partidax$A))
b <- as.matrix(table(partidax$B))
c <- as.matrix(table(partidax$C))
d <- as.matrix(table(partidax$D))
z <- as.matrix(table(partidax$Z))

lst <- list(a,b,c,d,z)

e <- unclass(do.call(cbind, lapply(lst, ts)))
tsp(e) <- colnames(e) <- NULL

colnames(e) <- c("J_A","J_B","J_C","J_D", "J_Z")
rownames(e) <- c("E_1","E_2","E_3","E_4","E_5")

# Charts
par(mfrow = c(1,3))

plot.igraph(g,vertex.label=V(g)$name, edge.color="black",edge.width=E(g)$weight)

plot.igraph(g_per,vertex.label=V(g_per)$name, edge.color="black",edge.width=E(g_per)$weight)
```

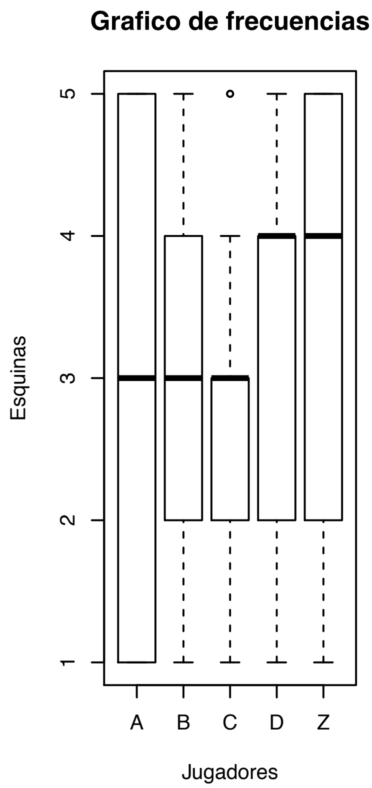
```
  boxplot(partidax[,4:8], main = "Grafico de frecuencias", xlab = "Jugadores", ylab = "Esquinas")


  # List with all the elements

  partida1 <- list(infpartx, frecper, adj_per, adj, e)

  setNames(partida1, "Informacion de la partida")


  partida1

}
```

So, if we apply this function to any game round, we will get all that information. For example, if we want to see the information of the game round 1, we have to write: datos_partida(1). Instead, if we want to see the information of the game round 2, we have to write: datos_partida(2). Here is an example of the information of game round 1:

```
datos_partida(1)
```








```
## [[1]]
##   id     ambito sexo.grupo deporte.grupo edad.grupo    id.JugA    id.JugB
## 1  1 secundaria        0.4           0.8         13 jonsanchez anderortiz
##    id.JugC   id.JugD     id.JugZ
## 1 mariaopo saragarin susanamonte
##
```

```
## [[2]]
##
## G010 G041 G093 G097 G154 G187 G192 G207 G217
##    3    1    1    1    3    1    2    1    1
##
## [[3]]
##      G010 G192 G041 G154 G207 G093 G187 G217 G097
## G010    0    1    0    0    0    0    1    1    0
## G192    1    0    1    0    0    0    0    0    0
## G041    0    0    0    1    0    0    0    0    0
## G154    0    1    0    0    1    0    0    0    1
## G207    0    0    0    0    0    1    0    0    0
## G093    0    0    0    1    0    0    0    0    0
## G187    1    0    0    0    0    0    0    0    0
## G217    0    0    0    1    0    0    0    0    0
## G097    0    0    0    0    0    0    0    0    0
##
## [[4]]
##   1 2 3 4 5
## 1 0 3 2 4 4
## 2 1 0 4 4 4
## 3 5 3 0 3 2
## 4 2 6 2 0 3
## 5 5 1 5 2 0
##
## [[5]]
##     J_A J_B J_C J_D J_Z
## E_1   5   1   3   2   3
## E_2   1   4   3   3   3
## E_3   4   4   5   1   3
## E_4   4   4   1   6   5
## E_5  NA   1   2   2  NA
```

If we want to see the permutations that have been performed in more than one game roun, we can see them in a matrix typing this code. The first column is the round number.The rest of the columns are permutations that have been performed and the number is the frequency.

```
frecuencias <- table(partidas$partida ,partidas$id)

frecuencias
```

```
##
##     G010 G022 G031 G041 G093 G097 G154 G164 G187 G192 G207 G217
##   1    3    0    0    1    1    1    3    0    1    2    1    1
##   2    2    1    1    3    0    0    2    1    2    0    0    1
```

The second function is related to the players. We can see their characteristics and game statistics by applying this function to the desired game round. The output of the function will be a list of 5 elements, each one corresponding to one player. That list, will have another sublist with 3 elements: 1 characteristics of the player, 2 post frequency of the player and an 3 adjacency matrix of the posts. Apart from the lists, there are also some graphs that ilustrate all this data.

```
jugadores_partida <- function(x){

  par(mfrow = c(1,2))
  dat_jA_partida <- function(x){

    partidax <- subset (partidas, partida == x)

    vertice <- partidax$A[1:length(partidax$A)-1]

    node <- partidax$A[2:length(partidax$A)]

    data_stat <- cbind(vertice, node)

    g <- graph.data.frame(data_stat, directed=TRUE)

    adj <- as.matrix(get.adjacency(g))

    numeros <- table(data_stat)

    jugadorA <- list(jugadores[1,], numeros,adj)



    plot.igraph(g,vertex.label=V(g)$name, edge.color="black",edge.width=E(g)$weight)

    hist(partidax$A, main = "Grafico de frecuencias jugador A", xlab = "Esquinas", ylab = "Frecuencia")
    jugadorA

  }

  dat_jB_partida <- function(x){

    partidax <- subset (partidas, partida == x)

    vertice <- partidax$B[1:length(partidax$B)-1]

    node <- partidax$B[2:length(partidax$B)]

    data_stat <- cbind(vertice, node)

    g <- graph.data.frame(data_stat, directed=TRUE)

    adj <- as.matrix(get.adjacency(g))

    numeros <- table(data_stat)


    jugadorA <- list(jugadores[2,], numeros,adj)

    plot.igraph(g,vertex.label=V(g)$name, edge.color="black",edge.width=E(g)$weight)

    hist(partidax$B, main = "Grafico de frecuencias jugador B", xlab = "Esquinas", ylab = "Frecuencia")
```

```
  jugadorA
}

dat_jC_partida <- function(x){

  partidax <- subset (partidas, partida == x)

  vertice <- partidax$C[1:length(partidax$C)-1]

  node <- partidax$C[2:length(partidax$C)]

  data_stat <- cbind(vertice, node)

  g <- graph.data.frame(data_stat, directed=TRUE)

  adj <- as.matrix(get.adjacency(g))

  numeros <- table(data_stat)

  jugadorA <- list(jugadores[3,], numeros,adj)


  plot.igraph(g,vertex.label=V(g)$name, edge.color="black",edge.width=E(g)$weight)

  hist(partidax$C, main = "Grafico de frecuencias jugador C", xlab = "Esquinas", ylab = "Frecuencia")

  jugadorA
}

dat_jD_partida <- function(x){

  partidax <- subset (partidas, partida == x)

  vertice <- partidax$D[1:length(partidax$D)-1]

  node <- partidax$D[2:length(partidax$D)]

  data_stat <- cbind(vertice, node)

  g <- graph.data.frame(data_stat, directed=TRUE)

  adj <- as.matrix(get.adjacency(g))

  numeros <- table(data_stat)

  jugadorA <- list(jugadores[4,], numeros,adj)


  plot.igraph(g,vertex.label=V(g)$name, edge.color="black",edge.width=E(g)$weight)

  hist(partidax$D, main = "Grafico de frecuencias jugador D", xlab = "Esquinas", ylab = "Frecuencia")
```

```
    jugadorA

  }

  dat_jZ_partida <- function(x){

    partidax <- subset (partidas, partida == x)

    vertice <- partidax$Z[1:length(partidax$Z)-1]

    node <- partidax$Z[2:length(partidax$Z)]

    data_stat <- cbind(vertice, node)

    g <- graph.data.frame(data_stat, directed=TRUE)

    adj <- as.matrix(get.adjacency(g))

    numeros <- table(data_stat)

    jugadorA <- list(jugadores[5,], numeros,adj)


    plot.igraph(g,vertex.label=V(g)$name, edge.color="black",edge.width=E(g)$weight)

    hist(partidax$Z, main = "Grafico de frecuencias jugador Z", xlab = "Esquinas", ylab = "Frecuencia")

    jugadorA

  }

  list(dat_jA_partida(x), dat_jB_partida(x), dat_jC_partida(x), dat_jD_partida(x), dat_jZ_partida(x))

}
```

If we would want to see the statistics of the players of the game round 1, we would have to type: jugadores_partida(1). We have not shown the output of this function since it is a lot of information and it can be better seen in the R Studio environment.