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APPLICATION OF GAME THEORY IN DESCRIBING EFFICACY OF DECISION MAKING IN SPORTSMAN'S TACTICAL PERFORMANCE IN TEAM SPORTS

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ABSTRACT

A mathematical method of decision-making in which a competitive or cooperative situation is analyzed to determine the optimal course of action for an interested "player" is often called game theory. Game theory has very broad application in different sciences. Team sports tactical performance is considered from the aspects of data processing theory and the phenomenon of selective attention, as well as from the game theory. Team sports tactical performance is an asymmetric, sequential (of imperfect information), non-zero-sum game. In decision making, predictability in team sports is in fact bargaining, and the player has to use a mixed strategy for choosing option with highest expected utility. Player could choose a trembling hand equilibrium, to eliminate imperfect equilibrium. Strategic dominance conceipt can explain that a player could choose strategy which dominates between other possible strategies, and/or could be led by "team reasoning", too. In this article, the level of predictability of the most frequent tactical performance of one player in a team sport game is considered, reflecting outcomes both for the same team's tactical performance (co-players in one player's team), as well as for the opponent team's tactical performance. Four different possible situations during team sport competition could lead to considering utilities of one player's specific decisions.

KEY WORDS

game theory, team sport, tactics

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INTRODUCTION

A mathematical method of decision-making in which a competitive or cooperative situation is analyzed to determine the optimal course of action for an interested "player" is often called game theory [1]. A game is any situation in which the outcomes ('pay-offs') are the product of interaction of more than one rational player. The term includes not only games in the ordinary sense, but a wide range of human interactions. Game theory studies situations where multiple players make decisions in an attempt to maximize their returns. The essential feature is that it provides a formal modelling approach to social situations in which decision makers interact with other agents.

Game theory has played, and continues to play a large role in the social sciences. Beginning in the 1970s, game theory has been applied to animal behaviour, including evolutionary theory [2]. Many games, especially the prisoner's dilemma [3], are used to illustrate ideas in political science and ethics. Game theory has recently drawn attention from computer scientists because of its use in artificial intelligence and cybernetics. The first known discussion of game theory was written by James Waldegrave in 1713. In 1838, Cournot considers a duopoly and presents a solution that is a restricted version of the Nash equilibrium [4]. But, game theory really exists as a unique field since John von Neumann published a series of papers in 1928 (he can rightfully be called the inventor of game theory). Von Neumann's work in game theory culminated in the book "The Theory of Games and Economic Behaviour" by von Neumann and Oskar Morgenstern [5]. This work contains the method for finding optimal solutions for two-person zero-sum games. During this time period, work on game theory was primarily focused on cooperative game theory, which analyzes optimal strategies for groups of individuals, presuming that they can enforce agreements between them about proper strategies.

In 1950, the first discussion of the prisoner's dilemma appeared, and around this same time, John Nash developed a definition of an "optimum" strategy for multiplayer games where no such optimum was previously defined, known as Nash equilibrium [6-8]. This equilibrium allowed the analysis of non-cooperative games as well as cooperative ones. Nash mathematically clarified the distinction between cooperative and noncooperative games [8]. In noncooperative games, unlike cooperative ones, no outside authority assures that players stick to the same predetermined rules, and binding agreements are not feasible. Further, he recognized that in noncooperative games there exist sets of optimal strategies (so-called Nash equilibrium) used by the players in a game so that no player can benefit by unilaterally changing his or her strategy if the strategies of the other players remain unchanged [1]. Because noncooperative games are common in the real world, the discovery revolutionized game theory. Nash also recognized that such an equilibrium solution would also be optimal in cooperative games. Nash also introduced the concept of bargaining [2, 3], in which two or more players collude to produce a situation where failure to collude would make each of them worse off. Reinhard Selten [9] introduced his solution concept of subgame perfect equilibrium, which further refined the Nash equilibrium. In 1967, John Harsanyi developed the concepts of complete information and Bayesian games [10]. In the 1970s, game theory was extensively applied in biology, largely as a result of the work of John Maynard Smith and his evolutionary stable strategy. In addition, the concepts of correlated equilibrium, trembling hand perfection, and common knowledge were introduced and analyzed. Schelling worked on dynamic models, early examples of evolutionary game theory. Aumann contributed more to the equilibrium school, developing an equilibrium coarsening correlated equilibrium and developing extensive analysis of the assumption of common knowledge [2].

In this article a review of decision making 'logic' has been given, in accordance with mathematical game theory hypotheses (Section 1.1.). Consequently, the issues of unstable equilibrium have been considered (Section 1.2.), as defined by Nash, describing a number of cases lacking the universal rational solution for the decision maker. As a specific case of necessarily unstable equilibrium the team resoning has been explained (Section 1.3.), where the decision maker attempts to maximize the collective and not the individual payoff. In this article, externally competitive (sport game is s competition between two teams) but internally (inside the same team) cooperative team sports were analyzed, which include interaction between players [31]. These are so-called sport games (football, soccer, basketball, volleyball, ice hockey, handball, water-polo, etc.).

Game theory has been applied in analysis of consequences of making a decision on tactical performance of an individual in team sport, for the players in both the player's and opponent team (Section 2). Beyond the game theory, psychological theoretic frames for describing efficacy of tactical sportsman's performance in competition are: data processing theory and phenomenon of the selective attention. Both "psychological frames" explain why a player might choose less rational decisions (unpredictable performance, for example) in sport situations.

The reasons why an individual may bring more or less rational decisions in tactical performance have been given within data processing model (Section 2.1.) and selective attention phenomenon (Section 2.2.). Predictibility of an individual player's behaviour may have an excitatory or inhibitory effect onto his co-players and players of the opponent team (Section 2.3.). The central part of the article (Section 2.4.) describes hypothetical situations in relation to predictability of a player's tactical performance during a game, and the effect onto the tactical performance efficacy of the players of his own or opponent team.

TYPES OF GAMES

In a symmetric game, payoffs for playing a particular strategy depend only on the other strategies employed, not on who is playing them. If identities of players can be changed without changing the payoff to the strategies, then a game is symmetric. In asymmetric games, there are no identical strategy sets for both players. It is possible, however, for a game to have identical strategies for both players, yet be asymmetric [11]. Zero sum games are a special case of constant sum games, in which choices by players can neither increase nor decrease the available resources. In zero-sum games the total benefit to all players in the game, for every combination of strategies, always adds to zero (a player benefits only at the expense of others). Many games studied by game theorists (including the Prisoner's Dilemma) are non-zero-sum games, because some outcomes have net results greater or less than zero. Informally, in non-zero-sum games, a gain by one player does not necessarily correspond with a loss by another. In simultaneous games, either both players move simultaneously, or the later players are unaware of the earlier players' actions (making them effectively simultaneous). Sequential (dynamic) games are games where later players have some knowledge about earlier actions. This need not be perfect knowledge about every action of earlier players; it might be very little information. For instance, a player may know that an earlier player did not perform one particular action, while he does not know which of the other available actions the first player actually performed. A subset of sequential games consists of games of perfect information. A game is one of perfect information if all players know the moves previously made by all other players. Thus, only sequential games can be games of perfect information, since in simultaneous games not every player knows the actions of the others. Most games studied in game theory are imperfect information games.

DECISION MAKING

Game theory is concerned with rational choice in decisions involving two or more interdependent decision makers. Its range of applicability is broad, including all decisions in which an outcome depends on the actions of two or more decision makers, called players, each having two or more ways of acting, called strategies, and sufficiently well-defined preferences among the possible outcomes to enable numerical payoffs reflecting these preferences to be assigned [12-14].

Decision theory has a certain logical primacy in psychology, because decision making drives all deliberate behaviour, and game theory is the portion of decision theory dealing with decisions involving strategic interdependence. The notion of rationality underlying game theory is instrumental rationality, according to which rational agents choose the best means to achieve their most preferred outcomes [13]. A person's reasons for acting in a particular way are invariably internal, hence an action is instrumentally rational, relative to the agent's knowledge and beliefs at the time of acting, if it is the best means to achieve the most preferred outcome, provided only that the knowledge and beliefs are not inconsistent or incoherent [13, 15]. Instrumental rationality is formalized in expected utility theory, introduced as an axiomatic system by von Neumann and Morgenstern [1], in which utilities are represented by payoffs, and the theory (presented by von Neumann and Morgenstern) is primarily normative, in as much as its basic aim is to determine what strategies rational players should choose to maximize their payoffs. It is not primarily a positive or descriptive theory that predicts what strategies human players are likely to choose in practice.

The starting point for modeling any decision problem must be an understanding of the problem as it is seen by the decision-maker, a definition of the objectives of the decision-maker, the identification of alternative solutions to the problem, and the formulation of means for representing the objectives in a way that can be used to select among the alternative answers [13]. A utility function is a means for representing the objectives in a way that can be used to select among the alternative answers. To represent the objectives, two aspects must be recognized. One is the relative importance of the objectives and the second is the scale for assessment individually for each of them. In this respect, it is important to note that an unweighted mix of criteria, such as "the greatest good for the greatest number," is irrational; one cannot in general optimize two objectives simultaneously. To do so, there must be a single criterion, and if there are two or more objectives, that criterion must suitably represent their relative importance. It is that requirement that makes the utility function necessary [13]. The process of modelling a decision-making problem has three steps. First is to translate the problem of comparison among objectives into "quantitative/qualitative" ratios. Second is to translate, to the extent possible, the qualitative objectives into quantitative ones. For example, this might be accomplished by translating "effectiveness" into a combination of measurable characteristics. Third, and most fundamental, is to translate the process of assessment into relative comparisons of alternative options [2].

The usual frame of reference for a game theoretic model is a competitive game, in which the contexts represent the opponent's strategies for play, and the utilities (if positive) are payments to the decision-maker from the opponent (or, if negative, from the decision-maker to the opponent).

As a principle, game theory assumes that the players in a game are "rational," in the sense that they will each make decisions that are best for their individual interests, as expressed by their respective utility functions. That implies, in particular, that the relative frequencies of the options and contexts will be determined by the optimal strategy of the player whose plays they represent.

It is further assumed that both players have complete knowledge of the utility functions for each.

In particular, there are applications of game theory for which the assumption of maximizing individual interests, with max-min as the resulting criterion for choice and with the use of randomization as the means for creating mixed strategies, may be changed. The means for doing so is called "bargaining" and the resulting games are called "cooperative games".

Bargaining is a process of making offers and demands with the objective of achieving total, joint results that are better than can be obtained from simply the competitive game [7, 8, 16].

In non-cooperative games, the players act independently, whereas in cooperative games they are free to negotiate coalitions based binding and enforceable agreements. The leading solution concept for non-cooperative games is Nash equilibrium. This is a profile of strategy choices, one for each of the n players in a game, such that each player's strategy is a best reply to the $n - 1$ others. The best reply is a strategy that maximizes a player's payoff, in case of strategies chosen by the others. An important psychological property of an equilibrium point is that it gives the players no cause to regret their strategy choices when those of their co-players are revealed. Nash [7, 8] gave two separate proofs that every game with a finite number of players (each having a finite number of strategies) has at least one equilibrium point, provided that mixed strategies are brought into consideration. A mixed strategy is a probability distribution over a player's (pure) strategies. In the popular Bayesian interpretation of game theory, a mixed strategy is viewed construed as uncertainty in the mind of a co-player about which pure strategy will be chosen [16].

The fundamental problem in an attempt to determine rational play in games is that individual players have incomplete control over the outcomes of their actions. A rational decision maker chooses the option with the highest expected utility or one of the options with the highest expected utility. But a game does not generally have a strategy that is best in this straightforward sense, because a player's preferences range over outcomes, not strategies, and outcomes are determined partly by the choices of other players.

Deviations from perfect rationality are inevitable, because human decision makers have restricted rationality. Bridging hypothesis provides game theory with a secondary objective, that of making testable predictions, thus justifying the otherwise inexplicable enterprise of experimental gaming [17-20].

UNSTABLE EQUILIBRIUM

The specification of the game and the players' rationality are common knowledge in the game. Any uniquely rational solution must be an equilibrium point, and any conclusion that a player validly deduces about a game will be deduced by the co-player(s) and will be common knowledge in the game. This logical implication is called the transparency of reason [21]. A Nash equilibrium, even if unique, is not necessarily a rational solution, because a game may have no uniquely rational solution.

If a particular outcome is a Nash equilibrium, that is not a sufficient reason for a rational player to choose the corresponding equilibrium strategy. It implies that neither player has any reason to expect the other to choose a mixed equilibrium strategy. In the mixed-strategy case, not only does the fact that a particular outcome is a Nash equilibrium fail to provide a player with a sufficient reason for choosing the corresponding equilibrium strategy, but, on the contrary, it appears to vitiate any reason that a player might have for choosing it.

Harsanyi [16] suggested that a player should always be assumed to have a small amount of uncertainty about a co-player's payoffs. If games with solutions in mixed strategies are modelled by disturbed games with randomly fluctuating payoffs, deviating slightly from the values in the payoff matrix, then mixed-strategy equilibrium becomes replaced by pure-strategy equilibrium points, and the fluctuating payoffs interact in such a way that rational players choose strategies with the probabilities prescribed by the original mixed-strategy solution. Thus, although rational players will simply choose their best pure strategies without making any attempt to randomize, they will choose them with the probabilities of the classical mixed-strategy solution.

Some equilibrium points require players to choose strategies that are arguably irrational. This anomaly was discovered by Selten [9, 22], who developed a refinement of Nash equilibrium, called the subgame-perfect equilibrium. This equilibrium is one that induces payoff-maximizing choices in every branch or subgame of its extensive form. Selten [22] introduced the concept of trembling-hand equilibrium to identify and eliminate imperfect equilibrium. At every decision node in the extensive form of a game there is assumed to be a small probability ε (epsilon) that the player's rationality will break down for some unspecified reason, resulting in a mistake or unintended move. Selten presupposes whenever a player's hand 'trembles', the erroneous move is assumed to be determined by a random process, and every move that could possibly be made at every decision node therefore has some positive probability of being played. Assuming that the players' trembling hands are common knowledge in a game, Selten proved that only the subgame-perfect equilibrium of the original game remain equilibrium points in the perturbed game, and they continue to be equilibrium points as the probability ε tends to zero. According to this widely accepted refinement of the equilibrium concept, the standard game-theoretic assumption of rationality is reinterpreted as a limiting case of incomplete rationality.

TEAM REASONING

Team reasoning [23-26] is based on the idea that, under certain circumstances, players act to maximize their collective payoff, relative to their knowledge and beliefs, rather than their individual payoffs. A team-reasoning player first identifies a profile of strategy choices that maximizes the collective payoff of the players, and if this profile is unique, plays the corresponding individual strategy that is a component of it. This involves a radical revision of the standard assumptions, according to which decision makers maximize individual payoffs. But examples of joint enterprises abound in which people appear to be motivated by collective rather than individual interests. In some circumstances de-individuation may even occur, with people tending to lose their sense of personal identity and accountability [27, 28]. Experimental research has confirmed the intuition that there are circumstances in which decision makers prefer outcomes that maximize collective payoffs [29].

A second suggestion for explaining the payoff-dominance phenomenon is Stackelberg reasoning, suggested by Colman and Stirk [30]. The assumption here is that players choose strategies that maximize their individual payoffs on the assumption that any choice will invariably be met by the co-player's best reply, as if players could read each others' minds.

In spite of strategic dominance, experimental evidence [18] has shown that players frequently cooperate, to their mutual advantage. Strategic dominance describes a situation when dominance is strong, when a strategy yields a strictly better payoff than any alternative against all possible counter-strategies, as in the Prisoner's Dilemma Game. In those circumstances, it seems obvious that it is the uniquely rational way of acting. Even if a strategy only weakly dominates all other strategies, that seems to be a strong argument for choosing it.

The most compelling solution concept of all is strategic dominance. Nothing seems more obvious than the rationality of choosing a strategy that yields a higher payoff than any other against every possible counter-strategy or combination of counter-strategies. If one course of action is unconditionally best in all circumstances that might arise, then it seems obvious that a rational player will invariably choose it.

GAME THEORY AND TACTICAL SPORT PERFORMANCE IN TEAM SPORTS

It's important to emphasize that games are commonly defined as sets of players, actions and preferences over the outcomes. In this article, "players" are sport teams (opponents and co-players) and predictability/unpredictability of individual player's actions.

Szymanski [32] used game theory in a sport economy, describing an influence of increasing gate revenue sharing among teams in one league, which reduces competitive balance. The same author [33] used game theory in describing the economy of the sport contests. Sindik et al. [34] used the model of non-zero-sum games to describe some problems in working circles, between the leader and employees.

In this article, game theory is used in an attempt to explain payoffs linked with predictability of individual player's actions, for co-players in his own team, as well as for the opponent team players. It is assumed that predictability in team sports could be explained as an asymmetric, sequential, non-zero-sum game. Individuals do not have the same importance in team performances (that is the reason for explaining them as asymmetric), payoff results are always greater or less than zero (non-zero-sum is caused by different "fatal" choices in various sport game's situations, but also in sometimes unpredictable positive payoffs, even in moderate negative payoffs). Moreover, predictability in team sports is a sequential game of imperfect information, because all players have some knowledge about the moves previously made by all other players, but not all their moves in all typical sport situations. From the decision making point of view, predictability in team sports is in fact bargaining, because a player can't make decisions only depending on opponent team tactical performance (rules of the competitive game). He must simultaneously consider the tactical performance of his co-players in the same team (rules of the cooperative game), and make some mixed strategy for choosing option with highest expected utility. So, a player could choose a trembling hand equilibrium, to eliminate imperfect equilibrium, which comes out from subgame-perfect equilibrium (complexity of the teams sport's performance can induce player's partial analysis of some aspects of sport tactical performance). Besides, team reasoning could lead to identifying a profile of strategy choices that maximizes collective payoff of the players. Finally, strategic dominance can explain that a player when making decision about tactical performance under certain circumstances could choose strategy which dominates among other possible strategies.

DATA PROCESSING AS A QUALITY LIMITING FACTOR IN ACTIONABLE PLAYER'S PERFORMANCE IN COMPETITION

Data processing capacity of each sportsman is limited. If one of the tasks requires total available data processing capacity 'space', it will result with other tasks being performed with less efficacy. Fast data processing determines correct and duly motor action, and that motor action induces the performance in sport competition.

That is the reason why the data processing model is of great importance for describing quality of the player's tactical performance, hence the sport result of the whole individual's sport team.

The quantity of the transferred information in a problem situation, could be quantified in terms of number of questions needed for solving that problem (number of information bits), or in the terms of the mathematical formulas [31]. The idea about limited capacity of the data processing helps in making difference between a very skilful sportsman and less skilful sportsman [31], which is measurable by testing the response time. Namely, it has been proven that by increased learning (training) the attention requirements needed for the motor action decrease, leaving more space for processing of other data, i.e. for acquiring new technical or tactical knowledge. If some task occupies all space for data processing of an individual, there is no more space for the other tasks which also need attention and data processing. That's the reason why well trained sportsmen have faster data processing. But, the situation is not so simple, good technical and tactical training is not enough. Even if a player is very skilful in performing particular technical and tactical elements, there is a possibility that he could perform slowly, while confronting an unpredictable situation in sport competition.

From the aspect of possibility of fast data processing in the team sports, synchronized cooperation between players is a factor which sometimes extremely contributes to the team success, much more than a fictive «sum» of individual qualities in individual players, respectively individual's motor and functional abilities, technical skills. Untrained or unforeseeable tactical performance of an individual within a team in sporting events necessarily influences the need for data processing capacity space enlargement, thus slowing down the 'team' reaction time and reflecting onto poorer team performance.

SELECTIVE ATTENTION AND SPORT PERFORMANCE

Selective attention is ability for suppressing entrance of irrelevant information, simultaneously focusing attention on relevant information.

Easterbrook's "theory of using signs" [31] describes the phenomenon of reducing the extent of attention. With a growing level of activation (arousal), player's attention latitude can be tight. This process of reducing attention latitude has some desirable «optimum» (optimal level of the arousal), when entrance of the irrelevant signs is reduced. However, further process of reducing, which grows along with the level of arousal, leads to reducing perception of irrelevant, and even some relevant signs, which will have non-desirable influence on action sport player's efficacy (performance in competition). Over-aroused player will make faults during sport performance, because he sub-optimally uses less processed information. Very probably, he gets less information and makes bad selections. Similar assumption may be made on team level, when contemplating unforeseeable tactical performance of an individual player in relation to agreed team tactics during a sporting event: it results in 'distraction' and over-arousal of other players in the team, who are required to put some extra effort to understand tactical moves of an individual player, instead of being focused onto team tactics. Consequently, their tactical performance is necessarily poorer.

INFLUENCE OF PREDICTABILITY OF ACTIONS OF PLAYERS IN THE SAME TEAM ON THE FINAL RESULT IN COMPETITION

Cooperation between players appears as an specially important factor, if we consider cooperation quality from the point of view of predictability for individual competitor, who interacts with his co-players (players in the same team) and opponents (players in the opponent team).

Analyzing theoretic assumptions, from the aspect of the team action in sport, it's probable that an individual player, exhibiting frequent unpredictable sport tactical performance for the players in the same team, is not highly responsible, consequent, disciplined, self-critical. But, if his unpredictability is expected by the players in the same team, and not expected by the opponent team, an individual will not damage group cohesion in his team. When co-players imply his unpredictability, they could perform more carefully in team tactical actions.

From the data processing point of view, it could be argued that data processing for unpredictable individual player's performance could last longer, for the players in the same team.

From the aspect of the arousal level (Easterbrook [31]), it is probable that in the situation of less predictable individual's performance, arousal level could be beyond optimal level, what could result in poorer sport performance in both teams (player's and opponent's), but more in the opponent team (the same explanation as in the situation of group action rules). "Expected" individual's unpredictable performance could result with less excited (calm) team performance of the co-players in the same team.

HYPOTHETICAL SITUATIONS: PREDICTABILITY/UNPREDICTABILITY FOR CO-PLAYERS/OPPONENTS AND THE PAYOFFS

Actions are defined as "average" or the most frequently used individual player's tactical performance, viewed from it's predictability level (predictable/unpredictable). Outcomes are considered from the aspect of utility of the sport performance: either for an individual player or for the co-team or opponent team.

In team sports, cooperation between players is the factor which sometimes extremely contributes to team success, much more than fictive "sum" of the team members individual qualities, such as individual motor and functional abilities, technical skills, etc. This model's main assumption describes consequences of the individual's tactical decisions during sport competition in relation with a plan for own team tactical acting (co-players), but also in relations with a plan for opponent team tactical acting. But in order to consider individual's tactical performance predictability, it is necessary to consider his motor activity during sport competition.

Observing this problem from the aspect of game theory, establishing different possible situations during sport competition could lead to considering advantages for specific decisions (outcomes). The dichotomy in this article considers:

- predictability or non-predictability (for the individual's technical and tactical action during sport competition), in relation with
- co-players (in the same team) or opponents (players in the opponent's team).

In practical experiment, an "isolated" situation of the sport competition, or a sample of the individual's performance during sport competition, is considered. Nevertheless, the individual's tactical performance is a 'mediator' in relation to which utility for players of the same or opponent team is being considered. In following tables, first number in the cell OUTCOME ADVANTAGE always represents utility for the same team, in which individual plays (co-players); second number represents the utility for opponent team (opponents).

Accordingly, following main situations are possible:

- predictability for the co-players and unpredictability for the opponents,
- predictability for co-players and predictability for the opponents,
- unpredictability for co-players and unpredictability for the opponents,
- unpredictability for co-players and predictability for the opponents.

Predictability for the co-players and unpredictability for the opponents

That is hypothetically the best possible outcome for player's (individual's) team (co-players): the player whose performance is predictable to players in the same team, could enable their systematic individual and team action. Precisely, assumed predictability is an idealisation, as in reality thereis always some contribution of unpredictable actions, or they could be assumed. All trained tactical variations could be performed.

On the other hand, unpredictability of his motor activity could have a “confusing” effect on opponents, who become disabled to currently recognize the pattern of tactical opponent’s performance. In this situation, opponent’s team could hardly apply adequate “contra – tactical” plan. That situation is the most rational option which player could choose, although in practice it is very hard to predict what pattern of player’s tactical performance is really unpredictable for the opponent team. But, that’s the option with the best utility, a number -10 (for opponent team), 10 (for his team) is added to this situation.

Table 1. Outcomes from the situation when a player’s tactical performance is predictable for players in the same team and unpredictable for players in the opponent team.

PREDICTABLE	UNPREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	10, 10

Predictability for co-players and predictability for the opponents

That’s hypothetically a very advantageous possible outcome. The player with predictable performance for the players in the same team, could enable a systematic individual and team acting to the team (same as in situation a). However, in this situation co-players include the possibility that the opponent could recognize a pattern of tactical individual’s performance. Consequently, all players in the individual’s team have to choose “the safer” tactical patterns of the motor performance.

On the other hand, unpredictability of his tactical performance cannot have any “confusing” effect onto the opponent team, who could currently recognize a pattern of tactical opponent’s performance. In this situation, opponent’s team could currently apply an adequate “contra – tactical” plan. However, this plan cannot be a surprise for co-players (who may expect counter-tactics of the opponent team), and consequently such situation cannot be considered as particularly convenient for the opponent team. That’s why numbers 0 (for opponent team) and 10 (for the co-players, in player’s team) are added to this hypothetic situation.

Table 2. Outcomes from the situation when a player’s tactical performance is predictable both for players in same team and for players in the opponent team

PREDICTABLE	PREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	10, 0

Unpredictability for co-players and unpredictability for the opponents

That’s hypothetically a relatively disadvantageous possible outcome. The player whose tactical performance is unpredictable for the players in the same team, could disable any systematic individual and team acting (in his team), especially when applying “risky” tactical patterns. Applying such patterns could be “suicidal” for the individual’s team, if his tactical performance is unpredictable. On the other hand, although unpredictability of his action performance could have some “confusing” effect on the opponent (so the opponent couldn’t apply adequate “contra-tactics”), this tactical pattern is disadvantageous for the opponent team, too. Namely, neither player’s team nor opponent team could include “the safest” or “risky” tactical patterns of tactical performance. That is the only option which brings absolute doubt, total unpredictability. However, possible favourable outcome of the individual “improvisation” could bring some “positive” outcome (mostly by “confusing” the opponent team). That’s why number –10 (for co-players in player’s team), and -10 (for opponent team) is added to this hypothetic situation.

Table 3. Outcomes from the situation when a player's tactical performance is unpredictable both for players in same team and for players in the opponent team

UNPREDICTABLE	UNPREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	-10, -10

Unpredictability for co-players and predictability for the opponents

That's hypothetically the most disadvantageous possible outcome. The player whose tactical performance is unpredictable for the players in the same team, could disable them in any systematic individual and team acting, especially while applying "risky" tactical patterns (same as in the situation c.). On the other hand, his action performance doesn't have "confusing" effect on the opponent, so the opponent could apply adequate "contra-tactics".

In described situation co-players wouldn't be able to include "the safest" or "risky" tactical patterns of tactical performance. Therefore, that is a completely "suicidal" possibility, which would most probably bring a negative outcome for the co-players and individual's team success, but positive outcome for the opponent team.

Consequently, numbers –10 (for player's team), 10 (for opponent team) are added to this hypothetic situation.

Table 4. Outcomes from the situation when a player's tactical performance is unpredictable for players in the same team and predictable for players in the opponent team

UNPREDICTABLE	PREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	-10, 10

Accordingly, below is shown the table which summarizes all these hypothetic options simultaneously.

Table 5. Outcomes from all situations when a player's tactical performance is predictable or unpredictable for players in the same team and for players in the opponent team

PLAYER / TEAM	CO-PLAYER(S)	OPPONENTS	Σ
PREDICTABLE	10	0	10
UNPREDICTABLE	-10	-10	-20
Σ	0	-10	-10

From these hypotheses made by the author, predictability could in general be better than unpredictability, whether for the players in the same team or for the opponent's team players.

Although the model shows only a very simplified option of describing individual's tactical action in competitive situations in collective sports, this description possible outcomes of the tactical individual's actions, could be a starting point for the individual tactical training.

Because it offers a relatively clear numeric description of different situations during sport competition, this model could be relatively easily tested, by systematic comparison of given tactical tasks (by trainer), the performance of these tasks by individual player (and all other players in the same team) during sport competition, and team statistics.

A more complex model could include the "net" of similar possible situations for all players in the same team, and a more complex situation could include all players from the opponent team. However, multiplying the number of interactive situations in the same game, the model could hypothetically predict more differentiated outcomes and utilities. Consequently, consideration of tactical predictability of an individual player during a sporting event could be the first step in the trainer's approach in the tactical training process.

CONCLUSIONS

In this article, the level of predictability of the most frequent tactical performance of one player in a team sport game is considered, reflecting outcomes both on the same team's tactical performance (co-players in one player's team), as well as for the opponent team's tactical performance. In this situation, the problem of cooperation between the players in the same team, during sport competition (between two teams) is simultaneously considered, explained by conjectures derived from the game theory and from psychological theories. Four different possible situations during team sport competition could lead to considering utilities of a player's specific decisions.

The model could be relatively easily tested, in specific team sports. According to the hypotheses offered by the author, predictability is in general better than unpredictability, both for the players in the same team and for the opponent's team players. Such an approach could be the first step in finding practical solutions in individual and team tactical training, for any team sport.

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PRIMJENA TEORIJE IGARA ZA OPISIVANJE UČINKOVITOSTI ODLUČIVANJA U TAKTIČKOM DJELOVANJU SPORTAŠA U TIMSKIM SPORTOVIMA

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SAŽETAK

Matematička metoda odlučivanja u kojoj se analizira kompetitivna ili kooperativna situacija radi određivanja optimalnog djelovanja zainteresiranog „igrača” uobičajeno se naziva teorijom igara. Teorija igara široke je primjene u različitim znanstvenim područjima. Taktičko djelovanje u timskim sportovima razmatrano je sa stajališta teorije procesiranja podataka i pojave selektivne pažnje, kao i sa stajališta teorije igara. Taktičko djelovanje u timskim sportovima je asimetrična, sekvencijalna (nepotpune informacije) igra s ishodom različitim od nule. U odlučivanju, predvidljivost u timskim sportovima je zapravo razmjena, a igrač mora koristiti mješovite strategije za odabir varijante najveće očekivane korisnosti. Igrač može odabrati *trembling hand* ravnotežu radi uklanjanja nesavršene ravnoteže. Koncept strateške dominacije može objasniti kako igrač može odabrati strategiju koja dominira ostalim mogućim strategijama, ili može također biti vođen „timskim pristupom”. U ovom radu razmatra se razina predvidljivosti najčešćih taktičkih djelovanja jednog igrača u timskom sportu. Pritom se razmatraju ishodi za taktičko djelovanje kako tima suigrača tako i protivničkog tima. Četiri moguće, različite situacije koje se javljaju tijekom natjecanja u timskim sportovima mogu dovesti do razmatranja korisnosti specifičnih odluka jednog igrača.

KLJUČNE RIJEČI

teorija igara, timski sportovi, taktike