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A dynamical system perspective to understanding badminton singles game play

Jia Yi Chow [a,*], Ludovic Seifert [b], Romain Hérault [c], Shannon Jing Yi Chia [d], Miriam Chang Yi Lee [a]

[a] *Physical Education & Sports Science, Nanyang Technological University, Singapore*
[b] *Centre d'Etude des Transformations des Activités Physiques et Sportives (CETAPS), Faculty of Sports Sciences, University of Rouen, France*
[c] *Laboratoire d'Informatique, du Traitement de l'Information et des Systèmes (LITIS), National Institute of Applied Science (INSA de Rouen), France*
[d] *Sport Science and Management, Nanyang Technological University, Singapore*

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ABSTRACT

By altering the task constraints of cooperative and competitive game contexts in badminton, insights can be obtained from a dynamical systems perspective to investigate the underlying processes that results in either a gradual shift or transition of playing patterns. Positional data of three pairs of skilled female badminton players (average age 20.5 ± 1.38 years) were captured and analyzed. Local correlation coefficient, which provides information on the relationship of players' displacement data, between each pair of players was computed for angle and distance from base position. Speed scalar product was in turn established from speed vectors of the players. The results revealed two patterns of playing behaviors (i.e., in-phase and anti-phase patterns) for movement displacement. Anti-phase relation was the dominant coupling pattern for speed scalar relationships among the pairs of players. Speed scalar product, as a collective variable, was different between cooperative and competitive plays with a greater variability in amplitude seen in competitive plays leading to a winning point. The findings from this study provide evidence for increasing stroke variability to perturb existing stable patterns of play and highlights the potential for speed scalar product to be a collective variable to distinguish different patterns of play (e.g., cooperative and competitive).

* Corresponding author. Address: Physical Education & Sports Science, National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, Singapore. Tel.: +65 6790 3692; fax: +65 6896 9260.
E-mail address: jiayi.chow@nie.edu.sg (J.Y. Chow).

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1. Introduction

Game dynamics is dependent on the complex and specific interactions among players in a game and a framework based on complex systems involving various interacting factors such as player–player relationships, the size of the court or the rules of the game can be used to describe game situations (McGarry, Anderson, Wallace, Hughes, & Franks, 2002). A common feature for complex systems is self-organization whereby, regularity emerges from within a system which consists of "many degrees of freedom in constant flux" (McGarry et al., 2002). The observable state of a system and in this case, the game dynamics that emerges is not due to an overarching controller deciding on how the game will evolve. Rather, the game may move through or self-organized into different preferred and stable conditions of play due to the interactions of the players in the game (e.g., Duarte et al., 2012 in soccer; Bourbousson, Sève, & McGarry, 2010 in basketball; Vilar, Araújo, Davids, & Button, 2012; Vilar, Araújo, Davids, & Travassos, 2012 in futsal) within the regulated environmental (e.g., surface, temperature) and task constraints (e.g., rules of the game, equipment available).

The specific game play dynamics that emerges is dependent on how players, with their inherent tactical and technical proficiencies, interact with each other. The specific dimensions of the court size and the rules of the game force certain behaviors to exist during the game. For example, there exists a predisposition for players within the game of badminton, seen as complex system, to return to a "base" position while exchanging strokes with their opponents during a game (Lames, 2006). McGarry and colleagues further elucidated that there is a tendency for players to "oscillate around a given point or locus" (McGarry et al., 2002, p. 778) as seen in squash, badminton and tennis.

This playing behavior, where the player oscillates to and from a base position, was first described in terms of a relative phase relationship by McGarry, Khan, and Franks (1999) in the context of squash. Specifically, McGarry and colleagues adopted the use of a time–motion analysis to express the behavioral patterns in terms of phase relation between the two players. In particular, players would only demonstrate two patterns of relative motions, either in-phase or anti-phase in a game situation. An in-phase pattern is used to describe a situation where the players move in the same direction. In contrast, an anti-phase pattern is observed when the players move in opposite directions (Palut & Zanone, 2005). Suitably, relative phase can be seen as a variable to describe the 'behaviour' of the system as it resides in different patterns or states of behaviors. Such a collective variable or *order parameter* can be defined as variables that characterize the collective state of the system (Davids, Button, & Bennett, 2008; McGarry et al., 2002). For example, a study by Palut and Zanone (2005) on tennis revealed that two stable behaviors with phase transitions were present, with the anti-phase pattern being the preferred stable behavior adopted by players during the game. Another study by Passos et al. (2008) on rugby 1v1 situation also found that the angle between players and distance act as a *control parameter* (i.e., a variable that can be manipulated to effect a change in the behavior of the system) that determine successful and unsuccessful tackles by players. However, in net barrier games such as badminton, where players attempt to return to a base position after every shot to gain optimal coverage of their court, it is unclear if distance and angle from this base position are determinant control parameters for a player to gain an advantage in winning a rally and therefore alter the state of the game system.

Palut and Zanone (2005) in their investigation of tennis clearly used relative phase as a collective variable to describe the patterns of play with no specific constraints on the type of tennis strokes to be executed. The distinct differences seen in phase relations were appropriate to describe the two play conditions (rallies with indirect winning point vs rallies with direct winning point). Participants were required to play each other under indirect winning point (i.e., winning points only from a mistake from their opponent) prior to the seventh rally before direct winning points were allowed. However, the analysis undertaken was restricted to mainly examining lateral movement of the players (due to the task constraint of the tennis game where lateral movements are more typical and also the instruction to trade baseline strokes in their study). Moreover, it is not known if other higher order derivatives such as speed of movement coupled with direction between players (e.g., a variable such as a