Manipulating task constraints shapes emergence of herding tendencies in team games performance

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Manipulating task constraints shapes emergence of herding tendencies in team games performance

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Abstract

The herding phenomenon is observed in nature and has been perceived to be less desirable use of space in impacting overall team play performance. The effective manipulating of rules and task constraints might be able to alter herding tendencies in sport performance. The aim of this study was to determine the impact of altering task constraints on herding tendencies, measured with the use of cluster phase analysis, which has also been used to analyse the synchrony exhibited by performers in invasion games such as professional association football matches. In this study, tracking positional data of individual players in a simulated pass and catch game was undertaken, with no specific verbal instructions provided to participants on how and where to move so that emergent behavioural tendencies could be observed. Data revealed how task constraint manipulations impacted on herding tendencies. Manipulation of task constraints revealed higher levels of clustering tendencies in the herding condition compared to, the non-herding condition. Within the herding condition, between-team synchrony was also strong, especially in the longitudinal direction. Ball possession also seemed to have some impact on within-team synchrony. Findings provided preliminary evidence on how manipulating task constraints can be effective in altering herding tendencies in team games.

Keywords

Task constraints, synchrony, cluster phase analysis, coordination tendencies, herding and non-herding behaviours

Introduction

In team sports, individuals interact and exhibit synchrony to achieve performance goals and these tendencies usually underlie emergent collective behaviours that are more than the sum of individual performances (Duarte, Araújo, Correia, Davids, Marques, & Richardson, 2013). This often gives rise to the herding or swarming phenomenon commonly observed in children and novices in team sports where players gather in close proximity to the ball or where the action is taking place (Button, Chow, Dutt Mazumder, & Vilar, 2011). Finding space on the field in team games like soccer is one of the keys to successful performance (e.g., Blom & Blom, 2009). The reduction of herding tendencies might play an important role in the development and performance of players involved in cooperative and competitive interactions within and between teams in invasion games. Nevertheless, it is also possible that not all herding behaviours in invasion or territorial games might be negative. For example, more generally, herding may be effective at allowing children to 'let off steam' (just to run together and chase after a ball), to bond with each other or to perhaps generate some training benefits from a physiological perspective. Socially, and at an emotional level of observation, there may also be greater fun and increased engagement when children have the opportunity to 'herd' together during game time. In addition, there are sub-phases of herding (e.g., the application of pressing an opponent to reduce time and space available) that could be seen as functional (Silva, Aguiar, Duarte, Davids, Araújo, & Garganta, 2014).

Importantly, the presence and extent of herding tendencies can be studied from a complex, dynamical systems perspective in which individual component parts continuously interact under constraints which results in rich patterns of coordinated behaviours emerging during task performance (see Davids, Araújo, & Shuttleworth, 2005). The underlying assumption of this study maintains that team play patterns can be modelled from a Dynamical Systems perspective (Akiyama & Kaneko, 2000). Using cluster phase analysis, we sought to distinguish between patterns of herding and non-herding tendencies in a modified territorial game. Cluster phase analysis, proposed by Frank and Richardson (2010) to be used to access between and within team synchrony, was first initiated to investigate phase synchronization in systems with a large number of oscillating components (Kuramoto, 1984). This method of quantitative analysis has been adopted by researchers to assess the dynamics of movement synchronization of players within and between teams during competitive association football performance (Duarte et al., 2013). It was found that there were strong couplings between professional teams in the longitudinal direction of play during matches. In addition, it was reported that changes in the synchrony of each team were closely related. The key findings in that study suggested that cluster phase analysis is a reliable means to distinguish between herding and non-herding tendencies.

It has been suggested previously that rules and task constraints can alter herding tendencies in sport (Renshaw, Chow, Davids, & Hammond, 2010). Task constraints may be one of the most important constraints for practitioners to manipulate due to the potential impact that they can have on learning. (Chow, Davids, Button, & Renshaw, 2015) They consist of the goals of a specific task, rules of the activity, field locations, involvement of other players and implements used (e.g., equipment) during performance and learning. Task constraints are known to directly influence the emergence of learners' intentional behaviours and are open to manipulation through instructional constraints (Davids, Button, & Bennett, 2008; Williams, Davids, & Williams, 1999). However, to what degree such rules and task constraints have an impact on altering herding tendencies in team behaviours is worthy of investigation. For example, possession of the ball can potentially influence the emergence of different game play patterns for a team. Specifically, a team may respond quite differently to opponents with or without ball possession. One possible influence of ball possession could be the attraction of teammates moving away from their own player with ball possession to provide width or to penetrate a defence. In this instance, herding behaviours for the team with ball possession may be less likely to emerge.

Importantly, findings from this study can also be used to guide the work of practitioners in developing an appropriate intervention programme (based on task constraints manipulation) to reduce herding tendencies, if required. Sometimes it may be useful for herding tendencies to emerge to help learners acquire awareness of space and sharpen their skills in terms of movement and ball manipulation. But often practitioners might also want to reduce herding tendencies to enhance synchronisation between teammates.

The specific purpose of the investigation was to determine the impact of altering task constraints on emergent herding tendencies through the use of cluster phase analysis. Importantly, we used cluster phase analysis as a tool to distinguish patterns of herding and non-herding tendencies in team games players. It was predicted that effective manipulation of task constraints could result in fewer herding tendencies and that the use of cluster phase analysis would be able to indicate such differences in game play patterns between task conditions. Ball possession by a team can potentially result in emergence of fewer herding tendencies.

Methods

Participants

Eight undergraduates from a university were recruited for this study and was a convenience sample. This group of participants consisted of 5 male and 3 female undergraduates (age 24±3.2 years) who all reported as able-bodied and healthy on the day of the study. All participants only had recreational experience in throw and catch type of invasion games (e.g., basketball, netball). While we acknowledge that younger participants with less experience of team sports are more likely to display herding behaviours, the inclusion of effective task constraints should nevertheless elicit both herding and non-herding behaviours during the intervention. Informed consent was provided by all participants and the procedures used in the study were in accordance with the participating institution's ethics code.

Equipment

The experiment was conducted in an indoor volleyball court shown in Figure 1, located at the multi-purpose hall of the university. The dimension of the playing area measured 18m in length and 9m in breadth. Four scoring zones, marked 1, 2, 3 and 4 were set up. Each scoring zone measured 6m in length and 1.5m in breadth.

The proceedings of the modified territorial game were recorded by a closed-circuit television (CCTV) system mounted on the ceiling of the multi-purpose hall above the playing area. The frequency of the CCTV system was set at 25Hz and captured players' movement and positional displacement throughout the duration of the game. A digital videodisk recorder, connected to the CCTV system, was used to store the captured video clips for subsequent analysis using the A-Eye motion analysis software (Barris, 2008).

Insert Figure 1 about here

Task

The players were randomly assigned into two teams with Red and Green colored tops distinguishing the two teams. The two teams were required to play in a small-sided 4 vs. 4 modified throw and catch possession game. The game was played either in a simulated herding or non-herding condition with the following rules and task constraints implemented shown in Table 1.

Insert Table 1 about here

Procedure

The participants were first briefed about the general context of performance and any safety concerns during the game. They were then given ten minutes to warm-up before the experiment started. The participants had to pass and catch a ball within teams to get everyone familiar with the ball and the scoring zones in the play area. It is important to note that the emphasis was on observing emergent coordination tendencies as task constraints were manipulated.

The first game was played under the task constraints of the herding condition. This game lasted 10 minutes with a rest interval of 3 minutes after 5 minutes of gameplay. In the game which simulated the herding condition, individuals of opposing teams were paired up before the game, See Table 1. Figure 2 shows the pairing of players and their marked positions during a sequence of play. R1 was paired with G1, R2 with G2, so on and so forth. The individuals in a pair were instructed to stay within 2m of each other for the duration of the entire game for the herding condition. A 30-mins break was used as a 'wash-out' period to reduce the effects of the previous condition on performance in the next condition.

Insert Figure 2 about here

The second game that was played simulated the non-herding condition. This game also lasted 10 minutes with a rest interval of 3 minutes after 5 minutes of gameplay. There was no restriction to pair or to stay with the opponent in this game. See Table 1 for instructions and cues. Throughout the two games, verbal instructions were given to the participants to encourage them to demonstrate herding and non-herding behaviours respectively for the two 10-minute games. Verbal cues such as “keep close to your opponent”, “go close to the ball” were used to remind participants of the game condition they were tasked to simulate.

On the second day, the sequence of the game play was reversed. Participants started with playing the game which simulated non-herding condition before proceeding to play the game which simulated herding condition. The same experimental conditions were applied on the second day.

Data Analysis

Every player's movements were tracked manually using the A-Eye software throughout all sequences of play. Figure 2 shows the position of all 8 players in the play area during a sequence of play. A sequence of play is determined by team ball possession. It constituted a time frame when a team makes an inbound pass until the time when that same team scored a point by catching the ball in the scoring zone or when the ball goes out of play. Turnovers via interception by the opposing team also indicated a new sequence of play. If the ball remained out of bounds for more than 6 seconds, the entire duration from the point when the ball went out until the next inbound pass was omitted for data analysis.

Prior to the analysis of the data recorded, the fish eye effect associated with the use of a wide-angle lens was removed by applying a transformation specific method to multiple regions, in particular, a general radial transformation (see Barris, 2008). The continuous degree of synchronization of the team as a whole (i.e., the cluster amplitude) $\rho_{group,i}$ at every time step t_i can be calculated as (see Duarte et al., 2013):

$$\rho_{group}(t_i) = \left|\frac{1}{n}\sum_{k=1}^{n} \exp\{i(\phi_k(t_i) - \bar{\phi}_k)\}\right|$$

where $\rho_{group,i} \in [0,1]$ and the mean degree to group synchronization is computed as:

$$\rho_{group} = \frac{1}{N}\sum_{i=1}^{n} \rho_{group,i}$$

The cluster amplitude corresponded to the inverse of the circular variance of $\phi_k(t_i)$. Thus, if $\rho_{group,i}$ or $\rho_{group} = 1$ the whole group was in complete intrinsic synchronization. If $\rho_{group,i}$ or $\rho_{group} = 0$, the whole group was completely unsynchronized. So, the larger the value of $\rho_{group,i}$ and ρ_{group} (i.e., closer to 1), the larger the degree of team synchronization (see Duarte et al., 2013). The Mean Cluster Amplitude for each team was determined for every play observed in all the games in this study.

Mixed Factorial ANOVAs were used to compare the Mean Cluster Amplitude across herding and non-herding conditions, between teams and as ball possession differed in respective teams. Pearson product-moment correlation coefficient was calculated for between-team synchrony based on the cluster amplitudes of both teams in representative sessions. Effect sizes were calculated using eta squared (η^2) and the significance level was set at < .05. All analyses were conducted through R (version 3.2.1).

Results

Cluster Amplitude as a function of Herding and Non-herding Conditions

Cluster amplitude values for both teams tended to be closer to 1 in the herding condition (Green Team: M=0.88 SD=0.15, Red Team: M=0.88 SD=0.17) compared to non-herding condition (Green Team: M=0.71 SD=0.24, Red Team: M=0.73 SD=0.25) (see Figures 3a and 3b for the longitudinal direction). This value was indicative of greater within-team synchrony for both teams in the herding condition. Between-team synchrony was also higher for herding (r=0.61, n=15896, p=0.00) as compared to non-herding conditions (r=0.47, n=16102, p=0.00). In addition, between-team synchrony values were higher in the longitudinal direction (r=0.76, n=9710, p=0.00) than in the lateral direction (r=0.63, n=9710, p=0.00) (see Figures 4a and 4b for an example from the herding condition). From the experiment set-up in Figure 1, the longitudinal direction is along the length of the court (from the ends at scoring zone 1 towards scoring zone 2).

Insert Figures 3a and 3b about here

Insert Figures 4a and 4b about here

Mean Cluster Amplitude was analysed using a 2(Conditions: Herding, Non-herding) x 2(Groups: Green Team, Red Team) ANOVA in which Conditions was a within-participant factor and Groups was a between-participant factor. A significant main effect was observed for Conditions, $F(1, 328) = 32.06$, $p < 0.05$, $\eta^2 = 0.989$. There was a significant difference in the mean cluster amplitude for the herding (M= 0.816, SD=0.17) and non-herding conditions (M= 0.699, SD= 0.20). See Figure 5. There was no significant main effect for Groups and there was no significant interaction between Condition and Groups.

Insert Figure 5 about here

Mean Cluster Amplitude of individual teams as a function of Conditions and Ball Possession

Mean Cluster Amplitude for each individual team was analysed using a 2(Conditions: Herding, Non-herding) x 2(Possession: Green Team, Red Team) ANOVA in which Conditions was a within-participant factor and Ball Possession was a between-participant factor.

Green Team

A significant main effect was observed for Conditions, $F(1, 162) = 13.95$, $p < 0.05$, $\eta^2 = 0.780$. There was a significant difference in the mean cluster amplitude value for the Green Team in the herding (M=0.814, SD=0.17) and non-herding conditions (M=0.701, SD=0.20). See Figure 6. There was no significant main effect for Ball Possession and there was no significant interaction between Condition and Ball Possession.

Insert Figure 6 about here

Red Team

A significant main effect was observed for Conditions, $F(1, 162) = 18.98$, $p < 0.05$, $\eta^2 = 0.711$. There was a significant difference in the mean cluster amplitude value for the Red Team in the herding (M= 0.819, SD=0.17) and non-herding conditions (M= 0.690, SD= 0.21). A significant main effect was also observed for Ball Possession, $F(1, 162) = 6.75$, $p < 0.05$, $\eta^2 = 0.042$. There was a significant difference in mean cluster amplitude for the Red Team for possession (M= 0.719, SD= 0.20) and non-possession of the ball (M= 0.797, SD=0.20). See Figure 7. There was no significant interaction between Condition and Ball Possession.

Insert Figure 7 about here

Discussion

The purpose of this investigation was to determine the impact of altering task constraints on herding tendencies through the use of cluster phase analysis. Results revealed sufficient empirical evidence to support the use of the cluster phase analysis to distinguish between herding and non-herding tendencies during team games performance under the current experimental task constraints. The results of this study revealed that the manipulation of task constraints (rules and scoring system) can be effective in encouraging herding and non-herding tendencies during practice in team sports.

Between herding and non-herding conditions, it was suggested that there was greater within- and between-team synchrony in the herding conditions. See Figures 3a and 3b. Specifically, there was a clear distinction in terms of mean cluster amplitude for the teams between the two conditions. Thus, the game play patterns of the two teams were strongly influenced by the different task constraints presented in the two respective herding and non-herding conditions. In this instance, the presentation of specific rules between conditions seemed to constrain the players of both teams to display quite different coupling of behaviours within and between teams. Nevertheless, there was no group difference for between-team synchrony, which indicated that both the teams responded in similar ways to herding and non-herding conditions, respectively. Critically, the presentation of specific task constraints can have a pertinent effect on players' movement behaviours (see Chow, Davids, Button & Renshaw, 2016). The results of this study suggested that herding tendencies can be tracked and intervention strategies (e.g., altering task constraints) can be applied to alter game play behaviours in invasion team games. This observation is in agreement with the suggestions of Renshaw et al. (2010) and Chow et al. (2016) which revealed that a constraints-led approach has the potential to provide practitioners with a framework for understanding how manipulation of performer, task and environmental constraints shape each individual's movement behaviours. However, a remaining question for future research is to ascertain whether non-herding behaviours stabilize when removing task constraints after some amount of practice.

In addition, herding tendencies were best captured along the longitudinal direction during performance. Inconsistency in the line plots (see Figures 4a and 4b) suggested that synchronisation tendencies were weaker in the lateral direction along the breadth of the playing area. It is likely that the movements of players were concentrated along the longitudinal direction to facilitate their main performance aims of scoring points by catching the ball within scoring zones 1 and 2 (along the longitudinal axes). This observation from the current study is supported by the findings of Duarte et al. (2013) and Folgado, Duarte, Fernandes and Sampaio (2014) in their examination of professional football matches where stronger couplings were also reported in the longitudinal direction of play. The current finding demonstrated a clear effect on player behavioural tendencies of this type of task constraint manipulation. Thus, under these task constraints, passes and movement of the players in the longitudinal direction were likely to be perceived as being more significant because of the affordances that can result in more goal scoring opportunities. The opposing teams might also have had a greater impetus to track and follow movement in the longitudinal direction than in the lateral direction.

The design of modified games based on an ecological dynamics approach such as representative design, and emergent self-organization tendencies under constraints suggest the need to provide opportunities for attunement to affordances channelled by manipulation of task constraints on each individual (Chow et al., 2016; Renshaw et al., 2010). The results of the current study show how nonlinear teaching pedagogies in sport can provide an effective and valid framework for enhancing skill in sport.

A noteworthy point in this study concerned the effect of ball possession on within team synchrony. From the results, there is some suggestion that ball possession may have an influence on how teams may move differently. This was evident for the Red Team where mean cluster amplitude values were lower with ball possession. This finding could indicate a decoupling or reduced team synchrony among the players in the team. The findings may imply the emergence of an attempt by the players in the Red Team to move away from one another into space to provide options to retain ball possession. However, this observation on the impact of ball possession was not seen for the Green Team. It is possible that Green Team chose to keep more compact by coupling their movements, even when in possession of the ball. Nevertheless, the possession of the ball had a significant impact on levels of within team synchrony, especially when applying task constraints to facilitate herding tendencies (perhaps for different purposes that may or may not be necessarily negative). These results suggest that practitioners ought to take into consideration how task constraints and instructions can be manipulated to impact team play patterns, especially in relation to providing opportunities for ball possession to the learners involved in the constrained game.

The effectiveness of each task constraint manipulation needs to be further studied in the future. Intervention studies need to be undertaken to examine the longer-term effects of task constraint manipulations in influencing herding and non-herding tendencies in learners. This would ascertain whether current intervention strategies actually affect learning and reduce herding behaviours.

Conclusion

The cluster phase analysis used in this study was able to distinguish between the herding and non-herding tendencies in learners as task constraints were manipulated. There is a suggestion that ball possession had a role to play in influencing the direction of within-team synchrony but this needs to be further investigated. Future research is required to verify the effectiveness of implementing specific task constraints and investigate different ways to shape performance behaviour tendencies in learners over extended periods of time.

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Table 1 Rules implemented in the two different simulated conditions (Herding and Non-Herding)

Herding	**Non-Herding**
Pair up & stay within 2m of your opponent	No restriction to pair or to stay with opponent
Stay close to the ball	No restriction to be near the ball
2 scoring zones (end)	4 scoring zones (end & side)

Figure Captions

Figure 1. Experiment set-up of the throw and catch game

Figure 2. Video representation depicting the pairing of players for the game

Figure 3 (a). Representative cluster amplitude of both Red and Green teams in the longitudinal direction for herding condition. 3 (b) Representative cluster amplitude of both Red and Green teams in the longitudinal direction for non-herding condition.

Figure 4 (a). Representative cluster amplitude of both Red and Green teams in the longitudinal direction. 4 (b) Representative cluster amplitude of both Red and Green teams in the lateral direction. This is an example from the herding condition.

Figure 5. Mean Cluster Amplitude as a function of Conditions and Groups. Note that there is a significant difference between conditions. From the Figure, each single dot represents a play. The presence of darker areas (congregation of dots) within each column would indicate a greater frequency of occurrences.

Figure 6. Mean Cluster Amplitude as a function of Conditions and Possession for Green Team. Note that there is a significant difference between conditions. From the Figure, each single dot represents a play. The presence of darker areas (congregation of dots) within each column would indicate a greater frequency of occurrences.

Figure 7. Mean Cluster Amplitude as a function of Conditions and Possession for Red Team. Note that there is a significant difference between conditions and for ball possession. From the Figure, each single dot represents a play. The presence of darker areas (congregation of dots) within each column would indicate a greater frequency of occurrences.

Figure 1.

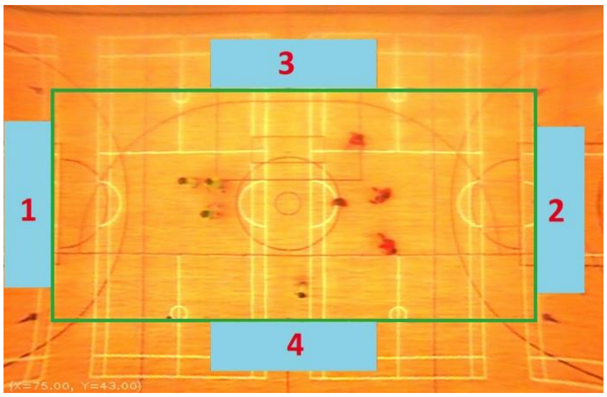


Figure 2.

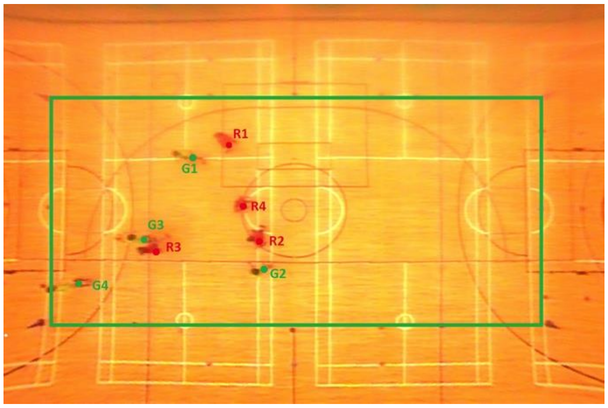
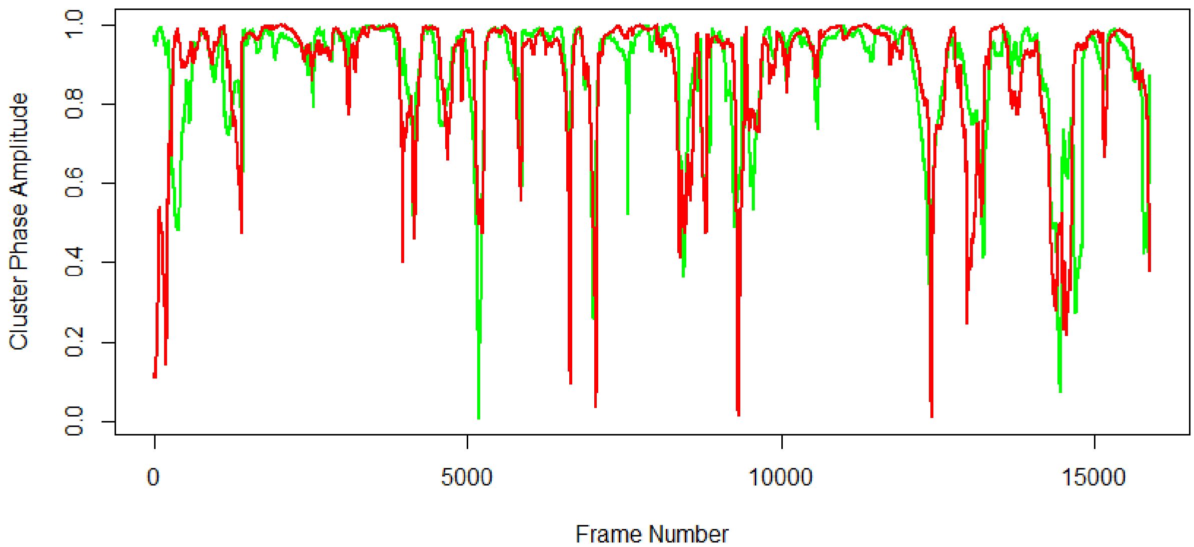


Figure 3a and 3b.

3a



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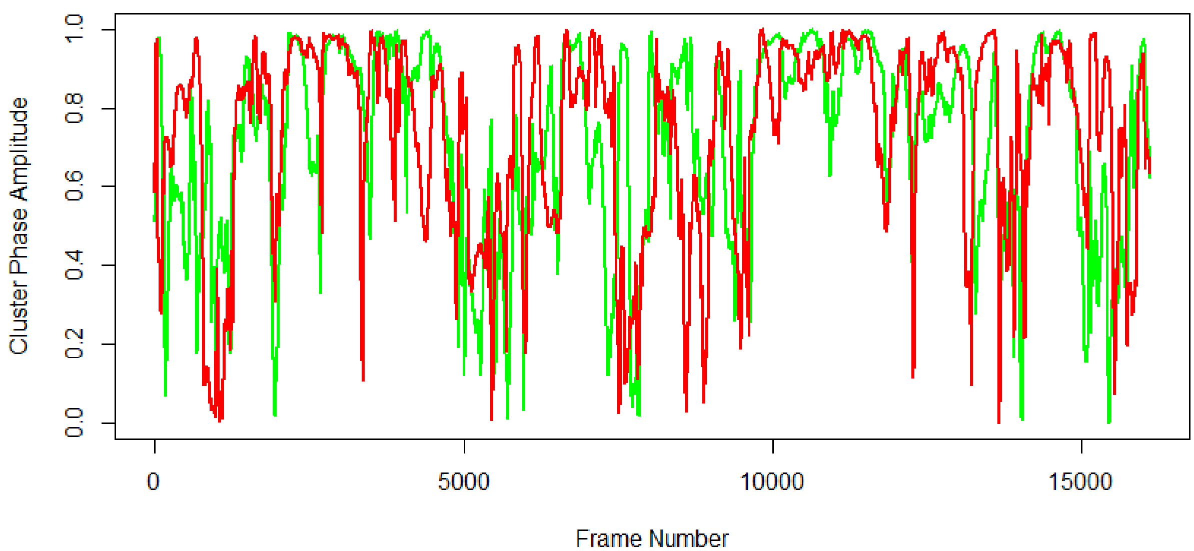
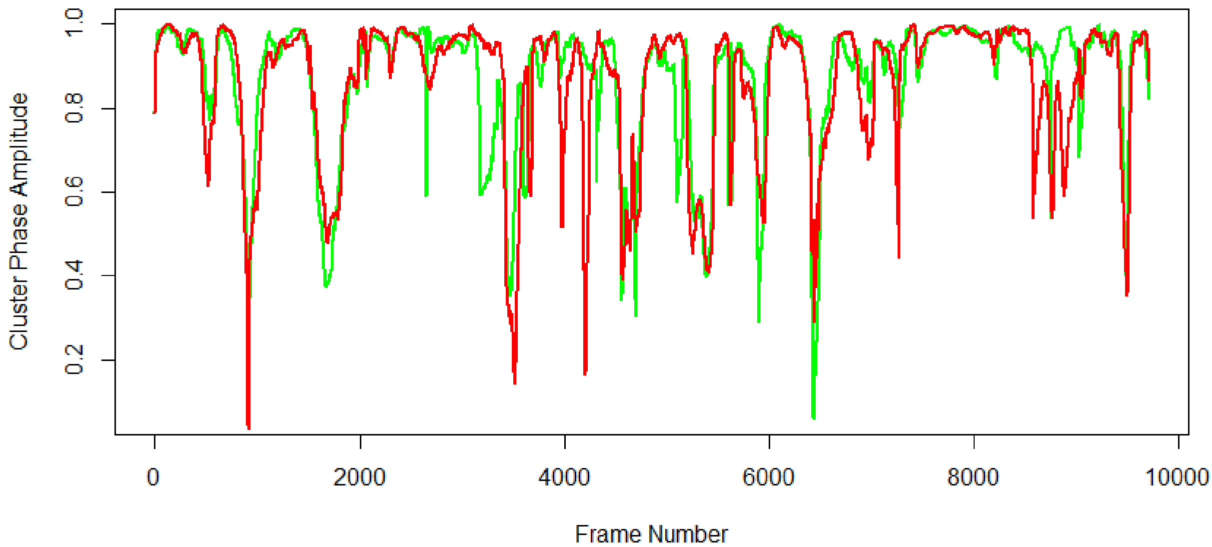


Figures 4a and 4b.

4a



4b

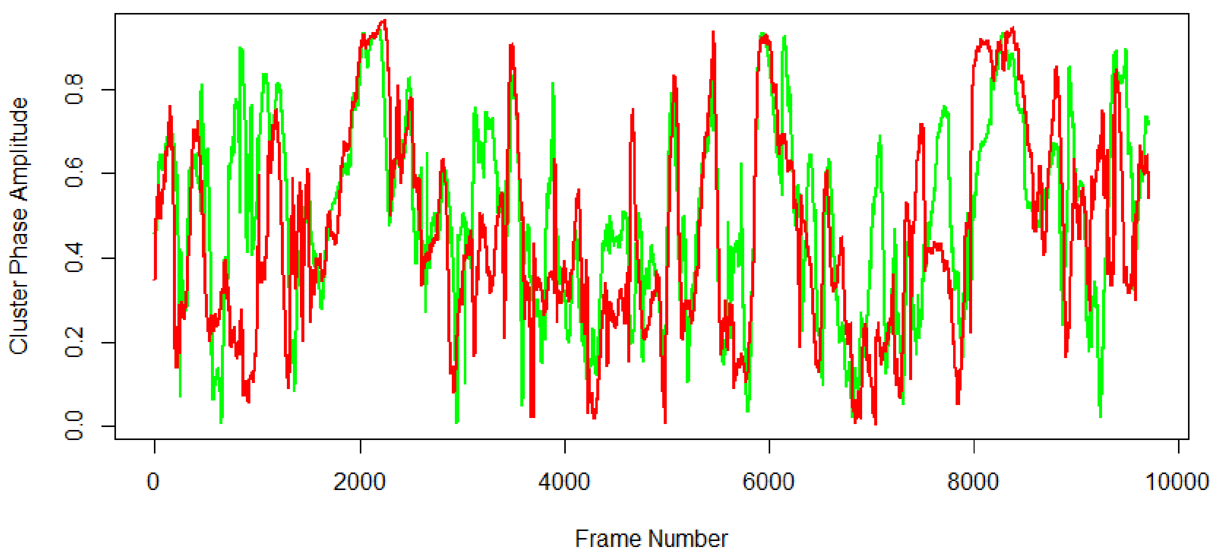
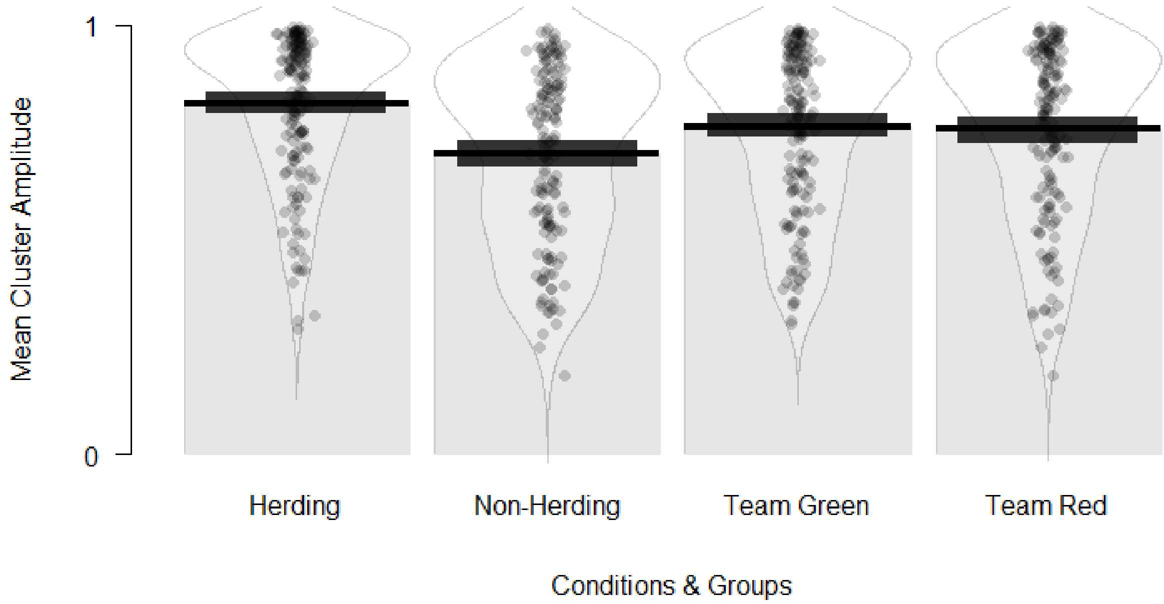


Figure 5.



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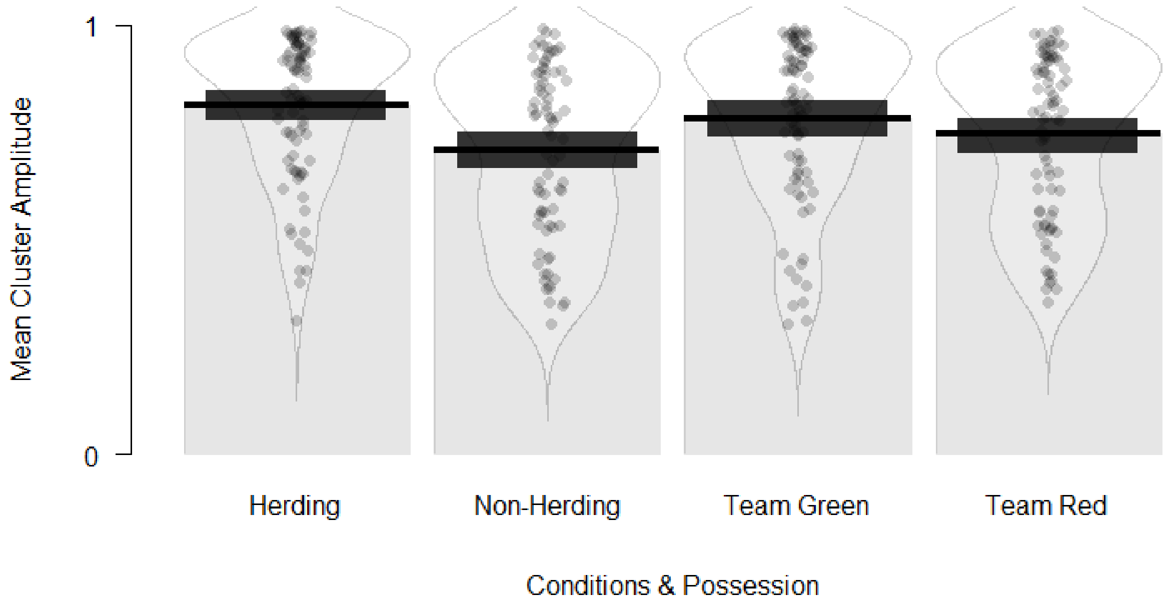
Mean Cluster Amplitude
Herding
Non-Herding
Team Green
Team Red
Conditions & Groups

Figure 6.



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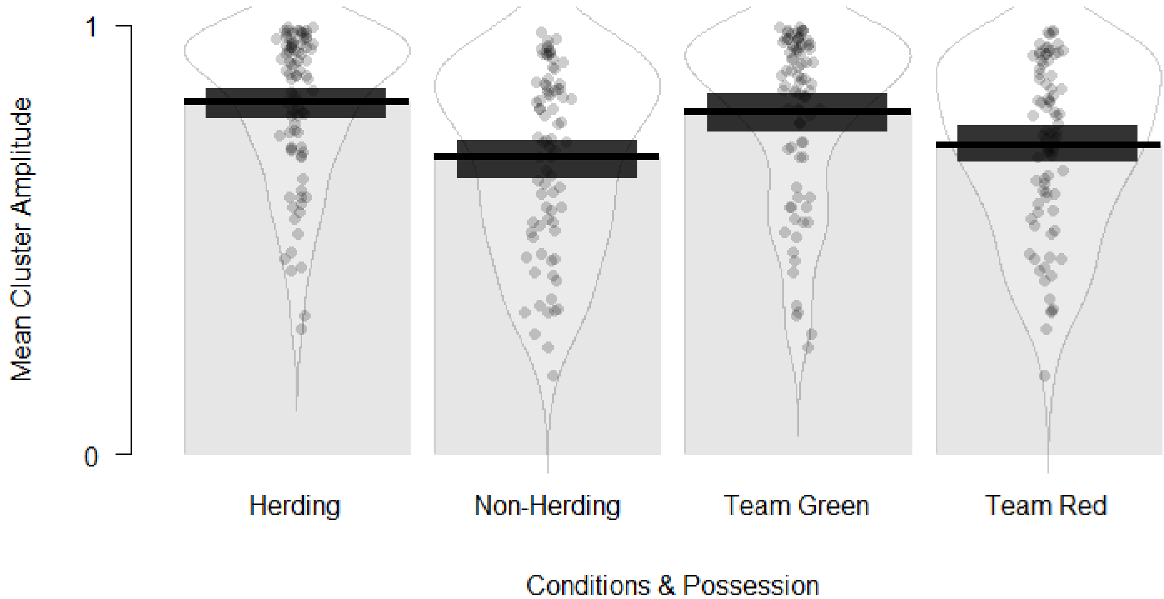
Mean Cluster Amplitude
Herding
Non-Herding
Team Green
Team Red
Conditions & Possession

Figure 7.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Mean Cluster Amplitude
Herding
Non-Herding
Team Green
Team Red
Conditions & Possession