Doctoral School of Regional and Business Administration Sciences

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Non-equilibrium in ice hockey: understanding the game with a transdisciplinary approach

Dissertation Highlights

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1. RESEARCH QUESTIONS OF THE DISSERTATION

The research questions formulated in this dissertation reflect the steps of the learning process the author underwent during his journey.

First paper

RQ1: Can playing ice-hockey contribute to the Emotional Intelligence level of the players?

RQ2: Can playing ice-hockey contribute to the Resilience level of the players?

The first step of the research focused on whether playing ice hockey has an increasing effect on two important life skill sets, namely emotional intelligence and resilience. These skillsets are considered to be decisive parts of the personality of the players.

Second paper

RQ3: Are the identified five factors of the coach's operation relevant and sufficient for understanding the complex operation of a coach?

RQ4: Are the identified five factors of the team's operation relevant and sufficient for understanding the complex operation of the team?

RQ5: How do visible and non-visible interactions arise in the cooperation of the coach and the players?

RQ6: How does the cooperation of the coach and the team function as a system that supports high performance?

As the second paper was a research design type article in which an explanatory model was created and proposed, research questions 3 to 6 inevitably focus on the different parts of the model. The interview questions aiming to corroborate and finalize the model later were conducted in accordance with these research questions.

Third paper

No research questions were investigated in this paper, instead, the paper serves as a container of definitions of the constituting factor of the proposed model.

Fourth paper

No new research questions were asked in this paper either as they were adopted from the second paper. The interviews and their results are presented in this article relying on which the proposed model of ice hockey team performance was finalized.

Fifth paper

RQ7: What are the characteristics of the "three goal events", and do they show antifragile behavior?

This, 7th research question focuses on specific events of an ice hockey game in which antifragile behavior emerges and is observed.

It is to be seen through the research questions that the psychological aspect of ice hockey is strongly addressed, along with the types of knowledge-sets and skill-sets required from the participants of an ice hockey team to perform.

2. METHODS

First paper

Firstly, the author had two research questions for which a targeted literature review was carried out to identify whether this field was covered by scientific knowledge, and whether the research questions needed modification. Though the literature review revealed that there was knowledge connectible with the research questions, the coverage was not satisfactory. An important knowledge gap was found here.

The cross-section study used two selected psychological abilities - emotional intelligence and resilience - to identify whether playing ice-hockey can contribute to the player's psychological power. An anonymous online questionnaire was sent out to all the adult Hungarian ice-hockey players (population size = 1673). The questionnaire contains four parts: 1. basic data of the participant, 2.

Schutte et al. (1998)'s Emotional Intelligence Scale, validly translated into Hungarian, 3. Wagnild and Young (1990)'s Resilience Scale, validly translated into Hungarian. According to the literature and hypotheses, the longer the player plays ice-hockey, the higher value he/she must reach on the emotional intelligence and resilience scales. To meet scientific standards, Cronbach's alpha was calculated for each scale, in order to identify whether the scale is a reliable measurer of these abilities.

The research used regression analysis, as it can reveal the causal relationship between parts of basic data and values measured by the scales used.

Second paper

The author decided on performing structured interviews with 15 experts of Hungarian ice-hockey, including 5 senior national team players, 5 national team coaches and 5 national team leaders. The semi-structured interviews offered a great chance to improve the proposed model, and to find the hidden connections among the factors, and to test whether the five factors of coach's, and those of players' operation covers the whole ice hockey team's operation. Therefore, the following interview questions were created:

1) According to your experiences, how would you describe the relationship between the coach's practical knowledge and team performance?

2) According to your experiences, how would you describe the relationship between the coach's theoretical knowledge and team performance?

3) According to your experiences, how would you describe the relationship between the conductive ability of the coach and team performance?

4) According to your experiences, how would you describe the relationship between the psychological state of the coach and team performance?

5) According to your experiences, how would you describe the relationship between knowing the dynamics of the team and team performance?

6) Do you think the five mentioned factors cover the whole operation of a coach?

7) If not, what would you add to the model?

8) According to your experiences, how would you describe the relationship between player's technical knowledge and team performance?

9) According to your experiences, how would you describe the relationship between player's tactical knowledge and team performance?

10) According to your experiences, how would you describe the relationship between conductive ability of players and team performance?

11) According to your experiences, how would you describe the relationship between psychological state of players and team performance?

12) According to your experiences, how would you describe the relationship between power status of players and team performance?

13) Do you think the five mentioned factors cover the whole operation of a team?

14) If not, what would you add to the model?

15) According to your experiences, should the coach and the players have visible and non-visible interactions in order to perform well?

16) According to your experiences, when the coach and the players acts as two opposing objects in the same team, do they perform well?

17) According to your experiences, when the coach and the players keeps their orbits and the system is balanced, does it support high performance?

18) Do you think the model describes the operation of a high-performing team?

19) If not, what would you add to the model?

Third paper

In this paper, the factors of the proposed model of ice hockey team performance were defined. The factors were created to cover the operation of an ice-hockey team from a performance perspective. The concept is built out of definitions of the factors, providing the robustness, and the boundaries of the model. The author presents six definitions based on the found literature together with his own definitions made through a synthesis process for every factor in order to ensure that the factors are well described such that the model should fit and be useful in practical contexts as well.

Fourth paper

The aim of this research phase was to finalize the model that describes the factors of high performance for ice hockey teams. The proposed model was tested with the help of highly qualified experts on Hungarian ice hockey. It was assumed that professional-level coaches and players are capable of providing insights for practitioners and players of any level of sports activity. In order to meet these quality standards, five Hungarian national team coaches and five Hungarian male senior national team players were interviewed through semi-structured interviews. The interview questions were presented in the second paper in this dissertation. As the interviews were semi-structured, all the factors and interactions were covered by the questions, enabling the interviewees to provide feedback on each part

of the model and highlight their relationships. In the case of choosing the national team players to be interviewees, diversity was the main goal. Therefore, a goalie, two defensemen, and two forwards were interviewed; two of them were team captains in their club teams. Seven of the ten interviews were held in person, while three of them were conducted online. The proposed model was shown and explained to the interviewees before the questions were presented. The interviewees were numbered from 1–10: 1–5 for coaches, 6–10 for players. The in-person interviews were recorded with an audio recorder, while the online interviews were recorded with the built-in record function of the software that was used. All of the interviewees gave their permission for the interviews to be recorded and used for the current research.

Fifth paper

In this study phase, the Erste League (the name of the highest-level Hungarian ice hockey league) is focused on, and data were obtained from its official website and other international databases (http://www.eliteprospects.com). Ranging from 2011 to 2020, a total of 2,183 games were analyzed using the examination criteria. Three-goal events were recorded in the dataset, meaning an event when an opponent's goal was immediately answered by two goals. A three-goal event was recorded only if no other goals were scored five minutes before the first goal and if the opponent did not score for five minutes

after the second goal. All were equal-opportunity situations, wherein both teams were playing with equal strength, with 5+1 players. A total of 35 three- goal events were identified in 34 games. Team and individual performance metrics were available in the data sources consulted, although data on collective line strength were not available. Therefore, individual measurements were averaged to obtain the strength of a given line when the three-goal events occurred. To obtain clarity on the strength of the players in the line, players' season statistics were used. Ice hockey offers multiple individual offensive statistics, such as goals, assists, and total points. However, plus-minus statistics are the most useful as they measure the player's overall contribution to the games.

Friedman test was performed as the data showed no normality in distribution. Pearson correlation was also used to measure the coach's line management activity. Wilcoxon signed-rank test was performed to compare the coaching activity of the coaches of the examined teams. The K-means cluster method was used to find the hidden structure in the data, which are three-goal event scenarios. The scenarios where a three-goal event might trigger antifragile behavior are the following: 1. Team A takes the lead with the third goal or 2. Team A's goal, the third goal, results in a draw. Convexity (Taleb, 2012a) is found in Team A when Team B scored a goal.

3. FINDINGS

First paper

Emotional Intelligence Scale subscales	Years spent playing ice-hockey	Age
1. Appraisal of others emotions subscale	No linear regression model could be built.	No linear regression model could be built.
2. Appraisal of own emotions subscale	No linear regression model could be built.	No linear regression model could be built.
3. Regulation subscale	No linear regression model could be built.	Adjusted R square = 0.129 F value = 16.227 Significance = 0.000
4. Social Skills subscale	No linear regression model could be built.	No linear regression model could be built.
5. Utilization of emotions subscale	No linear regression model could be built.	No linear regression model could be built.

6. Optimism subscale	No linear regression model could be built.	Adjusted R square = .100 F value = 12.505 Significance = 0.001

Table 1. *Emotional intelligence Scale subscales linear regression models with the players' years spent playing, and age. Source: Own creation*

As seen from Table 1., no linear regression model could be built between the years spent in ice-hockey of players and the emotional intelligence subscales, meaning no causal relationship exists in the data between them. This means, playing ice-hockey cannot contribute to the emotional intelligence of the players. A linear regression model could be built between the age of the players, the regulation of emotions and optimism. In every other case, no regression model could be built between the values. This means the regulation of emotions of the players and the optimism are improving over time, but show no relationship with playing ice-hockey.

Resilience Scale subscales	Years spent playing ice-hockey	Age
1. Meaningfulness subscale	No linear regression model could be built.	Adjusted R square = 0.032 F value = 4.449 Significance = 0.037
2. Perseverance subscale	No linear regression model could be built.	No linear regression model could be built.
3. Self-reliance subscale	No linear regression model could be built.	No linear regression model could be built.
4. Existential aloneness subscale	Adjusted R square = 0.031 F value = 4.319 Significance = 0.040	Adjusted R square = 0.073 F value = 9.079 Significance = 0.003
5. Equanimity subscale	No linear regression model could be built.	No linear regression model could be built.

Table 2. *Resilience Scale subscales linear regression models with the players' years spent playing, and age. Source: Own creation*

As seen from Table 2., in the case of Meaningfulness subscale, only with the age of player could a model be built. A linear regression

model could be built between years spent playing ice-hockey and Existential aloneness subscale value. However, a stronger causal relationship was found between the age of the player and the subscale. This means that resilience abilities improve when becoming older, and as the model was weaker in the case of years spent playing ice-hockey, this result suggests that this improvement is more likely to be caused by maturing, and only partially by playing ice-hockey. In every other case, no regression model could be built. Therefore, playing ice-hockey may contribute to the resilience ability of the players, as the improvement is more likely to be caused by becoming older. Experts of sport psychology suggested, however, that a linear regression model could be built between time spent playing ice-hockey and existential aloneness values, their experience suggest that the improvement effect is more likely to be caused by becoming older, and an interdependence is present between age and time spent playing ice-hockey.

Second paper

In order to be successful in the interviews with the experts of the field, a proposed model was created by the author to serve as the base of the interviews. According to the literature and the knowledge obtained from the experts, the proposed model for constructing the scale is seen in Fig. 3.

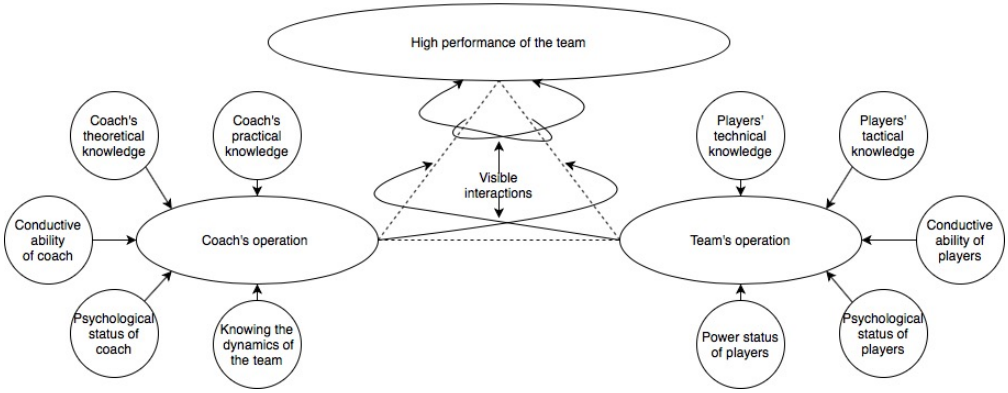

Figure 3. *Proposed model of ice-hockey team performance. Source: own creation.*

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Third paper

The results of the third paper are seen in Table 3. The own definitions were created through synthetizing existing definitions in the literature with the expert knowledge of the author.

Factor	Own definition
Coach's practical knowledge	A knowledge is categorized as coach's practical knowledge if it comes from the coach's **experience** in doing sport / coaching.
Coach's theoretical knowledge	A knowledge is categorized as coach's theoretical knowledge if the knowledge comes from **education**.
Coach's conductive ability	An ability is categorized as conductive ability of the coach if this ability is used when **transferring thoughts or emotions** into the players and other participants, through interactions.
Coach's psychological status	A status is categorized as coach's psychological status if it shows the **harmony** of the coach's cognitive, and emotional patterns.
Knowing the dynamics of the team	A knowledge is defined as knowing the dynamics of the team if it contains the **key pieces of information about the team.**

Players' technical knowledge	A knowledge is defined as player's technical knowledge if it contains **movement patterns** that enable the athlete to efficiently achieve a set goal in sport setting.
Players' tactical knowledge	A knowledge is categorized as player's tactical knowledge if it contains complex knowledge of the game, which as a **game-sense helps** what, how and why the player acts in different game situations.
Players' conductive ability	An ability is categorized as conductive ability of the players if this ability is used when **transferring thoughts or emotions** into the coach and other participants, through interactions.
Psychological status of players	A status is categorized as player's psychological status if it shows the **harmony** of the players' cognitive, and emotional patterns.
Power status of players	A status is categorized as power status of the players if it shows the ability to **overcome resistances**, either in physical or mental manners.

Table 3. Synthetized own definitions in the third paper. Source: Own creation

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Fourth paper

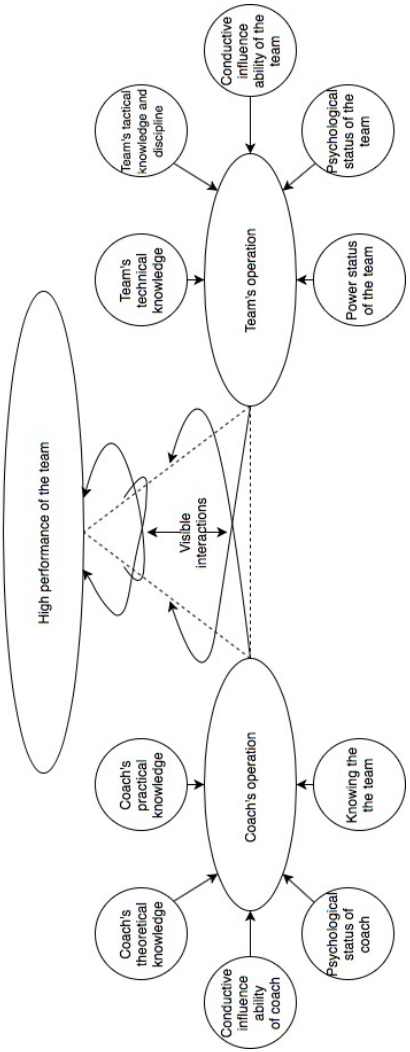

Figure 4. *The authors` finalized model of ice-hockey team performance. Source: own creation.*

Based on the interviews, it is clear that the psychological side of performance dramatically increases in significance when a coach wants to improve the team's performance. This method includes having an open-door policy, two-way communication, and feedback loops. The coach must know the players deeply in order to recognize and make use of players' moods. In addition, the coach must improve their communication abilities to act as an authentic role model for the players. The finalized model is capable of providing a thorough framework for practitioners who want to understand the performance issues of their teams or further improve the overall performance of their teams.

Fifth paper

The results of the average line strengths show that Team A had stronger lines on ice for all three goals. This means that the first goal, which was from Team B, was scored by a weaker line. The second and third goals were scored by Team A, which deployed stronger lines than Team B. As a pattern was found in these data, the mean comparison was reasonable.

The results suggest that Team A has evidently stronger lines for the three-goal events compared to Team B. The highest significant mean rank difference was found for the third goal. Coaches strategically send strong lines on ice shortly after the team scores a goal, resulting

in either another goal or higher pressure on the opponent. A mean rank difference was also found in second goals; the pattern is the same as in the case of the first goals. Coaches have offensive and defensive strategies, and matching line strengths with the opponent's line strengths is a good defensive strategy.

The results of the correlation analysis indicate that there is no correlation across the teams. For example, a Team A variable is only correlated with the other two Team A variables. The same applies to Team B, where correlation is observed only among Team B variables. This implies that Team B either had the same line strength or a stronger line on ice when the second goal was scored, while Team A's line strengths were evenly distributed. When the third goal was scored, Team A's line on ice had a similar strength to the line involved during the first goal. If we consider homogeneity in the individual plus-minus statistics of teams, Team A was more likely to change line strength than Team B after the first goal, either by changing another line on the ice or restructuring the makeup of their lines. Team B showed a similar line strength during the first and second goals, while having a differing line at the third goal. By contrast, Team A had different lines when the first and second goals were scored, and the line strength at the third goal was similar to the line at the first goal. Based on the results, Team A's lines were likely to have the same strength at the first and third goals, while Team B's lines were likely to have the same strength at the first and second goals.

As seen from the Wilcoxon test results, no significant differences can be found between the participant teams' line change behaviors, meaning equality may be assumed in the coach behaviors between Teams A and B.

The K-means cluster method could discern two clusters. In both clusters, Team B had weaker line strengths at every goal in the three-goal events, which meant that the first goals scored by Team B were against stronger opponents. The second and third goals were scored by Team A, which had stronger lines on ice compared to Team B. Additionally, in both clusters, Team A's line strengthened from the first goal to the third goal. This phenomenon showed antifragile characteristics, where the first goal acted as a stressor that triggered Team A to send stronger lines that allowed it to score the second and third goals. Based on the cluster centers, two main cases were identified. The first cluster showed a big difference between the line strengths of Teams A and B, while the second cluster showed almost identical line strengths.

Antifragility was found in cases wherein Team B gained the lead or had a two-goal lead after the first goal of a three-goal event.
There was no antifragility in 13 games. Type one antifragility was found in 15 games, while type two antifragility was found in six games. These complex behaviors, which resulted from cooperation

within the team, were found to be an emergent characteristic, as evidenced by Team A's strengthening of the lines after a goal from Team B.

4. AUTHOR'S PUBLICATIONS ON THE TOPIC

First paper

Reference: Géczi, G. and Komlósi, L. I. (2020) 'Ice-Hockey as a Potential Improvement for Emotional Intelligence and Resilience: Increasing Psychological Capital', *Economic and Social Development: Book of Proceedings*, Győr, 4-5 September 2020.

Second paper

Reference: Géczi, G. (2021a) 'Research Design for Developing and Validating Ice Hockey Team Diagnostics Scale', *International Journal of Sport and Health Sciences,* volume 15(8) [online]. Available at: https://publications.waset.org/10012179/pdf (Accessed: 2021. 09. 01)

Third paper

Reference: Géczi, G. (2021b) 'Antifragile Approach for Ice-Hockey Team Performance Modeling: The Definitions Component' *12th IEEE International Conference on Cognitive Infocommunications: Proceedings*, Győr, 23-24-25 September 2021.

Fourth paper

Reference: Géczi, G., Gurisatti, L. and Komlósi, L. I. (2022) 'Complex Ice Hockey Team Performance Model based on Expert Interviews', *Physical Culture and Sport. Studies and Research,* 95, pp. 75-83.

Fifth paper

Reference: Géczi, G. and Baracskai, Z. (2022) 'Statistical Analysis of Antifragility in Hungarian Ice Hockey Games', *Hungarian Statistical Review,* 5(1), pp. 75-93.

5. LITERATURE

Schutte, N. S., Malouff, J. M., Hall, L. E., Haggerty, D. J., Cooper, J. T., Golden, C. J. and Dornheim, L. (1998) 'Development and validation of a measure of emotional intelligence', *Personality and Individual Differences*, 25(2), pp. 167-177. https://doi.org/10.1016/s0191-8869(98)00001-4

Taleb, N. N. (2012a) *Antifragile: Things That Gain from Disorder*. 1st edn. New York: Random House.

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