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The Relationship of Decision-Making Style and Reaction Agility Performance Regarding the Type of Stimulus in Handball

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ABSTRACT

The purpose of this study was to verify the influence of contextual perception in sports on performance in reaction agility to a specific and non-specific stimulus on a sample of handball players. The object of the research was eleven players of the junior handball team playing in the top league (age: 16.73 years; decimal age 16.46 years). Visual signaling and video projection and a modified Y-test of reaction agility were used. In this study, two goals were set: a) to compare the performance level in the Y agility test with respect to a simple non-specific and a complex specific visual stimulus in the form of filmed scenes of the opponent's attacking actions, which simulated real situations in performance handball; b) find out the possible relationship between performance in the agility test and reaction time, decision-making competence, anxiety and overload, and involvement in decision-making and performance with regard to the nature of the stimulus. A questionnaire (CETD) was implemented in the sample to assess the decision-making style of athletes in a specific area. The results confirm the statistical significance of the differences between reaction times to a simple light stimulus and reaction times to video sequences, especially in activities associated with deceptive activity ($p = 0.000$), but also without it ($p = 0.006$). The relationship between performances in the Y Agility test to a video stimulus and reaction time ($r = -.272$), decision-making competences (0.116), anxiety and overload ($r = 0.105$) and involvement in decision-making ($r = 0\text{-}.059$) was not demonstrated. Simple linear regression analysis revealed that performance in the agility test to a simple stimulus (Witty; $F(1) = 6.52$, $p = 0.030$) is a significant predictor of context-specific agility performance and accounts for 73.4% of the explanatory variable ($R2 = 0.734$).

Keywords: handball; decision-making functions; anticipation; sport-specific stimulus; reactive agility

INTRODUCTION

Handball is one of the most popular sports not only in Slovakia and the Czech Republic, but also in Europe and the world. With the use of the knowledge of sports sciences, the knowledge base is dynamically developed, which results in an increase in the quality of sports training and, consequently, sports performance. The uncertainty and variability of the sports environment in handball play an important role in perception, cognition and motor control, and the theory of these processes defines a wide range of primarily biological factors. The way the organism perceives processes and combines sensory information from different sources and transforms it into the speed and quality of game skills in relation to the conditions of the game is currently becoming the object of many researches.

The ability to make decisions is a basic prerequisite in most sports, especially in the case of fast and dynamic collective sports such as handball. Decision-making can be considered one of the current research problems in fields such as: psychology, sociology, mathematics, economics, politics, geography, pedagogy and sports sciences (Lara, 1991; Tenenbaum and Bar-Eli, 1992). There is agreement on the key role of perceptual-cognitive abilities in the player‘s decision-making processes (Hadlow et al., 2018). They contribute to an unlimited number of skills that are the basis of high performances in sports games. Cognitive abilities are genetically limited because their heritability coefficient is very high (H2 = 0.85 -0.92). Development reaches its maximum around the age of 16 and is maintained until the age of 25, after which it begins to decline (Trunić and Mladenović, 2014). The ability to capture visual information, select and take appropriate action is the key to high performance (Williams and Ericsson, 2005; Williams, Ford, Eccles and Ward, 2011).

Decision-making is a cognitive operation during which we choose the option that is most suitable for the given situation and considered the best at the given time, considering the optional alternatives that are offered in the given environment (Kiss and Balogh, 2019). The quality and speed of the decision can be influenced by several factors, such as athleticism, acquired experience, time or other pressure and stress (Tenenbaum and Gershgoren, 2015), or environmental stimuli or mental state of the athlete (Tenenbaum, 2003). The results confirm the general assumption that cognitive mechanisms are in a statistically significant interaction with motor mechanisms of top players (Malacko and Stanković, 2011). The current mental state of the athlete (Tenenbaum, 2003), or fatigue (Skala and Zemková, 2022) can also play a key influence.

Apart from the economic aspects of decision theory (Simon, 1959), the discussion generally stems from the theory of the Bayesian formulation of visual perception (Knill, Kersten and Yuille, 1996), through descriptive theoretical models to a specific view of statistical decision theory (Maloney, 2002; Trommershäuser et al., 2008). Although decisions can vary dramatically in quality and content, research has revealed substantial and systematic regularities in how individuals make decisions and leads to the formulation of general cognitive and psychological principles that characterize decision-making behavior.

In sports games, we encounter difficulties associated with diagnostic procedures of perceptual-cognitive abilities in athletes, which would reflect on the specific conditions of a particular sports game. They were classified as basic cognitive functions based mainly on cognitive capacity or processing efficiency (e.g., attention, short-term memory, processing speed) and tasks that involve several cognitive capacities or require the coordination of several basic cognitive functions (e.g., working memory capacity, inhibition, and shifting), were classified as higher cognitive functions (Kalén et al., 2021).

Two theoretical approaches are commonly used to study decision-making in team sports. The cognitive approach focuses on the skills that the player uses when responding to various stimuli, often in a non-specific context. These skills include attention, memory and perception. On the contrary, a more recent naturalistic approach studies the way a player analyzes a real and lived situation, generates options, evaluates team knowledge and integrates them into a collective plan (Bonnet, Debanne and Laffaye, 2020). In addition, we also find specific approaches to the evaluation of cognitive functions by measuring reaction Go/NoGo time (Lucia, Bianco and Di Russo, 2023), using a binocular eye tracking device (Natsuhara, Kato and Asai, 2020; van Maarseveen, 2018); the CogState test battery (Goble and Christie, 2017); the Vienna Test System (VTS; Schuhfried, 2013), or a video stimulus reaction time paradigm was used (Rösch, Schultz and Höner, 2021).

In addition to the evaluation of basic motor parameters, it seems necessary to deal with the evaluation of athlete´s psychomotor abilities (Kioumourtzoglou et al., 1998). Thanks to skills such as the ability to obtain visual information about an approaching object (ball), players with a high level of hand-eye coordination can respond more effectively to external stimuli and adapt their movements to the situation on the field (Przednowek et al., 2019). Visual search strategies during ball movement suggest (Natsuhara et al., 2020) that the position of the ball and the situation of teammates and opponents are the most important information sources for an accurate and consistent decision to perform an action.

It is proven that experienced athletes have excellent decision-making and anticipatory skills in assessing game situations (McMorris and Graydon, 1997; Farrow and Abernethy, 2003; Elferink-Gemser, 2004; Mann et al., 2009). They use the kinematic information they get from the opponent›s movements to predict the trajectory of the ball. These findings (Cocić et al., 2021) underline the importance of kinematic knowledge for prediction. but also demonstrate the importance of carefully selected occlusion points. However, some findings clearly do not support theorists› claims that experienced athletes will be significantly more accurate and faster in decision making than inexperienced athletes (McMorris and Graydon, 1997).

The purpose of this study was to verify the dependence of performance in reaction agility on the type of visual stimulus (specific and non-specific) on a sample of handball players. It can be expected that as the number and quality of stimuli increases, the level of performance in reaction agility decreases.

METHODS

Eleven female players who play in the 1st Slovak teenage league in the club HŠK-74 Kolárovo (16.46 ± 2.0 years; 169.1 ± 5.7cm; 58.5 ± 8.9kg) voluntarily participated in this study. The criteria for including female players in the research were their subjective health, regular participation in training sessions at least three times a week. Injured players were excluded from the test, or female players who subjectively experienced health problems, or female players whose length of experience was less than five years. All observed players were right-handed. All participants were informed in advance about the procedures, main aims and purpose of the study. The procedures presented were in accordance with the ethical standards for human experimentation as outlined in the Declaration of Helsinki and its later amendments.

This is a cross-sectional correlational study. Before testing, all participants completed a 10-minute warm-up, including light aerobic running and dynamic stretching exercises. They then attended a familiarization session where the testing protocols were explained and practice tests were administered. They then performed three different types of reaction time tests using Fitro Reaction Check (FiTRONiC, Bratislava, Slovakia) and Witty SEM (Microgate, Bolzano, Italy). A precise Witty measuring device with an accuracy of 0.01 s was used to measure time. All tests were performed in a sports hall with a wooden deck floor with reduced exterior visibility.

Simple reaction test

The simple reaction time was measured by the diagnostic system FiTRO Reaction Check in accordance with the protocol (Zemková, 2018). This device consisted of two pressure switches connected to a computer. The task of the simple reaction time test was to respond as quickly as possible to a single visual stimulus (a green circle on a white background) by pressing a switch placed on a table. The test consisted of one trial with 4 answers. The result of these tests was the average of the two best times.

Y Agility test

A reliable and valid Y-shaped reaction agility test was used in this study (Lockie et al., 2014). Due to the elimination of speed capabilities, it was modified in length parameters. A Witty timing system based on light semaphores with LED technology was used to record time and set reactive conditions. The width of the gates was 1.5 m with a height of 1.2 m. 8 attempts were made and the average of the 4 best times was used for further analysis. In the first test, a Witty Sem traffic light was placed in front of the players to determine the direction. A green direction indicator arrow was used as a stimulus. It appeared at the moment of passing the starting gate without delay. The tested person stood 30 cm behind the starting line and at the moment of the stimulus display, they performed the task of running a 2 m long sprint to the goal gates at maximum speed at an angle of 45° to the left or right (Fig. 1).

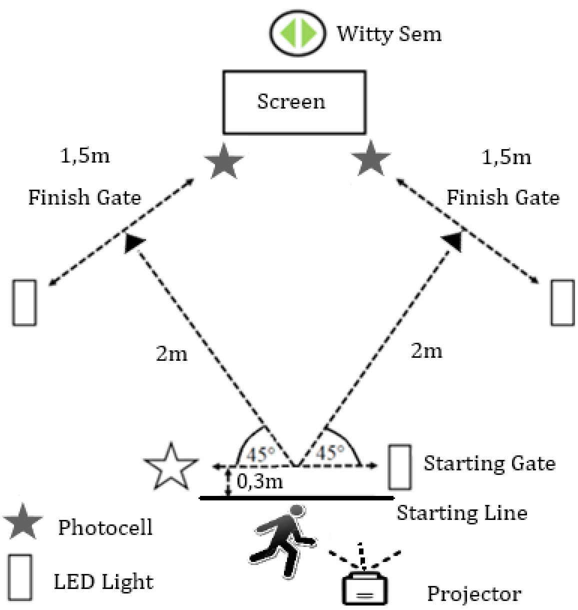

Figure 1. Modified Y test of reaction agility (Lockie et al., 2013)

In the second case, the test was conducted in the same way, but as a stimulus the players were shown video sequences on the screen using a PC and a projector (Fig. 2). The project or was placed behind the test person›s back so that the projected image was fully visible to the test person. In advance, 8 video clips were filmed and presented in random order, each clip lasting 3s, while the player who performed the game activities (Tab. 1) was instructed in advance about the type of activity. In 4 clips, the player performed a change of direction with a dribble or a pass in both directions, and in 4, she performed a deceptive action in advance. The task of the tested person was to react to the movement of the player, presented in front of her, by moving in the same direction as the person in the demonstration. The implementation of the test took place in the same way as in the Y Agility test, with the exception of the type of stimuli (Fig. 3).

Table 1

	Game actions
1.	driving the ball + change of direction – right
2.	driving the ball + changing direction – left
3.	driving the + ball passing – right
4.	driving the + ball passing – left
5.	driving the ball + deceptive action - left and changing direction – right
6.	driving the ball + deceptive action - right and changing direction – left
7.	driving the ball + deceptive action on the left and passing – right
8.	driving the ball + deceptive action on the left and passing – left

To assess decision functions, we used the best reaction time of 4 trials to the video without deceptive activity and 4 trials with deceptive activity. We did not include incorrect attempts in the final evaluation. In this test, only one subject was in the gym, the other participants were asked to go to the locker room. Before the actual testing, we thoroughly explained to the test persons how the test will be performed and we made sure that they understood it.

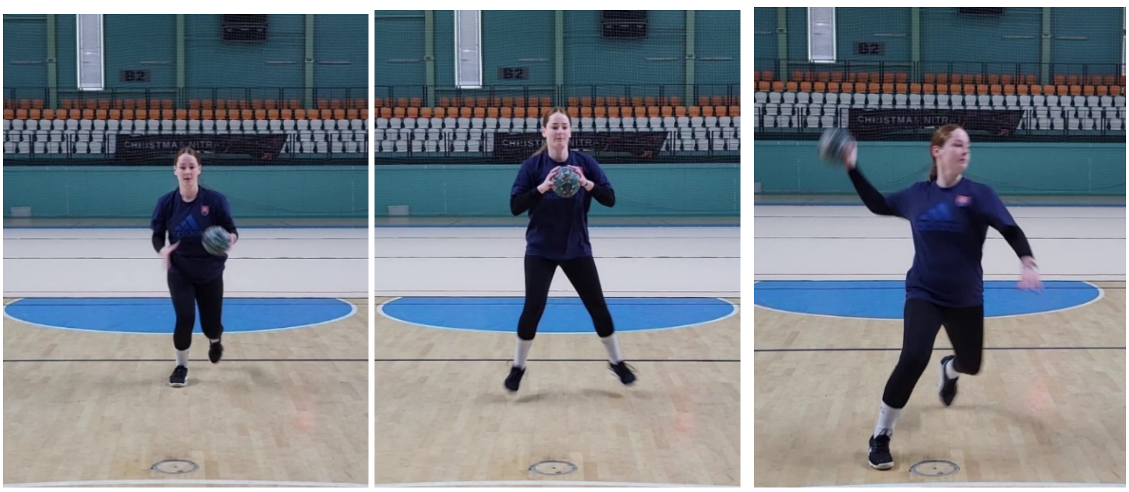

Figure 2. Driving the ball, initiating a change of direction and changing direction

Figure 3. Test procedure

Questionnaire on decision-making style in sports (CETD)

To carry out the research, players had to fill out a questionnaire on decision-making styles in sport, which allows analyzing the decision-making profile of athletes in a specific area (CETD; Dueñas Martínez, 2017; Ruiz-Perez, Graupera and Sánchez, 2000). It consists of 30 items and is divided into three categories, which are evaluated by 10 items: a) perceived decision-making competence, b) anxiety and overload in decision-making, and c) involvement in decision-making. Items (e.g.. I know that I am able to make better decisions in my sport than my other teammates) were measured using a Likert-type scale ranging from 1 – 4, where 1 represents: strongly disagree with the statement and 4 - strongly agree with the statement (Dueñas & Martínez, 2017). The questionnaire on decision-making style in sports (CETD) was applied individually in the monitored group. Its application was carried out by research associates previously trained for this purpose to resolve any type of doubt, while there were no significant difficulties with understanding or interpretation.

Statistical Analysis

All statistical analyzes were calculated in the statistical program IBM SPSS for Windows (version 22.0, Inc., Chicago, IL, USA). Before choosing statistical methods, a Shapiro-Wilk test for homogeneity of variance was performed, which revealed that the data were normally distributed (p-value ranged from .279 to .898). The standardized measure of variance of the probability distribution was controlled using the coefficient of variation (CV). Pearson›s correlation coefficient was used to find the relationship between Y-shaped agility test performance to the video stimulus and performance to the directional stimulus, simple reaction time, perceived decision-making competence, decision-making anxiety and burden, and decision-making engagement. Correlation is considered trivial ($r < 0.1$), weak ($0.1 \le r < 0.3$), moderately strong dependence ($0.3 \le r < 0.7$), strong ($0.7 \le r < 0.9$), very strong (> 0.9) (Borůvková et al. 2004).

Simple linear regression analysis (ENTER method; STEPWISE) was used to determine significant predictors of the dependent variable (agility performance to a specific stimulus) from the independent variables (parameters of reaction time, decisional competence, anxiety and decisional overload, and decisional engagement). The coefficient of determination (R2), calculated as the square of r, was used to indicate the measure out of the total variation in the dependent variable could be explained by the independent variable. The level of significance was set at $p < 0.05$.

G*Power 3.1 analysis was used to check the required sample size. An apriori sample size estimate was calculated for an alpha level of 0.05 with an effect size of 0.514 (calculated from R2 = 0.5) and a power of 0.99. A sample size of 11 participants appeared necessary to detect a relationship between Y-shaped agility performance and the measured variables. However, the number of participants in this study was slightly below the limit due to the health restrictions of the players (the inclusion criteria were regular participation in training and matches).

RESULTS

The results of the tests used in this study, the descriptive data and the variability of the variables are shown in Table 2. The reaction time tests reflect the sensory component, the questionnaire values the mental component and the agility tests (Y test) with respect to the type of stimulus reflect the motor component.

Table 2. Descriptive statistics of handball testing

	Descriptive Statistics					
	N	**Min [s]**	**Max [s]**	**Sum [s]**	**Mean [s]**	**SD [s]**
WittySem	11	.86	1.15	11.03	1.002	.089
Video 1/WFM	11	.93	1.38	12.44	1.131	.156
Video 2 /FM	11	1.09	1.41	13.86	1.260	.111
Video /WNF+FM	11	1.01	1.31	13.15	1.196	.107
Reaction time	11	230.17	339.50	2992.17	272.1	27.645
Question. part 1	11	21	33	272	24.73	3.379
Question. Part 2	11	22	30	279	25.36	2.730
Question. part 3	11	20	28	279	25.36	2.335
Questionnaire	11	67	82	830	75.45	5.047

Note: WFM – without fake moves; FM – fake moves;

The significance of differences in performance between individual motor tests was confirmed in all three cases (Tab. 3). The comparison of the performance of handball players with regard to the type of stimulus was significant especially in the case of the WittySem vs Video NF F test (sport-specific stimulus) with the execution of a deceptive movement ($p = 0.000$). Even in the case of differences in performance in the agility test (WittySem) and performance in the agility test as a reaction to a sport-specific stimulus (video) without performing deceptive movements, the differences were significant ($p = 0.006$).

Table 3. Paired t test

	Paired Differences				t	df	Sig. (2-tailed)
	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
Witty – Video_I	.124	.037	-.21173	-.04554	-3.449	10	**.006**
Witty – Video_II	.111	.034	-.33249	-.18296	-7.681	10	**.000**
Witty – Video	.083	.025	-.24921	-.13715	-7.683	10	**.000**

The difference is significant at the 0.05 level (2-tailed).

The performance in the agility test (Y test) for a sport-specific stimulus (video, SSS) was significantly correlated only with the time in the agility test for a simple stimulus (Witty; r = 0.652*; p = 0.015*). Other partial correlations in relation to the dependent variable were insignificant (Tab. 4). The time in the Y test agility test (SSS) did not correlate with any other measured variables; however, the relationship between the time in the Y test agility (SSS) and the simple reaction time showed a large effect size (Effect size; r = 0.514). According to assumptions, the subtests of the decision-making style were significantly correlated with each other: anxiety and overload in decision-making and engagement in decision-making (Q2 vs Q3 ; r = 0.654, r = 0.037); anxiety and overload and total score (Q2 vs Q; r = 0.557, r = 0.014) as well as decision engagement with decision style total score (Q3 vs Q; r = 0.680; p = 0.11).

Table 4. Relationship between agility (Video, Witty), reaction time (RT) decision-making competence (Q1), decision-making anxiety and overload (Q2), and decision-making engagement (Q3), decision-making style (Q) in handball players

Correlations								
		Video	**Witty**	**RT**	**Q1**	**Q2**	**Q3**	**Q**
Pearson Correlation	V	1	.652	-.272	-.254	.116	.105	-.059
	Witty	.652	1	.337	-.613	.019	-.007	-.403
	RT	.272	.337	1	-.282	.387	.093	.064
	Q1	-.254	-.613	-.282	1	-.216	-.126	.495
	Q2	.116	.019	.387	-.216	1.000	.557	.654
	Q3	.105	-.007	.093	-.126	.557	1.000	.680
	Q	-.059	-.403	.064	.495	.654	.680	1.000
Sig. (1-tailed)	V	.	.015	.209	.226	.367	.379	.432
	Witty	**.015***	.	.155	.023	.478	.492	.110
	RT	.209	.155	.	.201	.120	.393	.426
	Q1	.226	**.023***	.201	.	.262	.356	.061
	Q2	.367	.478	.120	.262	.	.037	.014
	Q3	.379	.492	.393	.356	**.037***	**.**	.011
	Q	.432	.110	.426	.061	**.014***	**.011***	.

Note: * Correlation is significant at the 0.05 level (2-tailed). V – Y Agility test/ video stimulus; Witty – Y Agility test/ light stimulus; RT reaction time; Q1 – decision-making competence; Q2 – anxiety and overload when making decisions; Q 3 – involvement in decision-making; Q – decision-making style

A simple linear regression analysis (Tab. 5) using the ENTER method revealed that the performance in the agility test to a simple stimulus (Witty; F (1) = 6.52, p = 0.030) is a significant predictor of performance and constitutes 73.4% of the explanatory variable (R2 = 0.734).

Table 5. Linear regression analysis for Y-shaped agility performance on a sport-specific stimulus

	Model Summary[b]									
						Change Statistics				
	Regres. Model	R	R Square	R2	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
ENTER	Witty	.931a	.867	.734	.055	.867	6.521	5	5	.030

Predictors: (Constant), Witty

DISCUSSION

The purpose of this work was to determine the difference in Y-shaped agility speed due to a non-specific and sport-specific stimulus, respectively verify whether specific contextual information is more effective than non-specific in the player‘s decision-making and the implementation of a simulated motor task in handball. The secondary aim was to investigate the relationship between decision-making style and performance in reactive agility with respect to the type of handball cue.

As expected, handball players achieved a better overall time in the agility test (simple light stimulus vs contextual one; $\bar{x}$ =1.002s and 1.131s, respectively). It is assumed that a wider spectrum of perceived and processed information can possibly be the likely cause.

The results showed significant differences between tests, with the difference being more pronounced for video stimuli than for simple stimuli, which is consistent with the work of Mori et al. (2002). The significance of differences in performances between individual motor tests was confirmed in all three cases. The comparison of the performance of handball players with regard to the type of stimulus was significantly different in the case of performance differences in both tests without performing deceptive movements (p = 0.006), but especially in the case of the Y agility test for a simple directional stimulus and a sport-specific stimulus with performing deceptive movements (p = 0.000), which indicates that these activities can be an indicator of a player‘s successful offensive activity. Finally, their effectiveness in interactive sports has also been proven scientifically (Güldenpenning et al. 2017, Mayer et al. 2022). Time analysis of agility showed that the shorter RT interval was not in the relationship with the better agility time ($p > 0.05$), so the values of reaction time did not contribute to the prediction of agility, which contradicts the work of Moradi and Esmaeilzadeha (2015).

The conditionality of performance in the Y agility test by motor skills, especially sprint speed at 5 and 20 m (45.7%) and reactive power (38.3%) was demonstrated in the work of Horníková and Zemková (2022) however, the study focused exclusively on motor factors. In our work, they sought an answer to the question of whether decision-making style factors can be one of the significant factors in reaction agility realized as a reaction to a video stimulus. The relationship between decision-making style and agility time was not confirmed in our work. The relationship between performances in the Y agility test in a specific context and reaction time (r = 0.272), decision-making competences (r = -.254), anxiety and overload (r = 0.116) and engagement in decision-making (r = 0.105) was not demonstrated. We found only a significant mutual conditionality of both agility tests (r = .652, p = 0.015). These facts raise the question of whether the observed psychometric properties and reliability of the instrument are sufficiently acceptable for use in this study, which justifies further research. Linear regression analysis revealed that the performance in the agility test for a simple stimulus (Witty; F (1) = 6.52 , p = 0.030) is a significant predictor of agility performance in a specific context and constitutes 73.4% of the explanatory variable (R2 = 0.734).

CONCLUSION

Understanding the conditioning processes of agility performance is becoming one of the main lines of research among scientists in the field of theoretical and applied research in sports. A standardized CETD questionnaire designed and validated by Ruiz and Graupera (2000) was used in the study to determine decision-making style. It has been applied in several researches in the field of sports (Aguilar Sánchez, Tamayo and Chirosa Rios, 2014; Jiménez Sánchez et al., 2015). In general, it was concluded that women show lower levels of emotion regulation and anxiety and perceived competence in decision-making, professional athletes differ significantly in dominance and persistence compared to amateurs, and that athletes in individual sports have a higher ability to control emotions than team sports players.

An important contribution of this study was to point out the existence of different aspects of decision-making in sports, which are highlighted and considered by the athletes themselves. Problems in the development of tests of decision-making in sport are discussed and questions about their validity and reliability are raised. Nevertheless, it was concluded that valid, reliable and objective test methods for decision-making in team sports have not yet been constructed. This may be due to test construction issues, but such differences may manifest differently in each sample.

The response times demonstrated in the research provide strong evidence for the complexity of perception and information processing in decision-making following motor displays in collective games. It is concluded that more research is needed if sport psychologists are to provide useful information to players and coaches.

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