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ORIGINAL

DECISION-MAKING IN SCHOOL-AGE SPORT MEASURED THROUGH A DIGITAL TOOL

TOMA DE DECISIONES EN DEPORTE EN EDAD ESCOLAR MEDIDA CON HERRAMIENTA DIGITAL

Vázquez-Ramos, F.J.[1]; Sosa-González, P.I.[2]; de Pablos-Pons, J.[3]

[1] Profesor de Educación Física, CEIP Miguel Rueda, Paradas. Sevilla (Spain) kiscoarahal@gmail.com

[2] Profesora Asociada, Departamento de Educación Física y Deporte, Universidad de Sevilla (Spain) psosa@us.es

[3] Catedrático de Universidad, Departamento de Didáctica y Organización Educativa, Universidad de Sevilla (Spain) jpablos@us.es

Spanish-English translators: Víctor Gutiérrez Martínez, info@idiomasleon.es

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ABSTRACT

The aim of this study was twofold. On the one hand, the design and creation of an evaluation software for decision-making in school-age children based on spatial-temporal aspects in the context of volleyball called 'Interactive Volleyball Game'. On the other hand, the analysis and establishment of its reliability and validity. The designed software was applied to a sample of 132 students (64 boys and 68 girls) aged between 10 and 13 years in public Elementary and Secondary Education schools of Seville towns, Arahal and Paradas (Spain). To determine the reliability, internal consistency was studied through Cronbach's alpha. The intraclass correlation coefficient (ICC) was also analyzed to calculate the optimal number of repetitions for future research. The validity was tested based on the assessment of a group of 5 experts. The results indicated that this new evaluation software reaches high levels of reliability and validity.

KEY WORDS: Decision-making, sport, volleyball, school-age, assessment software, digital tools, reliability, validity.

RESUMEN

El objetivo de este estudio ha sido doble. Por un lado, diseñar y crear un software de evaluación de toma de decisiones en edad escolar, en base a aspectos espacio-temporales, contextualizado en voleibol, denominado “Juego Interactivo de Voleibol”. Por otro lado, analizar y establecer su fiabilidad y validez. El software diseñado se aplicó a una muestra de 132 escolares (64 niños y 68 niñas) de entre 10 y 13 años, de los centros educativos públicos de Educación Primaria y Secundaria de las localidades sevillanas de Arahal y Paradas (España). Para determinar la fiabilidad se estudió la consistencia interna a través del coeficiente alfa de Cronbach. Para calcular el número óptimo de repeticiones se utilizó el Coeficiente de Correlación Intraclase. La validez se comprobó en base a la evaluación de un grupo de 5 expertos. Los resultados indicaron que este nuevo software de evaluación alcanza altos niveles de fiablidad y validez.

PALABRAS CLAVE: Toma de decisiones, deporte, voleibol, edad escolar, software de evaluación, herramientas digitales, fiabilidad, validez.

1. INTRODUCTION

In the last years, researchers have tried to analyze the psychological factors underlying the exceptional skills in individuals with outstanding performance in sport activities (Starkes & Ericsson, 2003) revealing that knowledge and decision-making factors clearly influence sport performance (Williams, Ford, Eccles & Ward, 2011). The concept of tactics is born from the relation between decision making and knowledge (McPherson, 2008). These two components of sport strategy (decision making and knowledge) are vital for the selection of a motor reaction during a specific performance situation.

Decision making is key to the complete development of athletes and their sport performance, especially in the case of volleyball since it is a team sport characterized by open collaboration and competition where neither teammates nor opponents' actions can be predicted beforehand (Macquet, 2009; Oliver-Coronado & Sosa-González, 1996; Otero, González & Calvo, 2012; Santos, Viciana & Delgado, 1996; Vila-Maldonado, Sáez-Gallego, Abellán & García-López, 2014).

Nowadays team sport teaching is still mainly focused on motor-based aspects at the expense of highly important cognitive aspects in teaching and sport performance such as decision making (Valera, Ureña, Ruiz & Alarcón, 2010).

Learning for decision making in early years is therefore important. Most authors are convinced that these young ages are favorable for cognitive development. In this respect, various studies advocate educational programs including the development of motor and perceptual decision making aspects (García & Ruiz, 2007; Méndez, 1999).

According to Thomas and Thomas (1994), the quality of decision making during competitions is as important as the skillful motor performance. There are two aspects that must be differentiated with regard to the research into decision-making and tactical processes: decision-making (mental solution) and performance (motor solution) (Christina, 2005; García-González, Araújo, Carvalho & Del Villar, 2011). Not only have the athletes to perform properly, but they also need to perceive and decide (Plou, 2007; Sáez-Gallego, Vila-Maldonado, Abellán & Contreras, 2013).

As regards sport in school-age children, there are very few tools designed to assess and determine the level of decision making in athletes. Bou and Roca's Sport Intelligence Test (Bou & Roca, 1998) should be mentioned. It was used in order to assess intelligent decision making with spatial-temporal logic by means of a basic temporal-spatial orientation test through the computer program called 'Dromo'. However, its inventors already pointed out a number of aspects to improve: to answer through direct interaction with the screen, to allow for a simple and fast implementation of the test, to improve the spatial-temporal progressions so as to allow for more complex situations.

Based on the separation between the mental solution and the motor one

(Christina, 2005; García-González & cols., 2011), this study aims to design and develop a computer assessment software which is simple to implement and will help to evaluate decision making based on spatial-temporal aspects, especially in volleyball games in school children aged between 10 and 13 as well as to analyze its reliability and validity.

2. MATERIAL AND METHOD

2.1. Participants

The sample was generated using the simple, systematic and stratified random sampling technique based on the population of school children enrolled in 5th and 6th years of Primary Education as well as those in 1st and 2nd years of Secondary Education in the Seville areas of Paradas and Arahal (Spain). They are 132 boys and girls aged between 10 and 13 years.

2.2. Instrument

This is a web application for Ipad with the format of a game which was called *Interactive Volleyball Game* (*Juego Interactivo de Voleibol*, JIVB® it was designed and created to assess decision making in sport performed by children aged between 10 and 13 years in relation to spatial-temporal aspects in the context of volleyball. In order to achieve this goal, the instrument was designed to be run on a tablet so as to allow the participant to make decisions and carry them out with just a 'tap' on the screen.

In its final design version, JIVB® is divided in four sections. Each section is made up of windows. Each window deals with a *tactical situation of the game* which has to be solved with a 'tap' on the tablet screen. The difficulty of the tactical situations found vary progressively according to spatial and temporal requirements in each section and three decision-making aspects or dimensions are assessed: 1) with regard to the selected area or space, known as spatial dimension; 2) with regard to the time taken for the decision to be made, known as temporal dimension and 3) the combination of both aspects, known as spatial-temporal dimension.

Section 0. Familiarization

The section consists of 5 windows to ensure the participant's familiarization with the perceptive characteristics of the game and to help them identify and learn the different options or zones they can press. It also helps them adapt and get used to pressing the tablet touch screen the as fast as possible.

The volleyball court is split into 12 zones for a greater spatial distinction (Figure 1). There is a volleyball drawing in each window and in different spaces or zones and the participant must press the zone where it appears.

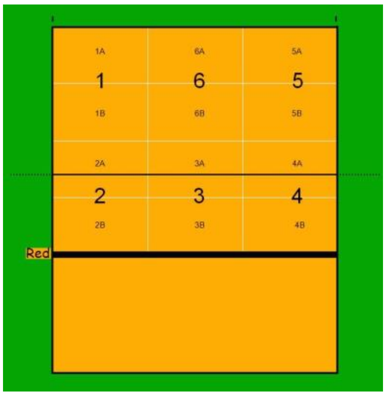


Figure 1. Spatial zones where the familiarization sections 1 & 2 are developed.

Section 1. Attack against static opponents

The spatial distribution of the court is identical to the one in section 0 and the participant plays the role of the attacker. There are 17 windows to solve with only the last 15 ones scoring points since the first two are meant to familiarize the player with the section. Static opponents appear in the opposite space of the court and the participant must press as far away from them as possible (decision making for optimal space) and as fast as possible (decision and performance speed). This allows us to know and record the time that the subject takes to make the decision as well as the extent of success of the decision at spatial level, which depending on the pressed zones (among the 12 possible ones) will obtain different scores. The further from the opponents, the higher the score (from 0 to 3 points). As regards time, it is recorded as soon as each window with its tactical situation waiting to be solved appears until it is finally solved ('tap' on the space or selected zone). If time exceeds 4 seconds, the window disappears no point is scored since it was not solved under that established maximum time limit. The difficulty level of the windows goes up with a progressively larger number of opponents appearing (from 1 to 6).

This section as well as the second and third ones include some response conditions which involve making decisions and taking some risks in order to achieve the highest score. In this case the participants are well informed that the further away from the opponents and the faster the decision is made, the more points they will score.

Section 2. Attack against moving opponents

The section features the same contents as section 1 (number of windows, increased difficulty, scoring method, etc.) except the fact that it also includes moving opponents. They move in a straightforward fashion without changing direction from point A to point B. Such a move takes approximately between 0.5 and 2 seconds and the submitted tactical situation has to be solved based on the final position of the opponents. This sections has a greater complexity than the first one and it allows us to know and record decision making in more challenging situations in terms of spatial-temporal structures.

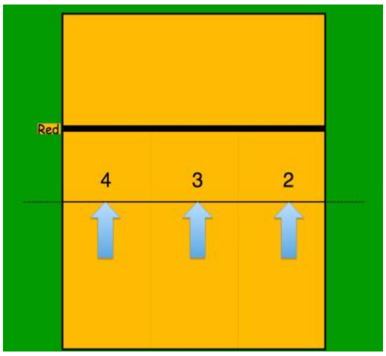


Figure 2. Spatial zones where section 3 is developed.

Section 3. Positioning according to the block

The participant's role in this section is to decide which zone is the best option to overpass the block. The zones which may be chosen have changed place and have been reduced from 12 to 3 (Figure 2). This section has 12 windows divided into 2 parts. Each part consists of 6 windows and only the last 5 are recorded as the first ones are used for familiarization. The first part of the section corresponds to positioning situations where the block is static whereas the second corresponds to tactical situations where the block sets in motion from an initial point A to final point B without changing direction. The pressed area of the screen is recorded in order to solve the tactical situation and the time used during this process. The spatial score may be 0, 1 and 3 points.

2.3. Procedure

JIVB® was implemented individually in a quiet room using an iPad lying on a desk and the participant was sitting in a chair facing it with the researcher also sitting very close in order to only intervene if the subject needed assistance since the instructions could be read on the screen. Each participant played the game three times in a row although the optimal number of repetitions according the results obtained in this study is twice in a row.

2.4. Scoring criteria of JIVB®

The scores are determined based on the response option chosen by each participant in every different tactical situation displayed on the iPad screen according to the success criteria which were previously established and are related to space and time.

The scores from a spatial approach depend on the distance from the moment the participant performs a 'tap' with respect to the opponents positioned on the court. The further from these the 'tap' is performed, the higher the score will be. These score vary between 0, 1, 2 and 3 points. The criteria used to determine these scores are the same as in sections 1 and 2 and different from section 3. Table 1 shows the scoring criteria for sections 1 and 2 while Table 2 reveals those for section 3.

Table 1. Spatial scoring criteria for sections 1 and 2.

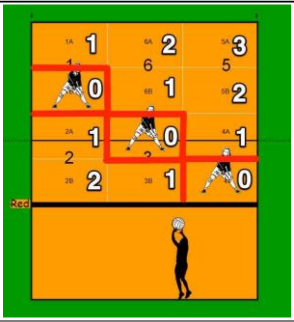
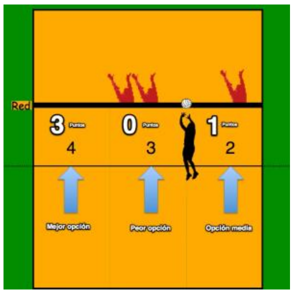
Spatial scoring criteria for sections 1 and 2		
Points	Criterion	Space
0	If subject taps right on opponent's space.	
1	The space(s) whose side(s) touch(es) the side of the opponent's space.	
2	The zones which are within the zones surrounding the opponent and the furthest zone from them.	
3	The furthest zone possible from the opponent(s).	

Table 2. Spatial scoring criteria for section 3.

Spatial scoring criteria for section 3		
Points	Criterion	Space
0	If the worst option is chosen, which is where the block is the toughest to overcome.	
1	If the intermediate position is chosen, that is to say, where the block is tough but is not the most difficult to overcome on the screen.	
3	If the choice made is the best possible on the screen, in other words, where there is no block or in case there is one, it is the least difficult of all to overcome.	

As regards the scores from the temporal approach, the maximum amount of time the participant has to provide a response to a tactical situation is 4 seconds. Beyond that time limit, the situation disappears from the screen. The faster the response, the less time is required for decision making and the higher the score. However, if the participant presents a response time of less than a second, the time value is 1. According to the preliminary study prior to the design of JIVB® the minimum time needed to respond in a conscious and willingful way was 1 second. Consequently, very high scores which may be generated from impulsive or unintended anxiety are avoided.

From a spatial-temporal approach, a formula combining spatial and temporal scores was developed. It consists in dividing the spatial score by the response time in order to obtain a score known as Spatial-Temporal Score, which is used to calculate the overall score achieved by the participant in each section and in the whole game.

2.5. Data analysis

The data were analyzed using the software package SPSS v.20.0. Parametric statistics was applied after checking that the sample comply with the established requirements. Its normal distribution was verified through Kolmogorov-Smirnov's test while the equality of variances was assessed thanks to Levenne's test. The instrument internal consistency was analyzed through Cronbach's alpha coefficient in order to determine its reliability at different levels and in each of its three performances: the whole instrument, each of its three dimensions and each of its three sections. $p < 0.05$ was established as significance level. In addition, the Intraclass Correlation Coefficient (ICC) was analyzed to quantify the concordance between various measurements of the same numerical variable and, therefore, to calculate the optimal number of repetitions for future studies. A team of 5 experts in the field (a university professor, three lecturers and a level 3 national volleyball coach) all with ample teaching experience and volleyball training analyzed its validity.

3. RESULTS

3.1. Reliability

3.1.1. Internal consistency: Cronbach's alpha coefficient

The results found in the internal consistency analysis for the whole instrument through Cronbach's alpha coefficient were 0.95 for the first performance, 0.93 for the second and 0.93 for the third (Table 3).

Table 3. Internal consistency (Cronbach's *alpha*) of the items grouped in the three dimensions of JIVB®.

Internal consistency of JIVB®			
		Cronbach's *alpha*	No. Items
JIVB® complete	1st Performance	0.955	120
	2nd Performance	0.935	120
	3rd Performance	0.936	120

During the internal consistency analysis of the different dimensions (spatial, temporal and spatial-temporal), it is noted that *alpha's* value varies between 0.83 and 0.94 and also that *alpha's* values are very similar within the same dimension performed at different times (Table 4).

Table 4. Internal consistency (Cronbach's *alpha*) of the items grouped in the three dimensions of JIVB®.

Internal consistency in the dimensions of JIVB®				
	Performances	Dimensions of items	Cronbach's *alpha*	No. Items
JIVB Complete	1st Performance	Spatial dimension	0.832	40
		Temporal dimension	0.942	40
		Spatial-temporal dimension	0.914	40
	2nd Performance	Spatial dimension	0.846	40
		Temporal dimension	0.93	40
		Spatial-temporal dimension	0.891	40
	3rd Performance	Spatial dimension	0.857	40
		Temporal dimension	0.932	40
		Spatial-temporal dimension	0.899	40

The sections show Cronbach's *alpha* values higher than 0.82 in all cases, which gives each section a solid internal consistency (Table 5).

Table 5. Internal consistency (Cronbach's *alpha*) of the items grouped in the three sections of JIVB®.

Internal consistency in the sections of JIVB®			
		Cronbach's *alpha*	No. Items
1st section	1st Performance	0.946	45
	2nd Performance	0.895	45
	3rd Performance	0.91	45
2nd section	1st Performance	0.859	45
	2nd Performance	0.829	45
	3rd Performance	0.822	45
3rd section	1st Performance	0.898	30
	2nd Performance	0.888	30
	3rd Performance	0.859	30

3.1.2. Relation between measurements: Intraclass Correlation Coefficient (ICC)

The ICC was used as the best index to quantify the level of concordance between the different measurements of the same numerical variable also known as the measurement which calculate the degree to which different measurements agree (Prieto, Lamarca & Casado, 1998).

Table 6 shows *alpha*'s values after the ICC was applied to the entire sample while comparing the different performances. First of all, the three performances were compared and were later compared two at a time.

Table 6. ICC of the different dimensions of JIVB® spatial, temporal and spatial-temporal.

Intraclass Correlation Coefficient					
			Confidence interval 95%		
		ICC	Higher limit	Lower limit	No. Items
Score Overall Spatial	*alpha* 1-2-3	0.874	0.907	0.832	3
	alpha 1-2	0.793	0.853	0.708	2
	alpha 1-3	0.759	0.829	0.66	2
	alpha 2-3	0.92	0.943	0.887	2
Score Overall Temporal	*alpha* 1-2-3	0.915	0.937	0.886	3
	alpha 1-2	0.879	0.914	0.829	2
	alpha 1-3	0.823	0.875	0.751	2
	alpha 2-3	0.942	0.959	0.918	2
Score Overall Spatial-temporal	*alpha* 1-2-3	0.929	0.948	0.905	3
	alpha 1-2	0.894	0.925	0.851	2
	alpha 1-3	0.864	0.903	0.808	2
	alpha 2-3	0.938	0.956	0.912	2

3.2. Validity

The internal validity of the instrument was verified through its apparent validity by means of reviews from the 5 experts who all perceived it as valid. The same team of experts later verified the rational or content validity. The following indicators were used: sufficiency, coherence, clarity and relevance. The experts, using those indicators, had to determine to which degree they agreed with the different tactical situations presented in the JIVB® and its sections on a 4-point scale similar to Likert's in order to confirm whether these tactical situations were representative of what was supposed to be analyzed. The experts' opinions on the indicators were very positive with concordance levels of 0.99.

The response validity was assessed by the researcher by checking that the understanding of JIVB® and the participants' responses were in line with what was expected to be measured and collected, which reveals a high level of understanding without generating any doubts in the subjects who carried it out. As regards the external or criterion validity, no evidence which could help, as *Gold Standard*, measure decision making based on spatial-temporal aspects in school-age children was found.

The construct validity of the assessment software was determined through the same procedure used with the experts for the internal content validity mentioned earlier checking that the tactical situations presented in JIVB® are undoubtedly considered appropriate to measure the construct that is going to be analyzed in the study. In this regard, spatial-temporal parameters are vital for decision making in sport. Subsequently, the spatial and temporal adjustments are presented together throughout the different tactical situations in JIVB® This instrument is used to assess decisions regarding the selection of the most suitable space as well as the participant's lowest response time possible. From a spatial approach, the situation of one or various opponent(s) on the court will determine what decision will be made. From a temporal approach, the response time and the opponents' movements will determine the different temporal adaptations. Therefore, both space and time need to be considered in order to successfully deal with any of the tactical situations presented in the study. As far as the theoretical aspects are concerned, each participant is required to continuously adjust to these spatial-temporal variations in order to make decisions. As a result, its construct validity is considered verified.

4. DISCUSSION

According to many authors, spatial-temporal interactions are essential combinations for decision making in sport. Thanks to their analysis and interpretation, players can make decisions understanding that space and time involve highly important elements such as the spacial positioning of their teammates, their opponents, the response time, etc. (Bou & Roca, 1998; Oliver-Coronado & Sosa-González, 1996; Pinaud & Díez, 2009; Santos, Viciana & Delgado, 1996). Based on these assumptions, the presented instrument was designed in order to assess decision making based on spatial and temporal aspects. Therefore, a specific spatial context was chosen to reveal the spatial-temporal variations in which decisions had to be made: the volleyball court.

Another important aspect was the design of the assessment software so as to motivate and appeal to the participants. On the other hand, the optimal performance of a task does not entirely depend on a person's abilities, but also on their motivation (Herrera, Herrera & Ramirez, 2003). Indeed, the influence of the motivational variables is linked to performance in a series of studies (Cleary & Chen, 2009; Miñano & Castejón, 2011; Rosario, Núñez, Valle, González-Pienda & Lourenço, 2013). Based on these reasons, JIVB® was designed following an interactive format.

The ages between 10 and 13 years were used as reference for the design of this assessment software. Consequently, the introduction to sport are linked to educational goals of not just motor but also full cognitive development. In this regard, Meinel and Schnabel (2004) claim that children aged between 10 and 12-13 years have the greatest concentration and perseverance capacity to solve motor problems, which results from their cognitive, emotional and volitional skills.

The results found in the study show that the designed assessment software JIVB® reveals reasonable levels of validity and reliability for its use in situations similar to those described earlier. The role and opinions of experts are crucial during the validation process of such an instrument, especially because there is no other tool available with similar characteristics that may be used to contrast and compare the results. The experts completely agree on the high relevance of the characteristics to assess decision making based on spatial-temporal aspects in school boys and girls aged between 10 and 13 years. Therefore, JIVB® is a valid instrument.

The results of the reliability analysis showed Cronbach's *alpha* values higher than 0.93 at a general level of the tool, values higher than 0.82 when the internal consistency through sections is analyzed and values higher than 0.83 in the internal consistency analysis though dimensions (spatial, temporal and spatial-temporal). These findings indicate very good JIVB® reliability values (Lowenta, 2001).

The reliability analysis of JIVB® concludes with the Intraclass Correlation Coefficient (ICC) study. The strong concordance levels in JIVB® are unquestionable when the three performance moments of the different dimensions are compared: 0.874 for the spatial dimension, 0.915 for the temporal dimension and 0.929 for the spatial-temporal dimension. Therefore, good and very good levels of concordance are obtained for spatial, temporal and spatial-temporal dimensions respectively according to Landis (1977, Ruiz et al., 2012).

As regards the CCI values (Table 6), the instrument was determined for future studies carried out with this assessment software, which should be performed twice in a row since the level of learning is scarcely significant between the second and third performances. The first performance would help the participant to familiarize with the tool whereas the second would help record useful data for its later analysis.

It should also be noted that a high level of consistency between the different performances was found, which further demonstrates the high reliability of this tool.

5. CONCLUSIONS

The assessment software 'Interactive Volleyball Game' (Juego Interactivo de Voleibol, JIVB®□□is a reliable and valid tool for the analysis and evaluation of decision making in sport in school-age children based on spatial-temporal aspects. It helps the researchers to assess each participant's decision making during the resolution of different tactical situations presented on the screen of an iPad tablet. These situations are represented through a volleyball court and always under a stressful time limit, which is a feature inherent to most collaborative and competitive team sports.

According to the Intraclass Correlation Coefficient (ICC), the optimal number of repetitions for future studies is twice in a row.

Given its low performance difficulty, it could be applied to sport situations as well as educational contexts with different aims: initial basic diagnosis, education and sport training, selection of athletes, etc. The ultimate goal is always to promote a more exhaustive physical and sport education.

In forthcoming studies, the sample must be expanded and comparisons based on the participants' gender, age and sport discipline should be carried out in order to determine whether these variables bear any influence on decision making in sport practice. Other studies should analyze the underlying relation between the levels of decision making in sport context and other educational environments.

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