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SoccerEye: A Software Solution to Observe and Record Behaviours in Sport Settings

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Abstract: In soccer, the need for direct observation of tactical behaviour has led to continuous technological advances in motion recording software. Here we present *SoccerEye*, a sports-specific software tool to observe and record the behaviour of soccer players in their natural setting and in real time. The software was written in Visual Basic Express 2010 and includes the following features: computerised coding, improved-quality recording, episodic sampling, the measurement of time, and diachronic analysis. Its configuration is well defined but allows for incorporation of *ad hoc* categories. Data can be exported in multiple generic formats, including the SDIS format for the analysis of interaction sequences with GSEQ software. However, by considering time and sequential decisions, *SoccerEye* itself tracks activity profiles and the dynamics of play. The greatest advantage of *SoccerEye* is the possibility to conduct diachronic analysis, which regards an event or multi event sequence in terms of change over time. This type of analysis takes into account the behaviour of a player and his or her team when facing the opponent, the space (pitch area) and time (starting time and duration) of each event, and other factors such as match status, match time, and competition stage. *SoccerEye* is a free-access user-friendly application that can be used to observe a single player or an entire team while controlling over the environment in which the observation takes place. This tool will hopefully contribute to the better understanding of the dynamics of soccer play.

Keywords: Computer application, Match analysis, Observational methodology, Sequential analysis, Situational variables, Tactical behaviour, Team sports.

1. INTRODUCTION

Over the past recent years, analysis of competitive match play has been key to identifying the traits and behaviours that lead to the success of an individual or a team [1-6]. Alarge amount of these data has traditionally been collected using paper-and-pencil notations. However, notational analysis is outcome-focused and discards important information on the intermediate steps, which might limit the interpretation of data [7]. This is the case with team sports, which are characterised by complex interrelationships between players and the environment [8]. To tackle the limitation, dynamical systems analysis has been proposed [9].

Soccer has been a good example of the translation of cutting-edge research into practical applications at the professional level [10]. As in other team sports, the success relies on cooperative relationships between players of the same team and their behaviour towards the opponent team [11-13], which together are known as idiosyncratic intra- and inter-dynamic interactions [14]. Previous studies have reported the importance of environmental and situational variables, such as the type of competition [13], match location (home *vs.* away) [4, 15], match status [16, 17], elapsed match time/game period [5, 18], and psychological goal [19]. These factors influence both attacking and defensive behaviours [20].

Accordingly, match analysis based on behavioural tactics appears to be the most effective for studying the dynamic patterns of the game [14]. With this in mind, a number of studies have adopted the observational methodology from psychological research, in particular the sequential and diachronic type of analysis [11, 12, 21, 22]. Observational methodology is rigorous but flexible due to the use of field formats, categorical systems, and/or rating scales. This allows observational methodology to be adapted to a variety of team sports. Perceivable behaviours are observed and recorded in natural contexts, hence taking into account their temporal and sequential structure, the motor skills, and the dynamics of play [3].

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Fig. (1). *SoccerEye* v3.2 user interface. A screenshot of the free restricted recording design (i-b) is shown (see Table **1**).

Performance analysis using time–motion or similar methods has been restricted to a single player, which is time-consuming and a limitation to large-sample academic research projects [1]. Advances in computer and video technology have provided opportunities to collect and analyse larger amounts of data. For instance, a media interface has been embedded in *Transcriptor* [23] and *Codex* [24] applications. However, better methods of data collection and analysis are needed to better understand the nature of sports performance [25]. These should provide coaches with valuable information to optimise individual and team training programmes [26, 27].

Semi automated systems are reliable and finest ways of researchers to collect data during matches; however, these systems remain very expensive [1]. In response to this issue, a series of sport-specific observational tools has been made available for free. Some examples include MOTS [28] (available at http://www.observesport.com/), LINCE [29] (available at http://lom.observesport.com/), and HOISAN [30] (available at http://www.menpas.com/). These applications are versatile, in that they allow the user to edit or create new tools. Moreover, improved-quality recording and episodic sampling have allowed the measurement of time, the capture of co-occurrences, and diachronic analysis [11]. Data can be exported in multiple generic formats compatible with the most used analytical software in observational methodology: Sequential Data Interchange Standard (SDIS)-GSEQ [31] and THEME [32].

Here we describe *SoccerEye*, one such software tool to observe and record tactical behaviours in soccer based on predefined or freely added observational instrument guidelines.

2. SOCCEREYE V3.2

SoccerEye (version 3.2, March 2013, Fig. **1**) is a software tool to observe, record, and export motion data to multiple formats, including the SDIS format for the analysis of interaction sequences with GSEQ software [31].

The program was written in Visual Basic Express 2010 and runs in a multitasking environment such as Windows®. Full software installation is straight forward by running a setup.exe file. *SoccerEye* v3.2 is added directly in Windows® Programs menu and launches automatically. Advanced computer skills are not required.

2.1. Recording Designs and Guidelines

SoccerEye v3.2 provides two different recording designs: (i) restricted recording and (ii) open recording. Each of the two is divided into two levels: (a) predefined and (b) free (Table **1**). These options allow the adjustment of the observational instrument to the specific aims of the research study.

1. **Restricted recording:** *SoccerEye* v3.2 is configured with well-defined *SoccerEye* observational instrument criteria and their respective categories (Table **2**).

In restricted predefined recording (Fig. **2**), recording precedence rules apply, i.e. the observer is able to select the active categories in black whereas inactive menu items appear in grey colour. The observer first records the situational variables (e.g. competition stage, match status, and match time), followed by behavioural, spatial, and interactional events. The result is a multi event sequence composed of four categories in fixed order.

Table 1. *SoccerEye* Recording Designs

	(i) Restricted Recording		(ii) Open Recording	
	(i-a) Predefined	**(i-b) Free**	**(ii-a) Predefined**	**(ii-b) Free**
Command	No command required	Free input	Edit buttons	Free input Edit buttons
Observational instrument	*SoccerEye*	*SoccerEye*	Open edition	Open edition
Recording guidelines	Predefined recording order	No recording order	Predefined recording order: Defined by the observer	No recording order
Data recorded	Multi event	Multi event Single event	Multi event	Multi event Single event

Table 2. *SoccerEye* Observational Instrument: Field Formats Combined with Systems of Categories

Criterion 1 **Start of offensive phase/ball recovery (BR)**	**Criterion 2** **Development of defence/attack transition-state (DT)**	**Criterion 3** **Progress of ball possession (DP)**	**Criterion 4** **End of offensive phase (F)**	**Criterion 5** **Pattern of pitch space position**	**Criterion 6** **Centre of game (CJ)**	**Criterion 7** **Spatial pattern of interaction between teams (CEI)**
DIRECT/DYNAMIC BALL RECOVERY Interception (BRi) Tackle (BRt) Intervention of the goalkeeper in the defensive phase (BRgk) Defensive behaviour followed by a pass (BRp) INDIRECT / STATIC BALL RECOVERY Start/restart of the offensive phase (BRst) Opponent's violation of the laws of the game (BRv) Corner kick (BRc) Goal kick (BRgki) Dropped ball (BRdb) Throw-in (BRti)	Positive short passing (DTpsp) Negative short passing (DTnsp) Positive long passing (DTplp) Negative long passing (DTnlp) Positive crossing (DTpcr) Negative crossing (DTncr) Running with the ball (DTrb) Dribbling (1×1) (DTd) Ball control (DTbc) Duel (DTdu) Shooting (DTs) Opponent's intervention with no success (DTns) Intervention of the goalkeeper in the offensive phase (DTogk) Intervention of the goalkeeper in the defensive phase (DTdgk)	Positive short passing (DPpsp) Negative short passing (DPnsp) Positive long passing (DPplp) Negative long passing (DPnlp) Positive crossing (DPpcr) Negative crossing (DPncr) Running with the ball (DPrb) Dribbling (1×1) (DPd) Ball control (DPbc) Duel (DPdu) Shooting (DPs) Opponent's intervention with no success (DPns) Intervention of the goalkeeper in the offensive phase (DPogk) Intervention of the goalkeeper in the defensive phase (DPdgk) Violation of the laws of the game (DPi) Corner kick (DPc) Goal kick (DPgki) Dropped ball (DPdb) Throw-in (DPti)	WITH EFFICACY Wide shot (Fws) Shot on target (Fst) Shot stopped, with no continuation of ball possession (Fso) Goal (Fgl) WITH NO EFFICACY Loss of ball possession by error of the ball carrier/defender's intervention (Fled) Loss of ball possession by intervention of the opponent's goalkeeper (Fgk) Throwing the ball out of the pitch (Fo) Violation of the laws of the game (Fi)	Zone one (1) Zone two (2) Zone three (3) Zone four (4) Zone five (5) Zone six (6) Zone seven (7) Zone eight (8) Zone nine (9) Zone ten (10) Zone eleven (11) Zone twelve (12)	WITH PRESSURE(P) Relative numerical inferiority (Pr) Absolute numerical inferiority (Pa) Pressure in numerical equality (Pe) WITH NO PRESSURE (NP) No pressure in numerical equality (NPe) Relative numerical superiority (NPr) Absolute numerical superiority (NPa)	Ball in the empty zone (goalkeeper) versus offensive line (EF) Back line versus offensive line (BF) Back line versus mid line (BM) Back line versus exterior zone (BE) Mid line versus offensive line (MF) Mid line versus mid line (MM) Mid line versus back line (MB) Offensive line versus mid line (FM) Offensive line versus back line (FB) Exterior zone versus back line (EB) Offensive line versus empty zone (goalkeeper) (FE)

Fig. (2). *SoccerEye* v3.2 user interface. A screenshot of the restricted predefined recording design (i-a) is shown.

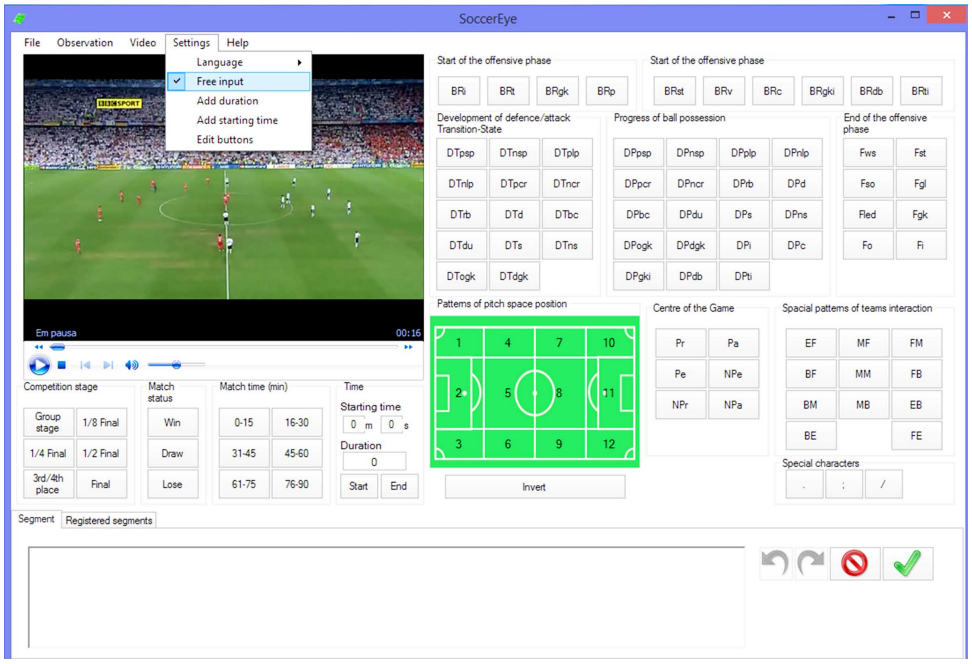


Fig. (3). *SoccerEye* v3.2 user interface. A screenshot of there stricted free recording design (i-b) is shown. The "Free input" option is highlighted.

If however the user selects the "Free input" option, restricted free recording design is activated (Fig. **3**). "Free input" means that the user is not obliged to record all of the predefined observational categories, or at least not in a fixed order.

2. **Open recording:** If the user has programming knowledge, he or she is free to edit the software by selecting option "Edit buttons" in the "Settings" drop-down menu (Figs. **4** and **5**).

3. In open predefined recording, the user defines the observational categories of interest in order to generate multi event sequence data. Recording precedence rules may be defined too.

If the user does not intend to follow any recording guidelines, open free recording design should be opted for (Fig. **4**). By selecting "Edit buttons" and "Free input" options, the software is freely editable.

2.2. Structure and Functionality

SoccerEye v3.2 supports digital video files, which allows for video, taxonomic tools, and recorded data to be displayed simultaneously on screen. The user interface is divided into

Fig. (4). *SoccerEye* v3.2 user interface. A screenshot of the open free recording design (ii-b) is shown. The "Edit buttons" and "Free input" options are highlighted.

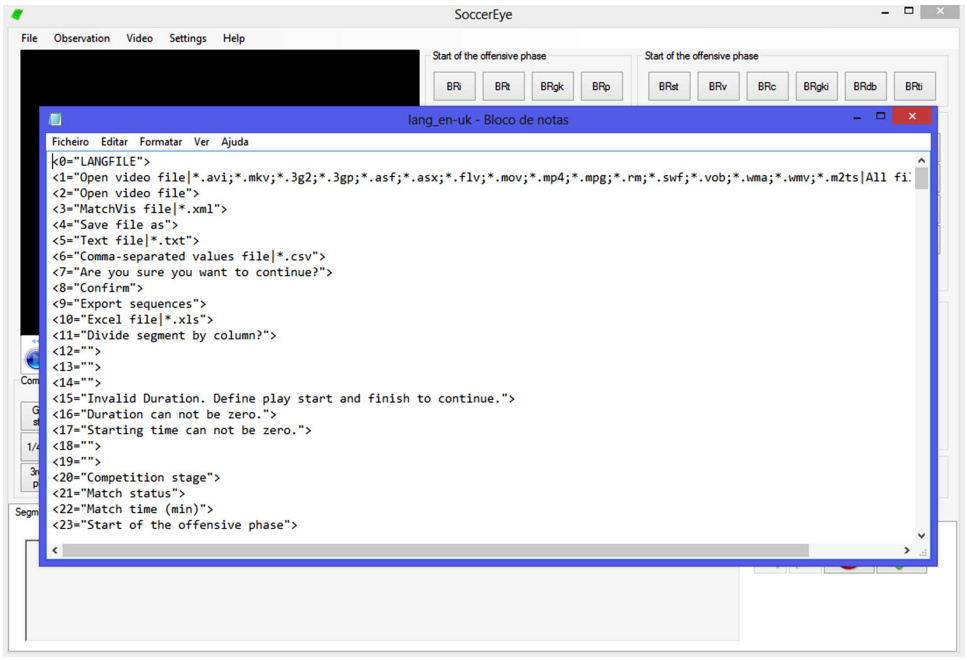


Fig. (5). *SoccerEye* v3.2 user interface. The"Edit buttons" pop-up window is shown.

eight main sections: a) Menu bar; b) Media player; c) Situational variables; d) Time information; e) Observational criteria and their respective categories (predefined or freely added); f) Special characters; g) Data editing tools; and h) Recording window (Fig. **6**).

SoccerEye v3.2 includes user-friendly details such as code attribute on mouse-over. It is possible to define the order of recording, which should be followed in order to successfully complete a bout of recording. This feature guides the researchers to thoroughly follow the steps of observational methodology.

The eight sections are hereafter described in more detail:

a) Menu bar

The menu bar includes the following drop-down lists: (i) "File", to close the application; (ii) "Observation", to start a new recording, open an existent file, import and export files ("Matchvis file"), and save the data in multiple formats (.csv, .xls and .txt) with the option of saving it in columns with headers; (iii) "Video", to open a media file and to change the speed of the playing video; (iv) "Settings", to select the software definitions and exporting language (Portuguese or English) and to activate "Free input", "Add duration", "Add

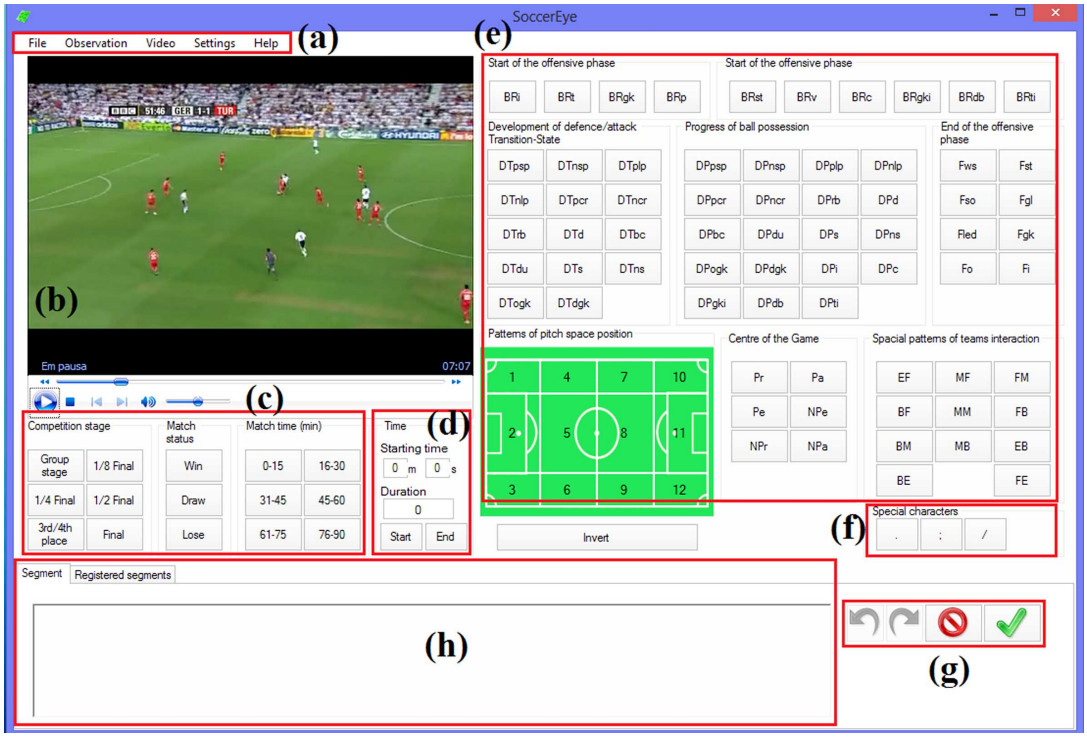


Fig. (6). *SoccerEye* v3.2 user interface layout. A screenshot of the predefined recording design is shown. **a**) Menu bar; **b**) Media player; **c**) Situational variables; **d**) Time information; **e**) Observational criteria and their respective categories; **f**) Special characters; **g**) Data editing tools; and h) Recording window.

starting time", and "Edit buttons" commands; and (v) "Help", to obtain information on the software version, the authors and their contact information, for technical support (*soccereye.help@gmail.com*) and for access to the User Manual.

b) Media player

Media player and library application Windows Media Player is embedded in the user interface. It is compatible with most multimedia files (e.g. .avi, .mpg and .wmv).

c) Situational variables

The recording sequence is contextualized with environmental and situational variables. The following variables are predefined: "competition stage", "match status", and "match time".

d) Time information

The starting time (in minutes and seconds) and duration of each event or sequence of events can be visualised by selecting the following options in the "Settings" menu: "Add starting time" and "Add attack duration", respectively.

e) Observational instrument

The *SoccerEye* observational instrument (Table **2**) is by predefinition the tool used in restricted recording (Table **1**). This instrument has been recently used elsewhere [18, 33] and is an updated version of the observational instruments reported by Barreira [34] and Barreira and Garganta [35]. *SoccerEye* observational instrument criteria and their respective categories (Table **2**) are suitable for the observation of the sequence of tactical and technical behaviours that take place during the offensive phase of play. The area of the pitch where the observations are made (structural criterion) and the relationship between the opponent teams (interactional criteria) are taken into account.

The instrument configuration is based on an updated version of the Organizational Model of Soccer [33] and comprises 80 categories distributed across seven criteria: four field-specific criteria plus three categorical criteria. The field-specific criteria are the following: 1) Start of offensive phase/Ball recovery; 2) Development of defence/attack transition-state; 3) Progress of ball possession; and 4) End of offensive phase. The categorical criteria are the following: 5) Pattern of pitch space position; 6) Centre of game; and 7) Spatial pattern of interaction between teams. The criteria are comprehensive in scope and mutual exclusive. Therefore, this tool provides general understanding of the behaviour of the two teams and their players during the course of a match.

A Coding Manual containing definitions of the categories, working examples, and syntactic rules has been developed.

a. Special characters

These commands enable the recording of data using the event and multi event syntax proposed by Bakeman and Quera [31, 36], which is compatible with SDIS language.

b. Data editing tools

If an error occurs, the user can delete the entire sequence at once, or use the "Undo"/"Redo" buttons to eliminate the code and/or subject entries, even if the sequence is already stored in the memory.

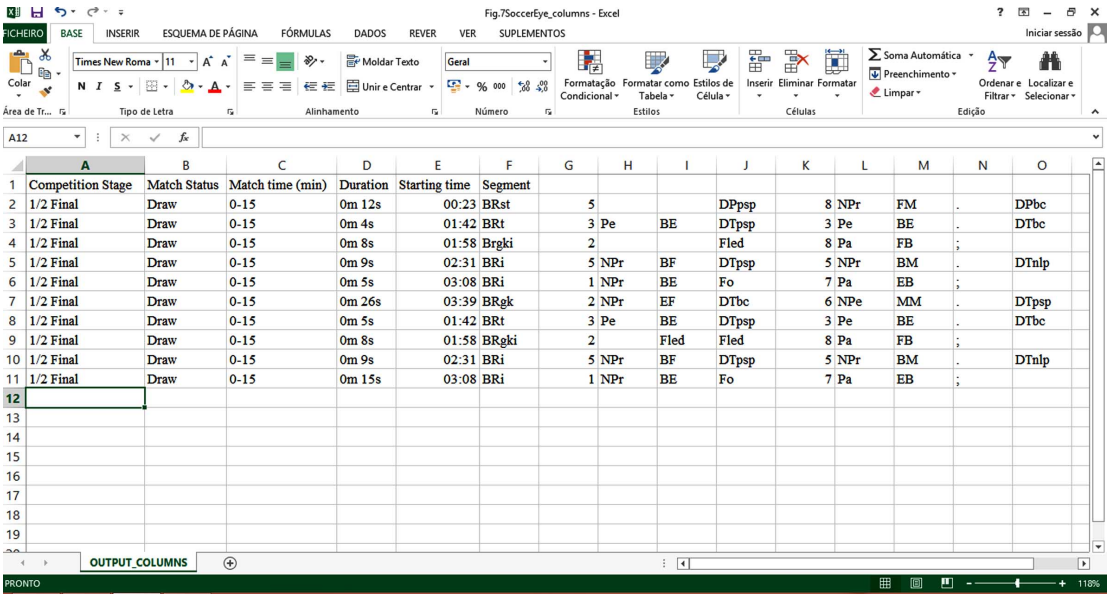


Fig.7SoccerEye_columns - Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Competition Stage	Match Status	Match time (min)	Duration	Starting time	Segment									
2	1/2 Final	Draw	0-15	0m 12s	00:23	BRst	5			DPpsp	8	NPr	FM	.	DPbc
3	1/2 Final	Draw	0-15	0m 4s	01:42	BRt	3	Pe	BE	DTpsp	3	Pe	BE	.	DTbc
4	1/2 Final	Draw	0-15	0m 8s	01:58	Brgki	2			Fled	8	Pa	FB	;	
5	1/2 Final	Draw	0-15	0m 9s	02:31	BRi	5	NPr	BF	DTpsp	5	NPr	BM	.	DTnlp
6	1/2 Final	Draw	0-15	0m 5s	03:08	BRi	1	NPr	BE	Fo	7	Pa	EB	;	
7	1/2 Final	Draw	0-15	0m 26s	03:39	BRgk	2	NPr	EF	DTbc	6	NPe	MM	.	DTpsp
8	1/2 Final	Draw	0-15	0m 5s	01:42	BRt	3	Pe	BE	DTpsp	3	Pe	BE	.	DTbc
9	1/2 Final	Draw	0-15	0m 8s	01:58	BRgki	2		Fled	Fled	8	Pa	FB	;	
10	1/2 Final	Draw	0-15	0m 9s	02:31	BRi	5	NPr	BF	DTpsp	5	NPr	BM	.	DTnlp
11	1/2 Final	Draw	0-15	0m 15s	03:08	BRi	1	NPr	BE	Fo	7	Pa	EB	;	

Fig. (7). Data were obtained with *SoccerEye* v3.2 software and exported in columns to an Excel sheet.

c. Recording window

Observation and recording images are registered simultaneously and in real time in the "Recording window". Recorded segments are stored in the "Registered segments" box, and distributed in rows.

2.3. Exporting Data

Data exported from *SoccerEye* v3.2 in generic formats such as, csv, .xls and .txt can be opened in spreadsheets (Figs. **7** and **8**), statistical packages, and word processor software for subsequent analysis. *SoccerEye* uses the event and multi event syntax proposed by Bakeman and Quera [31, 36], which is compatible with SDIS language. When saving the recorded segments, the user is prompted to choose between column-organised tables (Fig. **7**), e.g. for use in SPSS, or row-organised tables (Fig. **8**), e.g. for use in SDIS-GSEQ sequential analysis software.

3. *SOCCEREYE* V3.2 SOFTWARE ADVANTAGES

SoccerEye's recording design is selected according to the user's level of computer literacy and familiarity with the observational methodology as well as to the aims of the research study. The user may chose to rely on *SoccerEye* observational instrument categories or alternatively to freely edit the software program. Depending on its configuration (Table **1**), the software is more or less prone to errors during recording (Fig. **9**).

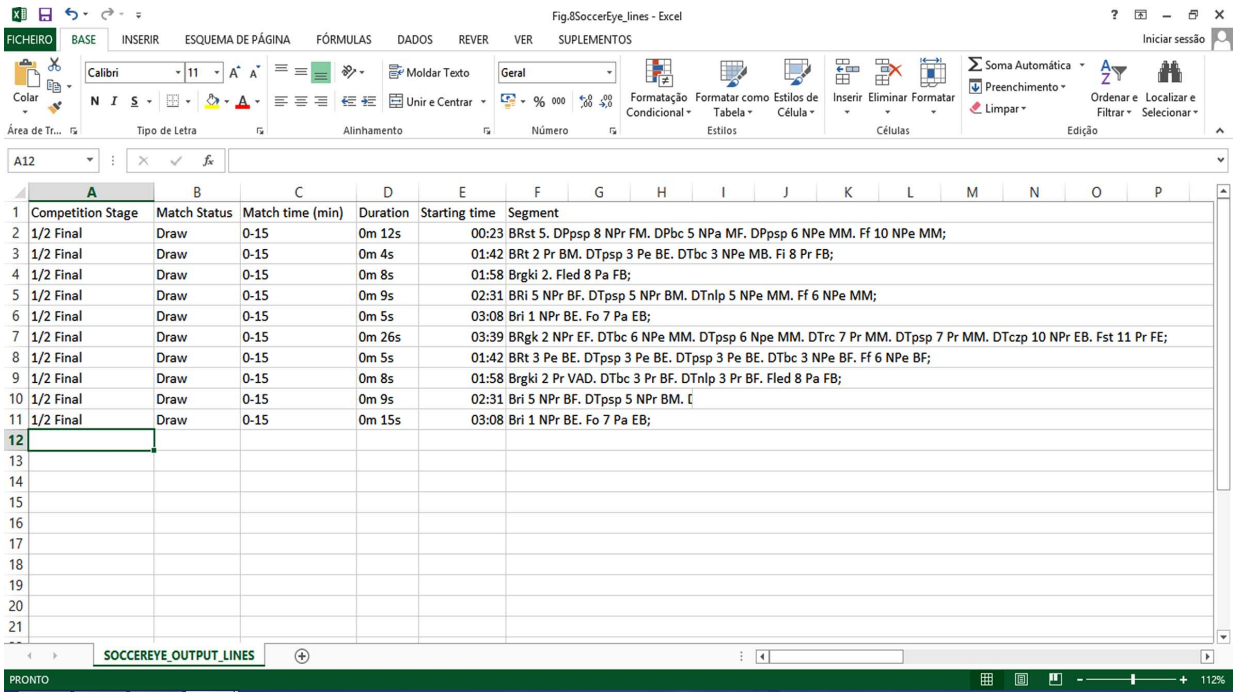
SoccerEye v3.2 is a user-friendly application that provides controlled simultaneous video observation and recording through well-designed and hierarchically organised buttons. Mouse-over title attributes assist a less-experienced user throughout the recording process. Moreover, the recorded data appear on screen and are immediately visible to the user at any moment. When registering an event or a multi event sequence, the starting time and duration (in minutes and seconds) are saved, which allows easy browsing of the data. Other advantages include the application of precedence rules, the use of SDIS-GSEQ analytic software syntax, and the exportation of data to multiple generic formats.

To understand the factors contributing to improved soccer performance, it is necessary to consider the sport's specific content and logic. Because it was developed for soccer research, *SoccerEye* provides specific observational data on time and sequence interaction, thus providing relevant information about the complexity and the dynamics of soccer performance. Using *SoccerEye* predefined settings, it is possible to conduct diachronic analysis, which regards an event or multi event sequence in terms of change over time. This type of analysis takes into account the behaviour of a player and his or her team when facing the opponent, the space (pitch area) and time (starting time and duration) of each event, and other factors such as match status, match time, and competition stage. The tactical behaviours are recorded in their natural setting and in real time by considering time and sequential decisions.

In comparison with paper-and-pencil notation and other methods of data collection, *SoccerEye* is a user-friendly, time saving, and high-quality method that produces fewer errors during recording and data exportation to analytic software. Complementarily, open recording designs allow researchers to include new categories to observe, codify, and register spontaneous behaviours that might occur in natural context.

4. CONCLUSIONS AND APPLICATIONS

With *SoccerEye* software, it is possible to collect data using free-access, user-friendly tools with shorter recording time, faster learning curve, and fewer errors. The data can be easily exported into multiple generic formats, including the SDIS format for the analysis of interaction sequences with GSEQ software. Although *SoccerEye* is specific to soccer, the observational methodology used might be applied to a range of sports in a variety of contexts, from competition to



	A	B	C	D	E	F
1	Competition Stage	Match Status	Match time (min)	Duration	Starting time	Segment
2	1/2 Final	Draw	0-15	0m 12s	00:23	BRst 5. DPpsp 8 NPr FM. DPbc 5 NPa MF. DPpsp 6 NPe MM. Ff 10 NPe MM;
3	1/2 Final	Draw	0-15	0m 4s	01:42	BRt 2 Pr BM. DTpsp 3 Pe BE. DTbc 3 NPe MB. Fi 8 Pr FB;
4	1/2 Final	Draw	0-15	0m 8s	01:58	Brgki 2. Fled 8 Pa FB;
5	1/2 Final	Draw	0-15	0m 9s	02:31	BRi 5 NPr BF. DTpsp 5 NPr BM. DTnlp 5 NPe MM. Ff 6 NPe MM;
6	1/2 Final	Draw	0-15	0m 5s	03:08	Bri 1 NPr BE. Fo 7 Pa EB;
7	1/2 Final	Draw	0-15	0m 26s	03:39	BRgk 2 NPr EF. DTbc 6 NPe MM. DTpsp 6 Npe MM. DTrc 7 Pr MM. DTpsp 7 Pr MM. DTczp 10 NPr EB. Fst 11 Pr FE;
8	1/2 Final	Draw	0-15	0m 5s	01:42	BRt 3 Pe BE. DTpsp 3 Pe BE. DTpsp 3 Pe BE. DTbc 3 NPe BF. Ff 6 NPe BF;
9	1/2 Final	Draw	0-15	0m 8s	01:58	Brgki 2 Pr VAD. DTbc 3 Pr BF. DTnlp 3 Pr BF. Fled 8 Pa FB;
10	1/2 Final	Draw	0-15	0m 9s	02:31	Bri 5 NPr BF. DTpsp 5 NPr BM. [
11	1/2 Final	Draw	0-15	0m 15s	03:08	Bri 1 NPr BE. Fo 7 Pa EB;

Fig. (8). Data were obtained with *SoccerEye* v3.2 software and exported in rows to an Excel sheet.

research. Such a computer application might help understanding the complex mechanisms underlying success in sports. *SoccerEye* can be used to observe a single player or an entire team. Particularly for coaches, it can provide the basis for weekly training programmes and seasonal schedules [37], which are designed to improve competitive play.

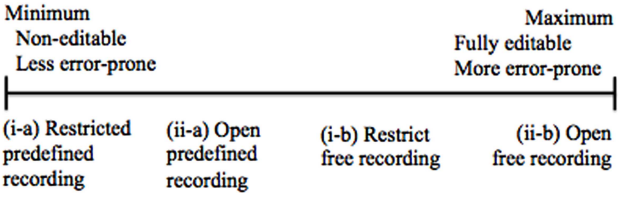


Fig. (9). Recording design characteristics according to a more restricted or more open configuration.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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SUPPLEMENTARY MATERIAL

Video **1.** *SoccerEye* software functionalities.

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