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# The Validity, Objectivity, and Reliability of a Soccer-specific Behaviour Measurement Tool

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# The Validity, Objectivity, and Reliability of a Soccer-Specific Behaviour Measurement Tool

**Purpose:** The purpose of the study was to assess the validity, objectivity, and reliability of a Soccer-Specific Behaviour Measurement Tool (S-SBMT) in relation to the soccer philosophy of a Category One Premier League soccer academy. **Methods:** A 30 minute, 8 vs. 8 small-sided game (SSG), played by the U12 squad of the participating academy was used for analyses. Validity was ensured through formulating the S-SBMT definitions with experienced soccer coaches from the same soccer academy. Percentage agreement with a reference value of ±1, 95% Confidence Intervals, median sign and Yule's Q were used to assess objectivity and reliability. **Results:** High levels of objectivity were found for the number of passes (98.8% agreement), runs with the ball (97.5% agreement), and goal attempts (100%). Reduced objectivity was apparent for forward zonal transitions (75.3%), along with tackles (70.4%), interceptions, (63%), and loose balls (48.1%). Reliability was tested after 1- and 4-weeks, with levels of percentage agreement found to be above the 85% acceptable threshold for most behaviours (passing = 95.1%, runs with the ball = 92.6%, goal attempts = 100%, tackles = 100%). **Conclusions:** The study demonstrated acceptable objectivity and reliability for S-SBMT behaviours and these findings demonstrate the potential utility of the S-SBMT in monitoring technical actions in a Category One Premier League soccer academy, and a methodological process for other academies to follow in ensuring the quality of performance data.

Keywords: soccer, analysis, validity, objectivity, reliability

## Introduction

As the most common users of performance analysis, professional soccer clubs across the world hire multiple specialist practitioners, commonly known as

Performance Analysts, to perform notational analysis on team and individual performance (Wright, Atkins, Jones, & Todd, 2013; Wright, Carling, & Collins, 2014). By systematically observing soccer performance using valid, objective, and reliable notational analysis tools, Performance Analysts are able to evaluate soccer performance, providing feedback to players and coaching staff to consequently enhance the decision-making process of coaches in relation to players and tactics (Wright et al., 2013). With advancements in modern technology, individual and team performance is captured in digital video format for subsequent use with computer-based systematic observation analysis tools and have become commonplace in professional soccer clubs (Wright et al., 2013). In English soccer, the recent emergence of the Premier League Elite Player Performance Plan (EPPP) has resulted in academies needing an identity in the form of their soccer playing 'philosophy' (The Premier League, 2011). As such, it is a common role of performance analysts to establish which aspects of the playing philosophy are required for analyses (Wright et al., 2013).

The performance analysis process serves to negate the issues associated with the subjective coach perception of performance, due to memory limitations (Franks & Miller, 1986; Franks, 1993; Laird & Waters, 2008; Nicholls & Worsfold, 2016) and the constraints of the viewing environment (Wright et al., 2014). The use, however, of humans as operators of computer-based notational analysis tools can result in significant measurement error due to the inherent subjective nature of systematic observation, when interpreting performance against predefined criteria (Bradley et al., 2007; O'Donoghue, 2007a). Consequently, it is important to establish content validity, objectivity, and reliability in the formulation of such tools to help reduce these issues.

Content validity of notational analysis tools has previously been established using experienced soccer coaches, due to their contextual expertise in generating applicable operational definitions that logically measure desired performance indicators (Brewer & Jones, 2002). The reliability of any given observational tool can be established through assessment of the same performance across multiple observations of the same event (Batterham & George, 2003). The establishment of validity, objectivity, and reliability when using notational analysis tools in elite youth soccer represents the under-pinning rationale for the present study.

Prior to 2002, 70% of notational analysis papers in sport, including soccer, failed to report any information regarding the reliability of notational analysis systems used to collect data (Hughes, Cooper & Nevill, 2002). Brewer and Jones (2002) produced a five-stage process for establishing contextually valid and reliable observation tools in sport. This includes the key concepts associated with validity outlined by Thomas and Nelson (1990); reliability outlined by Batterham and George (2003), and serves to act as the primary reference point for formulating tools of a similar nature. Consequently, this approach has been used by Ford, Yates, and Williams (2010) and Cushion, Harvey, Muir and Nelson (2012) to create domain-specific behavior assessment tools in an elite soccer coaching setting. However, while these studies provide valuable information regarding coaching behaviours, the behaviours of players within coaching sessions has yet to be explored.

Recent research has moved towards creating tools for the assessment of technical soccer performance in a coaching setting using small-sided games with elite female (age: 16 ± 1.1 years; soccer experience = 9.9 ± 2.3 years) (van

Maarseveen, Oudejans & Savelsbergh, 2017). The process by which the analysis system was created ensured validity and reliability using similar principles to those of aforementioned studies (Brewer & Jones, 2002; Cushion et al., 2012; Ford et al., 2010). Experienced professional coaches were recruited to ensure the validity of the system through checking the content of the tool, while traditional inter- and intra-observer approaches were implemented to ensure reliability.

However, the SSG structure was broken down into independent phases of play, without the inclusion of possession turnovers. This limits the natural 'flow' (i.e. both teams have the opportunity to attack and defend) of soccer, thus restricting ecological validity (Hughes & Bartlett, 2015; Robins & Hughes, 2015). With regards to the soccer behaviours included in the system, it is not clear whether they are based upon the specific soccer philosophy of the team from which the players and coaches were recruited. Additionally, by only assessing inter- and intra-observer reliability for 16 and 10% of the total trials respectively, several behaviours within the tool were unable to be considered reliable due to their infrequency of occurrence.

Without determining validity and reliability in notational analysis tools; performance data stakeholders (e.g. researchers, coaches, players, performance analysts) are unable to guarantee the accuracy of the data. The valid, objective, and reliable use of systematic observation tools is largely dependent upon the accuracy of the operational definitions (Brewer & Jones, 2002; Cushion et al., 2012; James, Taylor, & Stanley, 2007; Williams, 2012). Should a tool's definitions lack depth and accuracy with regards to what constitutes the occurrence of a particular event, or be of a length that requires the analyst to think for a significant period of time before making a judgement; data may be collected

incorrectly by missing an event's occurrence, recording an event when it did not occur, or using the functions of the tool incorrectly (Armitage, 2006; James et al., 2007; O'Donghue, 2007b). This has negative implications for professional soccer clubs, as a true reflection of player performance may be skewed either positively, or negatively, thus leading to incorrect player judgements, and a detrimental effect on the burgeoning coach-analyst relationship within soccer clubs (Wright et al., 2013; Wright et al., 2014). By investigating the reliability of Performance Analysts in their use of systematic observation tools, errors of this nature can be reduced or avoided, and establish whether the tool is contextually valid and reliable.

Consequently, the aim of the study was to assess the objectivity and reliability of a contextually valid, club soccer philosophy-specific, behaviour measurement tool (S-SBMT) using two experienced Performance Analysts within a 'Category One' Premier League soccer academy. It was hypothesised that there would be good levels of intra and inter-observer reliability of the S-SBMTas a result of following the Brewer and Jones (2002) five-stage process.

## Methods

### *Development of the S-SBMT*

The purpose of the S-SBMT was to assess the efficacy of a Category One Premier League soccer academy coaching curriculum in the development of soccer-specific behaviours related to the academy soccer playing philosophy. Therefore, the S-SBMT needed to be created in relation to the specific behaviours of the academy playing philosophy rather than including all generic soccer behaviours. An existing observation analysis tool (or combination of multiple existing tools),

with established validity and reliability, should be used as a template when formulating new systems (Brewer & Jones, 2002). Two Performance Analysts (PAs) from the same Category One English soccer academy each with an average of 4 years vocational experience were recruited to develop and test the S-SBMT. The PAs had extensive vocational experience in the use of the previously validated Prozone Match Viewer (PMV) observation tool when observing technical soccer performance indicators (e.g. passing, shooting, tackling) (Bradley et al., 2007). Therefore, the behaviours and definitions within PMV were used as the basis for the S-SBMT. The PAs collaboratively compared the PMV definitions to those within the academy soccer philosophy and proposed amendments to existing definitions. A total of 4 behaviours were directly linked to the playing philosophy. Therefore, additional definitions for absent behaviours in the PMV were created to increase specificity of the S-SBMT to the academy soccer philosophy. A total of 12 behaviours required new definitions, and were predominantly associated with the outcome of a behaviour (i.e. successful or unsuccessful attempt at performing the behaviour), as PMV definitions describe the behaviour itself, not the associated outcome (Table 1).

*** INSERT TABLE 1 NEAR HERE ***

***Tagging Procedure***

The S-SBMT was constructed using the 'Tagging' module within Dartfish 6 (Fribourg, Switzerland) on a laptop computer (Lenovo ThinkPad, Morrisville, United States). The tool was constructed to allow the tagging procedure to begin at the start of a team's passing and receiving sequence with the relevant button

press. At each point within the sequence where the PA felt a behaviour was evident, further relevant buttons were pressed on the tagging panel. Each press of a button created a mutually exclusive event within the Dartfish Timeline. The panel was configured to ensure that it was not possible for a single button press to place a behavior in two separate locations along the timeline. Pause, rewind, and variable playback speed functions were accessible to the observer to reduce the risk of behaviours being missed due to the natural game tempo of the SSG.

***Establishing S-SBMT Validity***

To establish face validity of the S-SBMT, two experienced researchers in the field of notational analysis were consulted regarding the number of behaviours included within the S-SBMT, along with the accuracy of the definitions as per the process outlined by Brewer and Jones (2002). Following this process, content validity was ensured by two UEFA A-licensed coaches with an average of 12 years coaching experience from the same academy as the PAs, viewing 3 video-based examples of each behaviour included in the S-SBMT. Archived match footage of the participating age group was used to determine whether all elements of the S-SBMT were representative of the club playing philosophy in relation to match play, along with whether important technical behaviours of the playing philosophy were omitted from the behaviour categories, or unimportant elements of playing philosophy were erroneously included. The coaches viewed the video-based examples at real-time speed, but were given the option to replay any clips they felt were not initially clear, along with adjusting playback speed when necessary. The only behaviour considered by the coaches to require amendment prior to further use was Ball Manipulation. The original definition presented to the

coaches did not include information as to which action ended the behaviour (e.g. pass, cross, shot).

### *Determining Reliability of the S-SBMT*

A small-sided game (SSG) was used as the sample of soccer performance in which to test the tool. A SSG was used as opposed to a full 11 vs. 11 game due to the inherent increase in the frequency of technical behaviours observed in SSGs (Dellal et al., 2012). Two Performance Analysts (PA1 and PA2) from the same Category One English soccer academy each with an average of 4 years vocational experience tested the reliability of the S-SBMT. Objectivity of the S-SBMT was established by comparing the frequency of observations for each behaviour between PA1 and PA2 for the SSG. Reliability was established by comparing the results of PA1's initial observation to subsequent observations of the same SSG by PA1 after periods of 1- and 4-weeks to account for the influence of PA1's memory on their recognition of behaviours.

#### *Small-sided game configuration*

Sixteen under-12 (U12) players (age: 11.4 ± 0.5 years, stature: 147.3 ± 7.3 cm, mass: 37.4 ± 6.8 kg) contracted to the academy were recruited to take part in the SSG. Participants trained at the academy for an average of 8.5 hours per week, 10 months per year, with an average of 4.2 years previously spent at the academy. The research procedure was conducted in accordance with the ethical guidelines of the academy, with ethical approval obtained from a Local University Ethics Committee. Participants provided written assent, with their parents/guardians providing written informed consent. All players had completed a full health check

with the club's medical staff, along with a medical questionnaire administered by the academy as part of their registration process; thus confirming that all participants were asymptomatic and fit to take part in the study.

The 8 vs. 8 SSG was 30 minutes in duration (2 x 15 minute periods), and took place at the academy on a 60 x 40 m 3rd generation artificial playing surface. The pitch was divided into three equal 20 x 40 m zones along the length of the pitch, with markers placed at 10 m intervals. Both teams were of equal playing ability based on the subjective assessment of the U12 team coaching staff. Both teams were instructed to play in a 1-2-3-2 formation, and follow conventional soccer rules. The SSG was recorded using a Sony video camera (Sony HDR, Tokyo, Japan) with a frame-rate of 30 fps and shutter speed of 1/60th placed on a tripod 1 m in height (Manfrotto, Ashby-de-la-Zouch, United Kingdom). The camera operator was positioned on a platform (Zarges TeleTower, Milton Keynes, United Kingdom) 3 m in height and 5 m from the side of the pitch (Figure 1). A 'wide-angle' filming perspective was used, with pan, tilt, and zoom functionality available to the camera operator. The zoom function was used when the ball travelled beyond the zones outlined in Figure 1 to enhance the accuracy of coding.

*** INSERT FIGURE 1 NEAR HERE ***

*Statistical Analysis*

Two types of frequency data are produced by the S-SBMT. Consequently, two different approaches were utilised to determine reliability of the tool. Frequency count-based data for each passing and receiving sequence was concerned solely with the number of passes, and therefore did not need to be placed into distinct

categories. Similarly, ball manipulation was concerned with the frequency of players travelling with the ball in their possession. Therefore, percentage agreement with a reference value of ±1 and 95% confidence intervals (CI) were calculated as per Cooper et al.'s (2007) methodology. The median sign test was then used to establish whether any differences between the observers were significant ($p < .05$). Statistically significant differences between observers suggest unreliable use of the systematic observation tool (Cooper et al., 2007). All other behaviours in the S-SBMT could be placed in distinct outcome categories (Table 2). Yule's Q was used to calculate the percentage agreement between observers for each category as opposed to the more conventional use of Cohen's Kappa. This was due to the calculation for Kappa including the element of luck or chance in finding concordant observations, and therefore producing an overly conservative estimate of agreement (James et al., 2007). Behaviours that exceeded 85% agreement were considered reliable (Siedentop, 1976; Brewer and Jones, 2002).

*** INSERT TABLE 2 NEAR HERE ***

## Results

### *Objectivity of the S-SBMT*

Table 3 shows that inter-observer reliability was 90.1%, 95% CI [83.6, 96.6], for the number of passes per sequence, with proportional agreement calculated at 98.8%, 95% CI [96.4, 100], when the ±1 reference value was applied. Median sign test showed that the absolute difference between PA1 and PA2 was not statistically significant ($p = .727$), therefore suggesting objectivity in the observations. The absolute percentage agreement was 72.8%, 95% CI [63.2, 82.5], between the PA1and PA2 when observing ball manipulation with

proportional agreement calculated at 97.5%, 95% [94.2, 100]. The absolute difference between PA1 and PA2 was statistically significant ($p$ = .052). However, the high proportional percentage agreement suggests objectivity in the observations.

*** INSERT TABLE 3 NEAR HERE ***

Table 4 shows objectivity for categories associated with goal attempts were the most reliable in the S-SBMT, with 91.7% agreement for all three categories ($Q$ = .917). Backwards zonal transitions were almost in complete agreement ($Q$ = .975), but sequences that were recorded as having no transition, or a forward transition, were less reliable (no transition: $Q$ = 0.728; forwards transition: $Q$ = 0.753). Where a disagreement between observers occurs in relation to zonal transitions, it is likely to be between whether the sequence travelled forwards or did not move between zones. Categories related to possession regains were found to be the most unreliable. Of the three regain categories, tackles were found to have the highest percentage agreement ($Q$ = .701). The main source of disagreement between the observers was whether the ball was regained via an interception ($Q$ = .63) or loose ball ($Q$ = .481).

*** INSERT TABLE 4 NEAR HERE ***

*Observer Reliability of PA1*

Table 5 shows the reliability for the number of passes per sequence was 95.1% ($p$ = 1), with proportional agreement calculated at 100%, 95% CI [100, 100] after a

period of 1-week. After 4-weeks, absolute percentage agreement drifted to 90.1% ($p$ = .363), with proportional agreement calculated at 100%, 95% CI [100, 100]. Ball manipulation was also highly reliable at 92.5% ($p$ = .656) after 1-week, before drifting to 87.7% ($p$ = .945) after 4-weeks.

*** INSERT TABLE 5 NEAR HERE ***

Table 6 shows levels of reliability between the initial PA1 observation and re-tests after 1- and 4-weeks for categorical data. PA1 coded the 23 goal attempts in the same category after both 1- and 4-weeks ($Q$ = .917). PA1 also coded the same frequency of tackles across all three observations ($Q$ = .929). Errors in the PA1's coding in relation to regain behaviours can be attributed to disagreements between interceptions and loose balls. Concordant observations of interception and loose ball regains drifted from 85.2%, week 1 ($Q$ = .852) to 77.8% ($Q$ = .778) 4-weeks after the original observation.

*** INSERT TABLE 6 NEAR HERE ***

**Discussion**

The purpose of this study was to create a soccer-specific behaviour measurement tool and assess its reliability when used by two experienced Performance Analysts. It was hypothesised that if the Brewer and Jones (2002) five-stage process was implemented appropriately, good levels of objectivity and observer reliability would be apparent. Results suggested that the S-SBMT could be regarded as having good levels of objectivity and reliability for several

behaviours. However, equally, there were unreliable aspects of the S-SBMT despite the coaches and analysts who assisted in the creation of the S-SBMT working within the same academy and possessing similar levels of vocational expertise.

The development of the S-SBMT provides additional support to the notion that following a prescribed method such as that of Brewer and Jones (2002) can result in the production of a notational analysis tool that is logically valid. The use of experienced coaches is crucial to this process due to their sophisticated knowledge of the sport. This ensures that the definitions assigned to each performance variable are logical and appropriately capture relevant performance indicators. Performance analysts often work closely with coaching staff (Wright et al., 2013; Wright et al., 2014). By involving coaches in the process of creating definitions for their notational analysis tool, the analyst can potentially develop a like-minded understanding of the sport, thus ensuring that the data collected is objective between coach and analyst. Additionally, the process outlined by Brewer and Jones (2002) has been shown in this study to be easily transferrable between sports, and as such, could be transferred between soccer clubs with differing playing philosophies to enable club-specific soccer performance data to be collected.

Aspects of the S-SBMT were found to be both objective and reliable in the collection of performance data. Passing and running with the ball behaviours between analysts were found to be at the acceptable 90% agreement level suggested by Cooper et al. (2007) for frequently occurring events. Application of the ±1 reference value resulted in near perfect inter-observer agreement (98.8%). Running with the ball occurred as frequently as passing, with objectivity found to

be below the 90% agreement level. However, use of the ±1 reference value increased to a near perfect 97.5%. Additionally, PA1 remained a reliable observer of passing and runs with the ball after a period of 4-weeks. Again, only running with the ball required a ±1 reference value adjustment to exceed the acceptable level of 90%.

Further support for objectivity and reliability was found in the calculation of objectivity and reliability for goal attempts. The same number of goal attempts were observed across observations, with outcomes categorised in the same manner. The high levels of objectivity and reliability may be attributed to the clarity of the definition for goal attempts and the subsequent outcomes (on target, off target, blocked) as the three outcomes differ considerably in their characteristics, therefore eliminating the potential for observer subjectivity to influence the results (Tenga et al., 2009). Therefore, the S-SBMT can be considered a valid tool for assessing the frequency of passing, running the ball, and goal attempt behaviours in youth soccer within a Category One Premier League Academy.

Although it should be noted that high levels of objectivity and reliability were found for backwards zonal transitions; there were discordant observations for both objectivity and reliability (after 4-weeks) in passing sequences that transitioned forwards, or remained in the same zone. Despite a clear definition, zonal transitions were predominantly a subjective assessment of the analyst, whose judgement was only aided by a cone along the side of the pitch as opposed to a pitch with clear markings (e.g. the penalty area) (Tenga et al., 2009). Additionally, the angle at which the game was recorded may have led to perceptual error of the observer in determining pitch location (Bradley et al.,

2007). Despite these constraints, there was at least a 72.8% chance of the analysts recording the same zonal transition outcome, and could be as a result of only using 3 different zones rather than the multiple zones found in Tenga et al.'s (2009) system.

The regain behaviours, tackle, interception, and loose ball lacked objectivity. A similar issue was reported by Armitage (2006) in the observation of breaking the game line in Rugby, whereby observers agreed strongly on going 'over' the game line, but disagreed on whether line breaks were 'around' or 'through'. This suggests that further work is required to investigate why the two analysts view these behaviours differently despite using the same definitions. Disagreements between observers could be attributed to the subjectivity in determining distance between opposing players prior to the behaviour, as it is not practically feasible to measure the distance between players when viewing 2-dimensional video footage. Additionally, as the footage was only 2-dimensional, observers may have been unable to detect a deflection on the ball caused by an opposing player at moments where the camera was fully zoomed out, therefore reducing the chance of an interception being correctly coded (Tenga et al., 2009).

Despite the positive results associated with passing, running with the ball, and goal attempt behaviour, results suggest that the S-SBMT cannot currently be considered a valid and reliable measure of transition and regain behaviours in youth soccer based on its use in a single SSG. The process of creating and developing the S-SBMT followed that of previously valid and reliable observational tools; incorporating the use of highly qualified and experienced soccer coaches, whom are well-versed in the academy soccer curriculum, along with vocationally-experienced performance analysts to ensure validity and

reliability in its functionality (Brewer & Jones, 2002; Cushion et al., 2012; Ford et al., 2010). Therefore, it could be suggested that the relatively low levels of reliability found for defensive behaviours could be attributed to the nature of the behaviours rather than the functionality of the tool (van Marseveen et al., 2017). Using a larger sample of games for analysis may negate this issue, as it may allow the behaviours associated with defensive actions more opportunity to stabilise, and therefore become more recognisable to the observer, due to their reduced frequency in comparison to more reliably observed behaviours (i.e. passing) (van Marseveen et al., 2017). The process of behaviours stabilising over time is known as 'normative profiling', and has demonstrated how data sets evolve over time, as the volume of data increases (Hughes, Evans & Wells, 2001; Hughes, Cooper, Nevill & Brown, 2003; O'Donoghue, 2005). Therefore, it may take an analyst a significant period of the competitive season to establish whether behaviours that occur less-frequently than others are objective and reliable. It would be interesting to use the S-SBMT over a prolonged period of time to determine whether defensive behaviours follow the assumptions of normative profiling.

The external validity of the S-SBMT could be questioned due to the tool only being used with youth soccer players in a single soccer academy, in a single age group. Further research is required to determine whether the age, playing ability, and soccer curriculum of the participants influences the ease at which common soccer behaviours can be observed. In a wider context, by treating each behaviour as an independent variable, those with poor levels of objectivity and reliability were not masked by acceptable results from other behaviours (Cooper et al., 2007). Therefore, results of this study provide further support for the use of simple statistical approaches; specifically advocating the use of Yule's Q in

assessing observer reliability due to the ability to detect specific behaviours that are unreliably observed. However, the use of this non-parametric statistical approach, combined with the small sample, size gives rise to reduced statistical power compared to parametric analyses (Bland & Altman, 1999).

Future research could look to explore the influence of vocational experience (expert vs. novice analyst paradigm) on an analyst's ability to reliably use systematic observation tools. This could carry potential implications for best practice, not only in soccer clubs, but other sports where the systematic observation of performance is common. It would be interesting to evaluate how the nature of the sport being analysed influences the process of establishing these key concepts. The results of the present study have highlighted the need to ensure the concepts of validity, objectivity, and reliability when creating notational analysis tools, while accounting for practical issues associated with sample size. Additionally, practitioners are encouraged to utilise this method as a template for ensuring best practice in this vocational setting.

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