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Examining soccer skill performance using a dual task paradigm

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Abstract

The purpose of this study was to evaluate the reliability and validity of a holistic test (Soccer Skills and Cognitive Aptitude Test [SoSCAT]) that assesses soccer skills and performance in a dual-task (DT) context. A total of 73 male soccer players aged 12–18 years joined in this study. They were playing in three official Spanish regional leagues, and were divided according to their age into under 14 (U14, n = 25), under 16 (U16, n = 26), and under 18 (U18, n = 22). Additionally, players were categorized dichotomously into high-talented (n = 20) and lower-talented (n = 53) groups. Several soccer-skill and cognitive tests were evaluated. Regarding absolute reliability, the standard error of measurement (SEM) was 2.27 (5.30%) and the minimal detectable change (MDC) was 4.17 (9.75%). In relative reliability, the intra-class correlation coefficient was 0.908 (95% confidence interval [CI] = 0.826–0.951, $p < 0.001$). By category, the U18 group showed a higher performance in SoSCAT ($p < 0.001$) than U16 and U14. In addition, the DT cost (DTC) and ΔTime were the lowest in the U18 group ($p = 0.041$). Moreover, the high-talent group showed the best performance in SoSCAT ($p = 0.001$), DTC ($p < 0.001$), and in ΔTime ($p < 0.001$). To sum, the SoSCAT is a reliable tool for use under the DT context and it discriminates between levels of players and determines several variables that are relevant to soccer performance and that could help to early identify soccer talent.

Keywords

Association football, cognitive test, talent identification, visual interference

Introduction

Soccer is one of the most-popular and most-practiced sports by children and young people. This sport is an invasive, open-skill sport in which players have to respond to unpredictable external stimuli such as decisions and actions both of the opponent and of teammates.Click or tap here to enter text.[1] Speed capacities (e.g., the ability to move quickly, accelerate or deaccelerate, and change direction) and technical abilities (i.e., on-the-ball performances including ball control, dribbling, and shooting) are essential in soccer performance.[2] Moreover, the ability of players to share the focus of attention among different cues in the environment (the ball, opponents, and teammates) is essential for successful decision making.[3] In this sense, visual search behaviour and knowledge of situational probabilities are important aspects of soccer performance.[4] Elite athletes face intense visuo-motor demands, requiring millisecond-level decision-making to translate vision into action, therefore, the ability to process visual information quickly has been considered an essential element for success in fast-action sports. Especially, saccadic eye movements are an essential feature of visuomotor coordination. Also, it offers a rapid and accurate mean of bringing high acuity foveal vision to bear on important regions of visual space and, in combination with head movements, are the main visual search resource.[5]

High-achieving athletes perform better than non-athletes or lower-performing athletes on various measures of visual, perceptual, cognitive, and motor abilities, all due to a better visual-motor reaction time.[6] Moreover, experts have shown to be superior to sub-elite and/or novices in sport-specific tasks including advanced visual-cue utilization and visual search strategies.Click or tap here to enter text.[7] In addition, visual capabilities not only influence sport performance directly, but also affect the achievement of motor skills.[8]

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Therefore, in soccer, it is imperative for players to distribute attention between numerous cues in the environment while concurrently executing other game actions.[9] Consequently, the relationship between executive mechanisms (action) and those of perception and decision-making (cognition) supports a better understanding of performance-related factors in soccer.[10] At this point, it is necessary to mention the dual-task (DT) paradigm that refers to the ability to perform two tasks at the same time (for example, cognitive and motor tasks), and which commits the person to divide their attention in order to perform both tasks correctly.Click or tap here to enter text.[11,12] In this sense, Plummer & Eskes[13] conclude that attention is limited when two tasks have to be performed together; consequently, one, or even both, of the tasks slows down. These changes depend not only on cognitive reserve, but also on adequate motor development[14] which is known as DT cost (DTC).[15] DTC can be calculated through the equation: DTC = [double task - single task]/ single task $* \pm 100$].[13] Notice that a lower DTC represent a better motor-cognitive performance. In this sense, the systematic review conducted by Moreira et al.Click or tap here to enter text.[16] concluded that higher-level athletes showed a lower DTC than lower-level athletes. In addition, soccer players who showed better performance in exercises related to DT maximized their performance by making the right moves at the right time and the right place.[3] This suggests that a high level of DT skill not only optimises performance in these specific exercises, but also translates into superior performance in soccer. Furthermore, on soccer, the amount of performance worsening decreased as the level of proficiency improved, despite the addition of cognitively-challenging elements causing a reduction in performance.[17] For these reasons, the DT paradigm could be a predictor of athletic talent in soccer. Although, the cognitive, perceptual and motor skills to rapidly changing situations such as in soccer there have been a few attempts to measure these parameters for talent identification (or development) purposes, skill acquisition, and intervention research.[18]

In this regard, although, the process of talent selection in soccer is influenced by a wide range of factors, the most prominent aspect evaluated by coaches and scouts (a person dedicated to identifying, evaluating and recommending players for a soccer team or club) is technical ability, as this is believed that it can demonstrate superior technical skills and be a strong predictor of performance. In talent identification procedures, dribbling, shooting, passing, and kicking at the goal are the most commonly-used soccer-specific skills.[7,19] Particularly, dribbling is an important soccer skill that, when effective, allows players to overcome opponents. It can provide a strong tactical advantage, and for this reason, all of its components (sprint, speed, and ball control) are fundamental to the development of young players. Dribbling can also be considered a decision-making process, and due to its characteristics, it is not always easy to study with ecological validity.[1] In regard to empirical evidence, dribbling ($0.47 \leq d \leq 1.24$), ball control ($0.57 \leq d \leq 1.28$), and decision-making ($d = 0.81$) demonstrated good predictive value as talent predictors in youth soccer players.[20] In addition, many studies conducted in youth soccer reported that change of direction speed discriminates elite from sub-elite soccer players, and could be considered a practically-relevant parameter for talent identification and selection.[9,21,22]

Therefore, there is a crucial role of sport-specific technical skills in performance and talent[23] that, together with perceptual and cognitive skills, appear to be the most interesting aspects for evaluating features of soccer performance.[18] However, in youth soccer players, most skill assessments are not appropriate for talent identification.[24] For example, some researchers have assessed the skill characteristics of youth soccer using the motor-skill tests of dribbling, passing, and shooting with the purpose of contributing to the identification and development process, but without taking the cognitive aspects of decision making into account.[22,25,26] In addition, the assessment of motor actions is generally conducted by observing isolated tasks (e.g., ball control, shooting, passing, and dribbling) and are analysed outside of the game context.[27] Furthermore, previous studies[28,29] that analyse visual perception and decision making have little ecological validity, since they focus on video-viewing. Other studies have analysed the association between cognition and perceptual abilities with motor skills in correlational studies through separate tests.[30] Only the Loughborough Soccer Passing Test (LSPT)[21] and the Loughborough Soccer Shooting Test showed that there is some external cognitive involvement with decision making, but with little inclusion of soccer skills. Furthermore, the LSPT may not be effective in interpreting the intra-individual changes of skill performance in practice due to the large measurement error.[31] Also, another study does not support the use of the LSPT as a valid test of in-game passing performance in this cohort of youth players.[32]

A possible reason for the lack of studies about the predictive value of perceptual-cognitive factors might be the difficulty in capturing such variables. Appropriate diagnostic instruments are often very time-consuming and complex, especially in a sport-specific context.[20] Therefore, since the skill element requires players to demonstrate several abilities under the constraint of time, the development of new and reliable tests that combine perceptual and cognitive abilities with technical mastery can have an extra added value in the assessment of this skills.[18] Consequently, it is necessary to use instruments that allow for evaluating players' response time in decision making in different game situations in an adolescent population (between 12 and 18 years), especially, in a DT paradigm.[33] This test should incorporate several features of soccer within a dynamic and holistic context, which would seem to be better in determining soccer talent.[18] Above all, the tests should have ecological validity. For this reason, the evaluation of eye-foot coordination in the context of DT is presented as an innovative method of analysis to better understand the functional processes that determine the soccer skills of young people.

Therefore, the aim of this study were: 1) To examine the validity and reliability of the Soccer Skills and Cognitive Aptitude Test (SoSCAT) in young soccer-trained players aged 12–18 years; 2) To examine the capacity of these tests to discriminate between different category and level groups (construct validity).

Methods

Participants

A cross-sectional study design was used in this study. A total of 73 healthy male soccer players aged 12–18 years (mean age: 14.84 ± 1.68 years) joined in this study. All were members of three semi-professional soccer clubs from the southern area of Spain and were engaged in official competition (three training sessions/week, 90 min per session, and one competitive match per week). The teams were participating in a 9-month (September-May) Spanish competitive season at the moment of the assessment. Inclusion criteria comprised possessing a federative soccer license and being free from injuries that affect soccer performance in the three months prior to performing the tests. Parents voluntarily signed an informed consent form for the participation of their children in this study. The study was completed in accordance with the norms of the Declaration of Helsinki (2013 version) and was approved by the Ethics Committee of the University of Jaén (Ref: 20231218/ENE.TES).

Players were in three official league (3ª division, $n = 24$; 2ª division, $n = 31$; and 1ª division, $n = 19$) and were grouped into three categories as specified by the Spanish Royal Soccer Federation: under 14 (U14, $n = 25$), under 16 (U16, $n = 26$) and under 18 (U18, $n = 22$). Additionally, players were categorized dichotomously into more-talented ($n = 20$) and less-talented ($n = 53$) groups according to the appreciation of their coaches. Therefore, each coach was asked to select two players who, based on his experience and observation in training, he considered to be the best players in his team.

Materials and testing Assessment

Soccer-skills test. Soccer abilities were measured using the dribbling and passing test. The results of the dribbling and passing test were combined to variable ∑skill (passing + dribbling).[34] Both tests were performed with official balls and test times were obtained using a stopwatch to the nearest 0.01 seconds. In the dribbling test, participants driving a ball ran straight to a post which was located 20 metres from the starting line. The player must have had at least three touches before to reach the cone. Subsequently, the participant dribbled back to the starting line between the cones which were placed at 4 m, 2 m, 2 m, 4 m, 2 m, 2 m, and 4 m from each other. The same straight-run dribbling action was repeated from the other side to complete the test. One successful trial was required, and the best of two attempts was selected for analysis unless the player failed to perform the test in less than 50 seconds, in which case 50 seconds was registered as the performance time (Figure 1). The reliability test/re-test of the dribbling test was $= 29.6 \pm 3.2$ s vs. 30.0 ± 3.1 seconds with a correlation coefficient of $r = 0.82$ ($p < 0.001$).[34]

The passing test was performed with two cones that were 6 m apart from each other and 2 m-wide passing walls placed 7 m apart from the cones. The test started when the participant kicked the first pass against the wall, then immediately repeated the cycle: pass, receive rebound, dribble between cones, and pass to the other wall. The test ended when the tenth pass hit the passing wall. Five of the passes must be made with the right foot and five with the left foot. One successful trial was required in the test, and the best out of two attempts was selected for analysis unless the player failed to perform the test in less than 60 seconds, in which case 60 seconds was registered as the result (Figure 2). The reliability test/re-test of the dribbling test was $= 45.0 \pm 6.7$ seconds vs. 45.4 ± 6.7 seconds $r = 0.81$ ($p < 0.001$).[34]

Cognitive test. To analyse cognitive function, the computerized Vismen-plan test was used which is based on the cube test. In this test, the participant must remember the greatest sequence of visual stimuli possible. A total of ten stimuli are shown arranged irregularly across the screen. In addition, the WOM-REST recognition test was used, which is based on the classic symbol-search tests (WAIS),[35] Wisconsin Card Sorting Test (WCST)[36] and the progressive matrix tests of Raven. In this test, the participant is required to memorize the stimuli that are presented, then recognize which were the original stimuli among the distractors. Both tests measure spatial perception, short-term memory, visual short-term memory, non-verbal memory, working memory, planning, processing speed, and response time, among other abilities. Both tests were applied using the web tool: https://www.cognifit.com/es/bateria-de-pruebas-y-tareas/test-vismem-plan/test-de-concentracion.

Dual-test

Stroop test. To assess interference related to inhibitory control processes, the Stroop test, consisting of three tasks, was used. In the first task, called the 'word condition' (W), a sheet of paper is presented with the words 'RED',

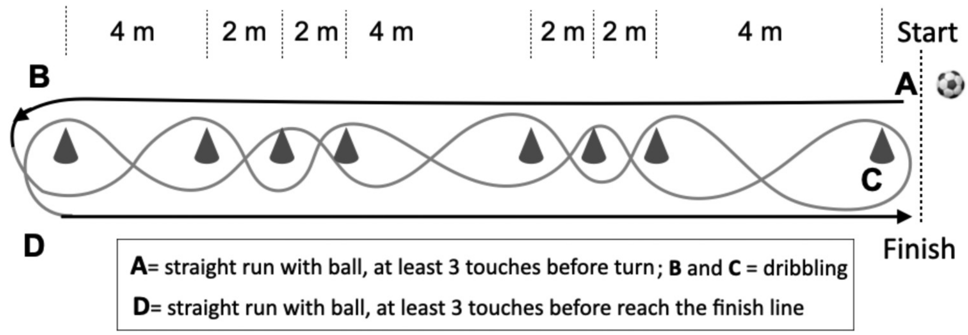

Figure 1. Dribling test.

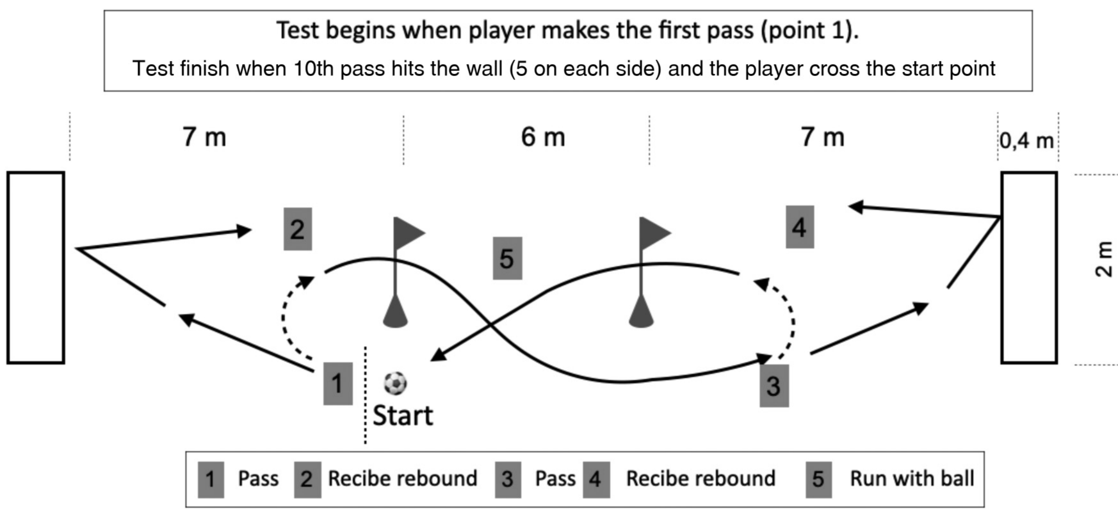

Figure 2. Passing test.

'GREEN', and 'BLUE', printed in black ink and randomly arranged, and the person has to read them aloud. In the second task, called 'colour condition' (C), a sheet of paper with sets of four 'X's printed in blue, green or red ink is shown, and the person has to name the colour of the ink. Finally, in the third task, called the 'word-colour condition' (WC), the same words as in the first task are presented but printed in the colours of the second task, so that the colour of the ink does not match the meaning of the word; the task is to name the colour of the ink, ignoring the written content. Each task must be completed in 45 s. This test yields the following scores: (a) first sheet, the correct number of words read (word 'W'); (b) second sheet, the correct number of colours read (colour 'C'); and (c) third sheet, the correct number of items read (word-colour 'WC'). To calculate the interference, the following formula was applied: (a) WC'= W×C/ W + C and (b) INT = WC - WC'.[37,38]

Trail-walking test (TWT). The TWT is an ambulatory test in which the participants walk as rapidly as possible through 15 numbered flags in ascending order. The flags are installed randomly at each of the 15 positions in a 25 m^2 area (5 × 5 m), according to the procedure used by Yamada & Ichihashi.Click or tap here to enter text.[39] The participants were asked to sequentially move from flag number 1 to flag number 15. A circle with a 30-cm diameter was drawn around each flag. Passage was considered to be successful when the participant stepped on the circle. The trial was timed using a stopwatch to the nearest 0.01 seconds The TWT was performed only once. The test score was determined as the running time, and a longer time indicated worse performance.

Soccer Skills and Cognitive Aptitude Test (SoSCAT). The SosCAT test was conducted in two different conditions (i.e., with and without visual interference).

SoSCAT without visual interference. To perform this test, the participant started conducting the ball from starting point following the driving line to finish point. The test starts with a 10 metres sprint, then a slalom between four cones (jinking run zone) had to be performed. Subsequently, the participants had to turn right or left (in this condition, the participant could choose any direction to go), turn around the cone (change of direction zone) and come back to the driving line. After that, they have to continue to run forward until reach kick area where they have to kick the ball against a wooden wall (they could decide right or left) simulating a partner's pass. Once, the ball kicked the wall, and it was received by the player, the participant has to reach the last cone and turn around. Then, they had to retrace the same track until reach the finish point, then they have to kick the ball (shoot area) between the space created by three cones (right or left) that represent a goal simulation (Figure 3(a)).

SoSCAT with visual interference. The same test was performed by the participants; however, five witty photocells and five witty SEM traffic lights were included in some areas such as change of direction area, kick area, and shoot area. The traffic lights were activated each time that the player crosses the witty photocell (each photocell was connected with a traffic light, (i.e., photocell number 1 with traffic light number 1 and so on)) which was situated 2 metres before the traffic light. It allows the player to watch the instruction properly, since the traffic lights were programmed to appear with two different options (red or green arrow). The instruction you have to follow the direction indicated by the arrow was given when the traffic light showed the green arrow. However, if the traffic light shows the red arrow, you have to go to the opposite direction indicated by the arrow. In each zone, the player's decision making was assessed as correct or incorrect based on the direction the soccer player chose in response to the SEM traffic lights signals (Figure 3(b)). The SoSCAT was performed with official balls and test times were obtained using a stopwatch to the nearest 0.01 seconds

Procedure

The soccer players were tested during the competitive season. No vigorous physical activity was performed on the day before testing. All tests were performed in the participants' usual training settings (i.e., on a turf soccer pitch). Three different sessions were used for the entire evaluation protocol. After a standardized 10-min warm-up, which included jogging, changes of direction and progressive

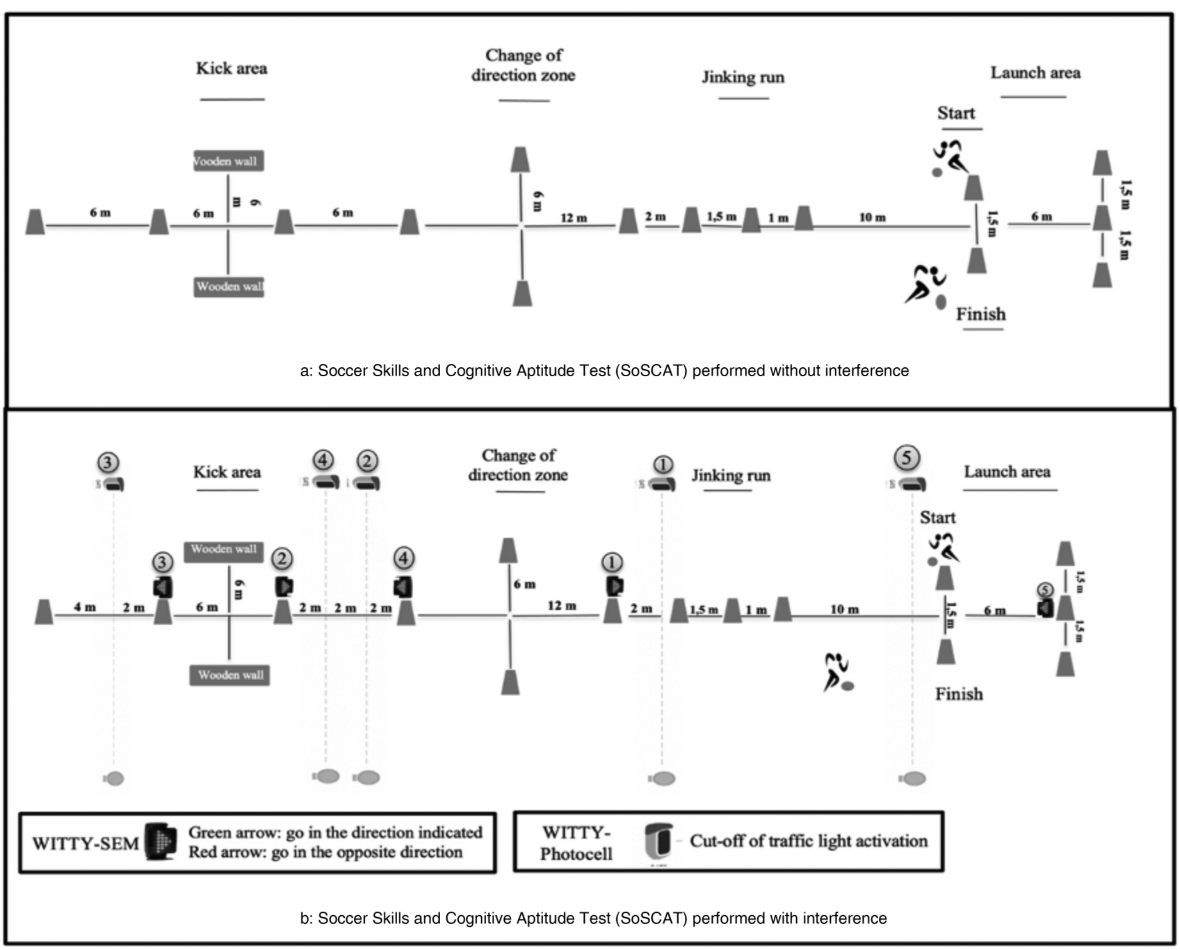

Figure 3. Soccer Skills and Cognitive Test with and without interference.

sprints, participants were given instructions and demonstrations by the research team, followed by two attempts at familiarization with all the tests. No guidance was provided to participants between recorded attempts. The order of the tests after the warm-up was as follows: 1) TWT; 2) The soccer-skills test; 3) the SoSCAT. In the SoSCAT, interference was randomized, so some players started with visual interference and finished without it, while others did so in reverse order. Two trials was performed and the best attempt was selected for analysis. In all trials, players rested for five minutes between each trial to ensure full recovery. The cognitive tests (vismem-plan and wom rest) and the dual test (Stroop test) were performed in a separate session in a closed room that allowed the players to concentrate properly.

Statistical analysis

Data were analysed using SPSS, v.22.0 for Windows (SPSS Inc., Chicago, USA). Tests of normal distribution and homogeneity (Kolmogorov-Smirnov and Levene's test, respectively) were conducted on all data after the analyses. Descriptive data are reported in terms of means and standard deviations (SD) and percentage (%). The current study aimed to determine the following types of validity and reliability of the SoSCAT: criterion validity (concurrent validity), relative reliability (test-re-test), and absolute reliability (standard error of measurement [SEM] and minimal detectable change [MDC]). SEM was computed as the SD of the mean differences between test and re-test divided by $\sqrt{2}$.[40] The SEM is considered very good if <5% of the total score, good if ≥5% and <10%, doubtful if ≥10% and <20%, and negative if >20%.[41] MDC is defined as the limits within a change in the measurement score that could be attributed to measurement error. MDC is computed as $1.96 * \sqrt{2} * \text{SEM}$.[42] The SEM and MDC were expressed as a percentage according to the following formula: SEM% or MCD% = (SEM or MCD/mean) × 100. Where the mean is the average of the test and re-test.[43]

These analyses were conducted over time in the DT condition. In addition, the relative reliability with the intra-class correlation coefficient (ICC) was assessed using Pearson's correlation (r) and Bland-Altman plots, illustrating the agreement between the two tests (day 1 and day 2) and detecting outliers. The 95% CI of the mean difference was used to determine systematic bias. The performance threshold that best discriminated soccer levels (construct validity between more-talented and less-talented) was determined by using the receiver operating characteristic (ROC) curve, and binary logistic regression was performed using soccer levels as the dependent variable and time in DT and ΔTime as the independent variables. Test-re-test reliability was examined with a sample of 40 soccer players assessed twice and separated by 7–10 days.

Moreover, to investigate if the test was able to discriminate between age and player level, the differences in the different parameters between groups were analysed using an analysis of variance (ANOVA) and post hoc analysis by Bonferroni test. The following ANOVA tests were conducted: three groups (U14, U16, and U18) and two groups (high talented level vs. low level). Moreover, in nonparametric variables, the Kruskal-Walli test with post hoc analysis by the Mann-Whitney U-test was used. In addition, to verify the relationship between several parameters, partial correlation analysis and a simple linear regression analysis were used (adjusted for errors in this test). The magnitude of correlation between measurement variables was designated as: < 0.1 (trivial), 0.1–0.3 (small), 0.3–0.5 (moderate), 0.5–0.7 (large), 0.7–0.9 (very large), and 0.9–1.0 (almost perfect).[44] The significance level was set at $p < 0.05$.

Results

Table 1 shows the anthropometric and sociodemographic characteristic of the participants separated by category and sport level. It is worth highlighting the significant differences between level groups in the number of goals scored in the season, which was greater in the high-level players.

Table 2 shows the differences between the different cognitive and soccer skill variables by categories and level groups. By categories, the U18 group showed a higher

Table 1. Anthropometric and sociodemographic characteristics of soccer players by category and sporting level.

	Category				Skill level		
	U14 n = 25	U16 n = 26	U18 n = 22	p-value	Low Talent n = 53	High talent n = 20	p-value
Age (Years)	13.12 (0.66)	14.69 (0.55)	16.95 (0.78)	**<0.001**	14.62 (1.56)	15.40 (1.90)	0.155
Weight (kg)	50,92 (11.33)	57.92 (8.25)	67.36 (5.63)	**<0.001**	57.75 (10.80)	60 (11.43)	0.343
Height (m)	1.64 (0.10)	1.71 (0.09)	1.74 (0.06)	**0.001**	1.70 (0.10)	1.69 (0.08)	0.894
IMC	18.62 (2.42)	19.74 (2.31)	22.27 (1.84)	**<0.001**	19.89 (2.56)	20.72 (2.88)	0.235
Federated years playing soccer	4.76 (2.05)	5.42 (2.64)	7.86 (2.83)	**<0.001**	5.58 (2.75)	6.85 (2.80)	0.182
N° of goals in the league matches	5.60 (5.75)	4.31 (6.05)	6.18 (6.56)	0.430	3.98 (5.37)	8.85 (6.55)	**0.002**

BMI: Body mass index; U14, U16, U18: Under 14, 16, 18 respectively.

Table 2. Performance in soccer skills and cognitive measures of players by category and skill level.

	Category				Skill level		
	U14 n = 25	**U16 n = 26**	**U18 n = 22**	**p-value**	**Low Talent n = 53**	**High Talent n = 20**	**p-value**
SoSCAT without interference(s)	34.99 (4.19)	33.85 (4.34)	33.27 (3.10)	0.318	34.06 (4.04)	34.09 (3.85)	0.974
SoSCAT with visual interference (s)	45.59 (4.99) a	41.23 (4,64)b	39.78 (3.52) b	**<0.001**	43.49 (4.88)	39.10 (4.12)	**0.001**
ΔTime (s)	10.60 (6.77) a	7.38 (3.15)a,b	6.51 (2.55)b	**0.016**	9.43 (5.11)	5.01 (1.86)	**<0.001**
Mistakes	1.92 (1.25)	1.46 (1.07)	1.36 (1.09)	0.173	1.63 (1.13)	1.50 (1.23)	0.686
DTC (%)	32.29 (23.78)	22.45(10.66)	19.91 (8.80)	**0.041**	28.88 (17.82)	14.93 (6.37)	**<0.001**
Wom Rest (s)	2.24 (0.28)a	2.07 (0.42)a,b	1.84 (0.35)b	**0.001**	2.09 (0.42)	1.98 (0.29)	0.359
Vismen Plan (%)	45.44 (6.35) a	52.35 (7.26)b	61.27 (6.68) c	**<0.001**	51.58 (9.75)	55.55 (7.24)	0.103
TWT (s)	46.41 (4.40) a	42.45 (7.65)a,b	39.86 (4.81) b	**0.029**	44.39 (6.15)	41.80 (5.87)	0.188
Stroop test interference	−2.53 (9.26)	−1.15 (8.46)	1.71 (7.97)	0.238	−2.01 (8.53)	2.50 (8.32)	**0.047**
Soccer Dribbling test (s)	31.35 (3.61) a	30.10 (3.12)a,b	28.30 (2.89) b	**0.007**	30.56 (3.53)	28.48 (2.64)	**0.020**
Soccer passing test (s)	47.33 (5.23) a	46.26 (4.76)a	43.53 (3.63) b	**0.020**	46.27 (4.26)	44.58 (6.04)	0.185
∑skill (passing + dribbling)	78.68 (7.33) a	76.36 (5.86)a	71.83 (5.96) b	**0.002**	76.83 (6.34)	73.06 (7.83)	**0.038**

U14, U16, U18: Under 14, 16,18 respectively; DTC: Dual task cost; TWT: Trail walking test; Note that different letters implies significant differences

performance in SoSCAT with visual interference ($p < 0.001$) and Vismen plan ($p < 0.001$) than the U16 and U14 groups. Also, U18 group showed a better result in WOM test ($p = 0.001$) than the other groups. In addition, DTC ($p = 0.041$) and ΔTime ($p = 0.016$) were the lowest values in the U18 group. Regarding level groups, the high-talent group showed a greater performance in SoSCAT with visual interference ($p = 0.001$), DTC ($p < 0.001$), ΔTime ($p < 0.001$), Stroop test interference ($p = 0.047$), Soccer Dribbling test ($p = 0.020$), and ∑skill (= passing + dribbling) ($p = 0.038$).

Regarding absolute reliability, the SEM was 2.27 (5.30%) and the MDC was 4.17 (9.75%). In the test-re-test analysis, the initial test time was 42.75 ± 6.09 seconds and the re-test time was 44.54 ± 4.90 seconds ($p = 0.001$). The ICC was 0.908 (95% confidence interval [CI] = 0.826–0.951, $p < 0.001$). The Bland-Altman graph showed limits of agreement (two SD) of 4.5 seconds and −8.09 seconds, and the mean of the differences was −1.79 seconds Three participants fell outside the limits of agreement, indicating a good agreement between the test and re-test sessions (Figure 4).

Additionally, the Pearson correlation analysis revealed a significant correlation between the initial test and re-test ($r = 0.851$, $p < 0.001$). Scatter plots between SoSCAT performance in pre-test and re-test are shown in Figure 5, obtaining a linear $R^2 = 0.725$. Concurrent validity showed significant correlations between the SoSCAT with visual interference and TWT ($r = 0.465$, $p = 0.003$), with WON test ($r = 0.400$, $p < 0.001$), Vismem test ($r = -0.492$, $p < 0.001$), skill dribbling test ($r = 0.499$, $p < 0.001$), passing test ($r = 0.426$, $p < 0.001$), and ∑ soccer skills ($r = 0.546$, $p < 0.001$).

A Pearson correlation analysis (Table 3) revealed significant relationships between several variables. Finally, the binary logistic regression analysis revealed that a high score in the three dual test conducted in the current study (Stroop, TWT, and SoSCAT) was a risk factor for low soccer-talent level (odds ratio = 1.256, 95% CI = 1.088–1.454, $p = 0.002$).

Figure 6 shows the ROC curve for DT prediction with soccer talent (area under the curve [AUC] = 0.748, 95% CI = 0.625–0.871, $p = 0.001$). The cut-point was 39.28 seconds (sensitivity = 0.792, 1-specificity = 0.450). Moreover, the ROC curve for ΔTime prediction with soccer talent was (area under the curve [AUC] = 0.802, 95% CI = 0.704–0.900, $p < 0.001$) and the cut-point was 6.48 seconds (sensitivity = 0.679, 1-specificity = 0.200).

Discussion

The aims of this study were: 1) To examine the validity and reliability of the SoSCAT in young soccer-trained players aged 12–18 years; 2) To examine the capacity of these tests to discriminate between different category and level groups (construct validity). The SoSCAT exhibits a good

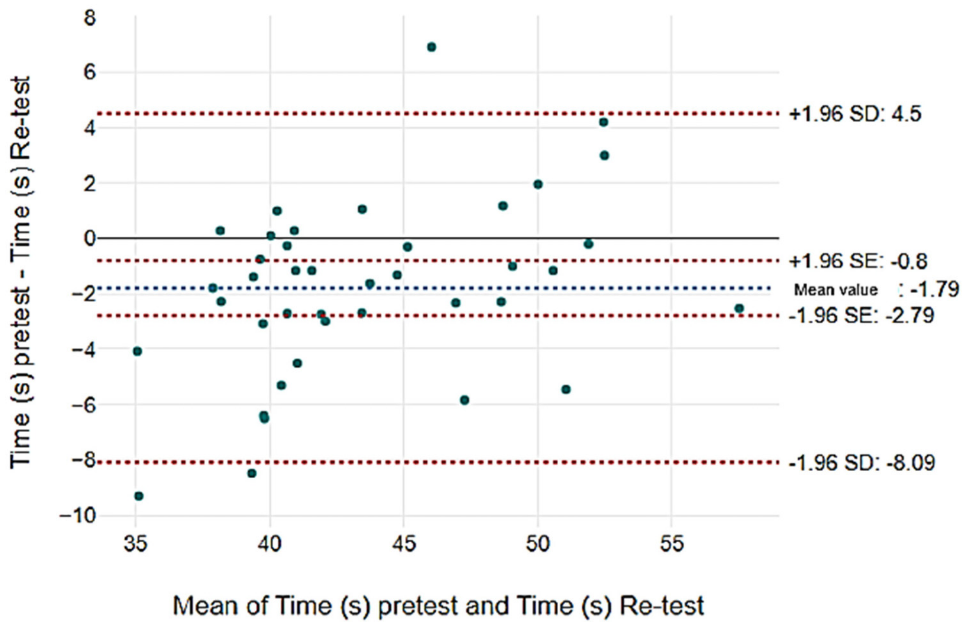

Figure 4. Bland-Altman graph for SoSCAT performance. The x-axis shows mean SoSCAT values and the y-axis indicates the difference values for SoSCAT test-re-test.

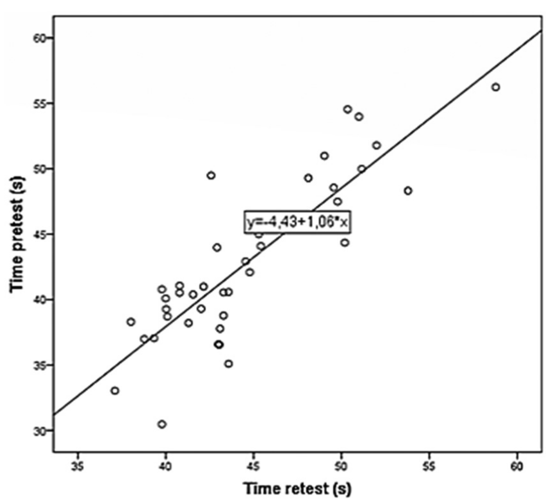

Figure 5. Scatter plot between DT performance in pre-test and re-test.

construct validity since it can easily discriminate between different players levels. It also has ''ecological'' or external validity, since it allows for the reflection of what happens in ''real match'' situations and assesses the multifaceted aspects of soccer skills including passing, dribbling, control, and decision making. In addition, the SoSCAT showed adequate absolute and relative reliability, also an acceptable parameter of concurrent validity with spatial perception and soccer skills.

During soccer games, players are habitually required to perform a certain amount of motor actions in a sequential mode; for example, receive a ball, control it with various parts of their body, and dribble past an opponent before shooting at the goal.[18] When performing the SoSCAT, participants need to display a high proficiency in several soccer skills such as driving, passing, dribbling, and control of the ball to achieve a good performance time, similarly to what happens in the LSPT. Additionally, cognitive and perceptual aspects are also observed, as players have to decide on upcoming actions and use peripheral vision. All actions in a dynamic and holistic context would appear to be superior in the determination of soccer talent; however, in LSPT, decision making is conditioned a priority.[18]

Another aim of this study was to examine whether the SoSCAT could discriminate between players according to their soccer categories and talent level. It is known that age, expertise, and sensorimotor skills can be advantageous in a DT context.[45] Broadly, the SoSCAT discriminates between the three different soccer categories and two of talent level groups, as measured with DT. In this regard, the results obtained in the current study showed that the performance in the SoSCAT was affected when players had to manage cognitive interference, although the performance deterioration of the high-talent, older, and more experienced players was minor under DT conditions. Furthermore, in SoSCAT without visual interference no significant differences were observed between level groups. Nevertheless, significant differences were found in this groups when SoSCAT was conducted with visual interference.

The results of the current study agree with the findings of the study conducted by Gabbett et al.[46] in which the attentional demands of drawing and passing in rugby players

Table 3. Pearson correlation analysis among several variables.

Variables	r	p-value
SoSCAT without interference vs. SoSCAT with visual interference	0.421	<0.001
SoSCAT without interference vs. interference	0.487	<0.001
Δ Time vs. TWT	0.356	0.042
Δ Time vs. WOM	0.357	0.002
Δ Time vs. dribbling test	0.536	<0.001
Δ Time vs. ∑skill (passing + dribbling)	0.415	<0.001
DTC vs. WOM	0.335	0.004
DTC vs. dribbling test	0.529	<0.001
DTC vs. ∑skill (passing + dribbling)	0.375	0.001
TWT vs. WOM	0.387	0.024
VISMEM_PLAN vs. age	0.687	<0.001
VISMEM_PLAN vs. Year Federate	0.524	<0.001

DTC: Dual task cost; TWT: Trail walking test; WON: Cognitive test; Vismen_plan: Cognitive test; SoSCAT: Soccer Skills and Cognitive Aptitude Test; Federate: Federate implies that player is register in official football competition.

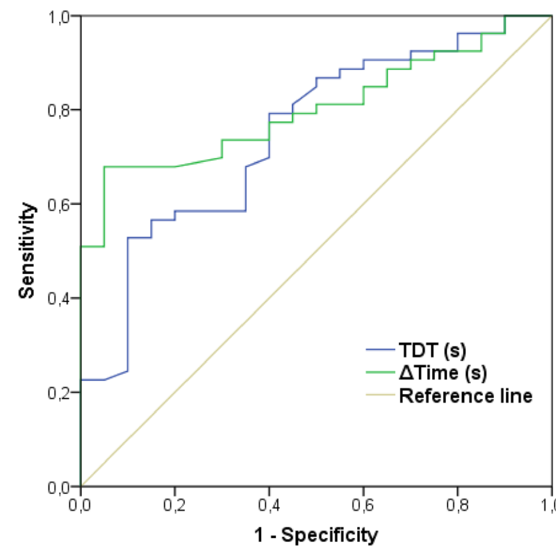

Figure 6. ROC curve that summarizes the potential of DT and ΔTime to identify soccer-talent level.

was evaluated. In this study, no differences were detected in primary task performance between groups, although the performance of the high-skilled players was more resistant to skill decrement under DT conditions. Another study, when compared with their less-successful counterparts, successful decision makers used more goal-oriented search strategies, which resulted in superior performance, as characterized by faster decision times and a greater response accuracy.[47] In another study,[48] dribbling performance and visual skills in both experienced and novice soccer players was evaluated. Both groups performed two dribbling tests with four levels of difficulty in visual signals, and all players performed slower when visual signals were added to the testing process (~2.5 seconds, $p < 0.01$). Experienced players completed all tests faster than novice players (~3 seconds, $p < 0.01$), and the average number of visual mistakes was significantly lower for experienced than novice players in all tests ($p < 0.01$). In the same study on the effects of a combined visual and dribbling performance in young soccer players of different levels (experienced vs. novice), the average number of visual mistakes was significantly lower for experienced than novice players in all tests, and these results demonstrated the importance of evaluating dribbling along with visual stimuli in young soccer players.[48] Likewise, in a study that explored the differences in the attentional mechanisms supporting online sensorimotor-skill execution in novice and experienced soccer players under a DT environment, the DT condition involved dribbling through the slalom course while performing a secondary auditory word-monitoring task. In this study, novice participants performed at a lower level in the DT condition, designed to distract attention from task performance, in comparison with the skill-focused manipulation, designed to draw attention toward the task at hand.[49]

Therefore, and in accordance with Smith & Chamberlin,[17] although the addition of cognitively-challenging components produced a decrement in performance in soccer players, the amount of decrement diminished as the level of expertize improved. In sum, studies on cognitive-motor dual-tasking have shown that experts are more successful than novices to maintain their performances in DT situations.[45]

On the other hand, it is noteworthy that visual search strategy and anticipation seem to contribute to the efficiency of tactical behaviour in young soccer players.[50] Visual search strategies are different between high-level players and middle-level soccer players.[51] Skilled players used their superior knowledge to control the eye-movement patterns required for seeking and picking up essential sources of information.[19] These results are likely due to expert soccer players benefitting from long-term training and competitive experience to develop their perceptual-cognitive capacities, Click or tap here to enter text.[52] since it seems that experts do not possess higher visual hardware compared to their lesser-experienced counterparts. The evidence presented thus far supports the idea that participants who possessed better ball handling and passing skills adopted a different visual strategy than their less-skilled peers, characterized by looking less at the ball while handling it and paying less attention to task-irrelevant areas. This implies that gaze strategies develop alongside technical skills.[53] In the current study talented soccer players displayed better inhibitory control than their low-talent counterparts. This finding is in agreement with a previous study which investigated cognitive functioning in elite and sub-elite youth soccer players and showed that with similar reaction times and visual-perceptual abilities, elite youth soccer players have better inhibitory control, cognitive flexibility, and in particular, metacognition than their sub-elite counterparts.[1]

Limitations and strengths

In the current study, there are some limitations that should be mentioned: 1) the cross-sectional nature of our current study did not allow us to make a cause-and-effect relationship between several variables analysed; 2) Playing positions have not been analysed due to the disproportionate number of players in each position, and future studies on the current topic with a larger and more-evenly-spread sample of playing positions are recommended; 3) This test was not tested on female soccer players. Nevertheless, a strength of this study is that it was ecological since the procedure was carried out on a soccer field, and various soccer skills were recorded in a dynamic context along with perceptual and decision-making variables. Consequently, from a practical point of view, the SoSCAT could be an important element in the selection of soccer talent.

Conclusion

To sum, the SoSCAT is a reliable tool under the DT conditions in male soccer players aged 12–18. It discriminates between levels of players and determines several variables that are very relevant to soccer performance and that could help to early identify soccer talent in a dynamic and holistic context, as well as with acceptable levels of ecological validity. Additionally, the test is easy to carried out, it is performed on the soccer field, and the required equipment is inexpensive and attainable for most teams.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon request.

Declaration of conflicting interests

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