

How the Game of Soccer can Foster Creative Research in Natural Sciences Cómo el fútbol puede fomentar la investigación creativa en ciencias naturales

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Abstract. The systems science approach based on exploration of analogies between distinct fields of inquiry can lead to the creation of new interdisciplinary branches of knowledge. In this essay, a series of such analogies between soccer and natural sciences is elaborated with the objective of recognizing the scientific elements intrinsic to the game of soccer and transcribing them to the creative practice of science. The sources of analogies are multifold, involving the tactical setups of the teamwork, the geometry and cybernetic principles governing the coordination of the players, the kinesthetic intelligence thereof and various psychological factors. The essay also intends to inspire the crafters of academic curricula to consider building courses around the intersections of a sport such as soccer and natural sciences so as to promote sportier and more spirited scientific communities. Along with the humanization of sciences via their cross-fertilization with soccer, the enlightenment of the latter profession may also result from this interdisciplinary marriage, so that the animalistic competitiveness in this sport gets suppressed and its artistic elements accentuated.

Keywords: Academic culture, analogical reasoning, art, association football, science.

Resumen. El enfoque de la ciencia de sistemas basado en la exploración de analogías entre distintos campos de investigación puede conducir a la creación de nuevas ramas interdisciplinarias del conocimiento. En este ensayo se elabora una serie de analogías entre el fútbol y las ciencias naturales con el objetivo de reconocer los elementos científicos intrínsecos al juego de fútbol y transcribirlos a la práctica creativa de la ciencia. Las fuentes de analogías son múltiples e involucran las configuraciones tácticas del trabajo en equipo, la geometría y los principios cibernéticos que gobiernan la coordinación de los jugadores, la inteligencia cinestésica de los mismos y diversos factores psicológicos. El ensayo también pretende inspirar a los creadores de planes de estudio académicos a considerar la posibilidad de crear cursos en torno a las intersecciones de un deporte como el fútbol y las ciencias naturales para promover comunidades científicas más deportivas y enérgicas. Junto con la humanización de las ciencias a través de su fertilización cruzada con el fútbol, la iluminación de esta última profesión también puede resultar de este matrimonio interdisciplinario, de modo que la competitividad animal en este deporte queda suprimida y sus elementos artísticos se acentúan.

Palabras clave: Arte, ciencia, cultura académica, fútbol asociación, razonamiento analógico.

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Introduction

“Who plays for the people and ignores the tactic wil end up the career in low-ranked Vratnik”
Zabranjeno pušenje, 1984

Systems science, at its foundations, is about discovering and elaborating analogies between relationships extracted from different experiential domains (Uskoković 2009a). In the pedagogic setting, one example can be that of Gregory Bateson’s bringing a crab to a class and instigating the students to reflect on the similarity of relationships defining the anatomy of this sea creature and relationships from other spheres of experience, christening them “patterns that connect” (Bateson 1979). As a natural science educator, myself, who has taught in the classrooms and mentored in the labs hundreds of students at different public and private universities in the states of Illinois and California, I can admit that resorting to analogies to illustrate specific points at hand and reinforce their retention among students is the method that I have practiced daily in interaction with them. The analogy, to put it simply, is an indispensable tool in my method of instruction (Uskoković 2014; Uskoković 2023b).

Such analogies, however, are not always employable with success. One prerequisite for their resonance with the recipients is the latter’s relative breadth of general education. Because such analogies may take me to music, film, painting, literature, board games, sports or politics, if the students

are unfamiliar with such domains, the analogies will invariably fail. One type of analogies that I often employ when I feel that these preconditions are satisfied refers to sports, including, most commonly, soccer, the sport that I have played recreationally and followed as a fan since my earliest childhood.

Despite the fact that the abundance of scientific literature on soccer tops that on any other team sport (Mamani-Jilaja *et al.* 2023), the relationship between soccer and natural sciences has been similar to that between art and natural sciences: either superficial and conceptually redundant or serving the interests of the intellectual shareholders. As for art and science, for example, the most common forms of their integration are still those where scientific inventions embodied in the form of high technologies are used as aids in artistic projects. As for soccer and natural sciences, methods derived from the latter are mostly employed to improve the athletic performance and analyze tactical patterns that lead to viable outcomes. Very often, however, such analyses fall into the trap of reiterating the premises, which is a fallacy widely known to philosophers of science. Namely, although these premises predetermine the inferences derivable from an empirical or theoretical inquiry, such inferences *per se* cannot be used to confirm or refute the given premises. One famous example of this epistemic error is that made by Reep and Benjamin from the Royal Statistical Society in the UK, who ran a statistical study in the mid-1960s, around the time England won its only World Cup,

showing how around 4 in 5 goals in the official games played in England resulted from three passes or less and concluding from there on that long-range passes must be the most successful approach to the game (Reep & Benjamin 1968), thus regressing the English soccer philosophy for the next couple of decades. On a similar note, it was recently deduced that in contrast to the English Premier League, the Spanish La Liga and the German Bundesliga, where a positive correlation was found between the team's pass completion and the expected goal difference in favor of the team, ranging from 0.71 to 0.75 to 0.89, respectively, this correlation was negative, -0.09, in the American Major League Soccer (MLS) (Young 2023). Still, it would be erroneous to conclude based on this that the advice given by Ljupko Petrović to Siniša Mihajlović before the beginning of the 1991 Champions Cup final between Red Star Belgrade and Olympique de Marseille, which was to hand the ball over to the opponent as soon as one receives it, or the advice given by pundits to the Spanish national team at the 2022 World Cup, which was to employ a basketball coach who would limit the endless tiki-taka cornering of the opponent to 24 seconds or so long attacks, let alone the idea that the run-and-gun displays of heedless individual play common in American basketball should be applied by the MLS teams, when in reality it is the quality of the passes and the all-around understanding of the positional aspects of the game that are to be improved. A concordant study determined that most goals in soccer are scored when the final third is reached through the central corridor, prompting the researchers to recommend, rather tautologically, that the teams compact the offense and continue exploring the central spaces and then, during defense, to direct the opponent to the sideline (Guimarães *et al.* 2022), disregarding that the right approach could never be one-sided and is always dependent on the tactical principles employed by the opponent and the sets of skills possessed by both teams. Another recent study determined that teams positioning one or more players at both posts concede most goals from set pieces (Beregi 2019), which may be casually, albeit erroneously, taken as a refutation of the idea that there are situations where playing without the offside trap and packing "the bus and the boat and the airplane" (Westwood 2021), to quote Jose Mourinho, near the goal line provides the only viable means of defending the goal. This is, of course, not to say that investments in new tools and methods for scientific analyses of soccer trends and patterns cannot lead to innovation in data acquisition and analytics, because they evidently can. Still, the adverse effects of performance analysis technologies should always be considered, given that they are cited as the main reason why many professional clubs and associations are increasingly viewing them with skepticism today (Barker-Ruchti *et al.* 2021).

Soccer, more than any popular team sport, is dominated by tactical doctrines and principles. Without playing by specific tactical rules and without relying on rigorously defined training regimens, it is hard to believe that any professional soccer team today would win a single game.

As a result, soccer can be deemed a team sport most receptive to the input of considerations of scientific nature. In this respect, the complexity of soccer exceeds that of the team ball sports such as basketball, handball, volleyball, water polo, cricket, baseball or American football, not only because of the larger team sizes on the field or their greater freedoms of movement, but also because of the greater variability of tactical schemes and strategic plans. A soccer squad, for example, can opt for playing only defensively, without intending to score at all, or for periodically varying the defensive and the offensive plans implementable in a variety of ways, which is something that cannot compare to the more limited tactical concepts that teams in all these other aforementioned team ball games are obliged to adopt. Moreover, given that engaging in any team sport is a form of communication, this makes soccer a sport with one of the profoundest potentials for socialization (Alcayne *et al.* 2022), which can also be studied by scientific means (Buch Sánchez & Bores-Garcia 2023; Szalánczi *et al.* 2020). Yet, although coordination of players, both alone and within a team, can be controlled through scientific input, practically all the innovation in the present and past at this level has emerged from the empirical testing of purely qualitative ideas and principles at the club level. Still, an endless room exists for the input of various sciences to a sport such as soccer and future will undoubtedly witness an unprecedented progress in this marriage of two distant disciplines.

Some of the recent literature examples of the contribution of scientific methods to soccer may include the utilization of machine learning for match outcome, physical performance, tactics and talent forecasting (Rico-González *et al.* 2023); construction of tactical plans based on position tracking data analytics (Goes *et al.* 2021); discernment of metabolic markers acting as post-match recovery indicators (Pérez-Castillo *et al.* 2023); analyses of the impact of the score on ball-passing and other interactions between players (Maneiro *et al.* 2023); the use of soccer for robot research platform testing purposes (Cheng 2022); the application of mathematical models and deep learning to guide training practices (Men 2023); the design of wearable wireless microprocessors for the prevention of ankle and other joint injuries (Li 2022); the probing of the relationship between the performance of soccer players and their adipose tissue mass (Hernández-Mosqueira *et al.* 2022; Figueiredo *et al.* 2021) and other anthropometric and fitness parameters (Ceballos-Gurrola *et al.* 2021; Caballero-Ruiz *et al.* 2019), or their hereditary genetic polymorphisms, such as ACTN3 R577X and ACE I/D (Arroyo Moya 2021); and other. Analytics making use of the real-time acquisition of positional data pertaining to the movement of the ball and of every player on the pitch so as to predict the goals and other key events in a game are intensely researched, but are yet to make groundbreaking strides (Rein & Memmert 2016; Mead *et al.* 2023). Nevertheless, it is foreseeable that advances in the science of proxemics, which has been applied with success in cell and population biology (Uskoković *et*

al. 2022; Uskoković 2022a; Uskoković 2022b), will expand the knowledge on optimal teamwork in soccer. For example, individual player's heat maps and kinematic variables indicative of distances between players, spaces covered by players and other collective patterns within a team are being routinely collected using global and local positioning systems and video cameras (Rico-González *et al.* 2020; Errekagorri *et al.* 2022; Moniz Carvalho *et al.* 2021) and fed into data analytics models ranging from as simple as Goals Added (G+) (Muller 2023) or Expected Goals (xG) (Kullowatz 2017) to more complex ones, but their potentials for use in creating precise tactical setups and boosting the team performance are just starting to be unlocked. Aggregation of geometric patterns of player movements and ball progressions from tens of thousands of soccer games or more and the subsequent delineation of patterns corresponding to the greatest possibilities of scoring will certainly be performed with ever greater precision and confidence in the near future, but the same question as that raised in the wake of the aforementioned seminal studies by Reep and Benjamin will remain, namely what guarantees that the tactics proven the most effective in the past is the best *per se*, which is an insight that poses definite limits on the influence of the scientific method of determining the most ideal approach to soccer play. Regardless of the extent to which numerical principles are applied in the effort to determine the most effective tactical ideas, this methodology will always remain fundamentally limited and in need of being complemented with purely empirical and qualitative methods, like the one pursued here.

What I argue in this position paper, therefore, is a new standpoint relative to the aforementioned examples of the intersection of science and soccer extracted from the literature. It is the idea that insight into the game of soccer can lead to principles applicable in the creative conduct of scientific research on subjects unrelated to either soccer or any other sport. This insight can be multifold, involving the tactical schemes of the teamwork, the geometry of the players' coordination and/or formation, the kinesthetic intelligence or various psychological factors. This versatility of sources will be exemplified by mentioning some of the analogies I commonly employ in the natural sciences classroom in the section that follows.

Examples of pedagogic analogies between soccer and science

Thirteen analogies, each corresponding to one standard player position in a soccer team, alongside the bench and the referee, are discussed in the following subsections to exemplify the connections between soccer and science. The listing of analogies will, accordingly, start with the goalkeeper and then proceed to defense, midfield and attack, before moving to the bench and ending with the referee. Moreover, each of the subsections corresponding to the eleven players is named after a position or a playstyle and occasionally illustrated by a particular prominent player or a team.

Goalie

The most fondly remembered moment of any soccer game in Yugoslavia was played in the Dalmatian city of Split on December 21, 1983. It was a game between Yugoslavia and Bulgaria in the last round of qualifiers for the EURO 84 finals in France. Three possible outcomes of the game were to send three different teams to this final tournament from Group 4. If Bulgaria won, their national team would advance to the final. In the event of a draw, Wales would qualify, while for Yugoslavia to qualify, it would have to win the game.

The game went into the stoppage time at the score of 2-2 and both teams tried their very best to score and win, for nothing other but the win mattered to either side. The Bosnian midfielder, Safet Sušić, who scored both goals for the Yugoslav team up to that point, tried a dribble in the inside right zone, but failed and lost the ball. This prompted the irked Croatian announcer, Mladen Delić, to utter the memorable line, "not alone, Safet", which is used today colloquially in countless contexts outside of the sports domain. Alas, the gaze of the panicky spectators was now switching to the other half of the field, where the Bulgarians were launching a seemingly deadly counterattack. In no time, three attackers appeared unmarked in front of the Montenegrin goalkeeper, Zoran Simović, a scene rarely seen at any soccer level, yet the keeper, who would be chosen later for the Yugoslav soccer player of the year, managed to make one save and then another and then reach the live ball before all three of the Bulgarian forwards. He then leaped up and provided a phenomenal punting pass to Sulejman Halilović (Figure 1), who replaced Ivan Gudelj in the 70th minute of the game and found himself in that instant on the left side of the midfield, even though he had been instructed by the Serbian coach, Todor Veselinović, to stay on the right and let the left side be covered by the Croatian offensive midfielder, Marko Mlinarić. Despite trapping the ball rather sloppily, Halilović passed it on remarkably well ahead of Zlatko Vujović, the inverted winger stationed in the left wing area. Vujović, who, like Gudelj and Simović, played in front of the home crowd at Poljud stadium, stopped the ball, shifted it to his dominant foot and sent it without delay inside the penalty box. While the ball was midair, the Montenegrin defender, Ljubomir Radanović headed it into the net, in the 91st minute of the game, sending the whole stadium, including the aforementioned Croatian announcer, into a delirium.

Interestingly, as the years went on, this goal, alongside the commentary, would be remembered disproportionately to the remembrance of the remarkable goalkeeping saves that preceded it. This point is the one of essential importance to convey to newcomers to the world of science: namely, their extraordinary accomplishments will sometimes be rewarded by the scientific community, but many more times they would be either ignored or straightly disparaged.



Figure 1. Yugoslavia vs. Bulgaria 3:2 (1:1), Split, EURO 1984 Qualifier. Having stopped the counterattack of three players in white and green who popped before him, the Hajduk Split goalkeeper, Zoran Simović drop-kicks the ball to the Dinamo Vinkovci midfielder, Sulejman Halilović, who would start the Yugoslav counterattack, which resulted in the stoppage time goal for the “blues” and the last-minute qualification for the EURO 1984 tournament in France.

The reasons for this are manifold, but the resistance of any discipline to progressive ideas represents one major factor. If science was represented as a tangible edifice, for example a castle, new residents in it would not only be promptly kicked to the curb if they proposed amending the foundations or the roof, but the attempts at slightest adjustments of the architectonic structure, even in the remotest corners of it, would also be routinely facing opposition. Another important point evocable by Simović's saves is that a great deal of luck precedes some of the greatest victories and that the triumphs and the losses are always separated by very, very thin lines. Converted to the world of science, this should, ideally, instill humbleness in scientific apprentices and also liberate them from the attachment to socially endowed rewards and accolades. Having become independent on praises and prizes alike, they can move on towards far more stellar vistas than with these anchors of social submission and recognition dragging them down. Finally, Simović's string of saves can remind the scientist and the layman alike that prolific actions and thought processes always start from their farthest backs, *i.e.*, from the deepest of foundations. Good scientific models are rooted in outstanding premises, whereas houses, be they physical or abstract, crumble if they are not built on solid grounds.

As for soccer, the idea that the goalkeeper can also be a playmaker is currently being only shyly tested, as by Pep Guardiola's lining up Manuel Neuer with defensive midfield in Bayern Munich or swapping shot-stopping Joe Hart for more technically proficient Claudio Bravo in Manchester City (Payne 2016). In future, however, goalkeepers are likely to become integral parts of the offensive play, just as much as the role of the striker would be increasingly important without the ball, be it as a false nine in the attack or by pressing the opponent timely and directionally on the defensive end, which we already see today emerging as a trend (Carpenter 2022). In this future we may also witness the reversal of the paradigm that the solidity-to-fluidity ratio should be high in the back and low in the front. Simultaneously, the thinking processes underlying scientific research might increasingly become such that the foundations

are maintained in as flexible of the shape as the ideas springing atop them. If so, the dogmatic sticking on to one's own theories and models, which is pervasive in today's science, will be less and selfless, unbiased, fully open-minded reasoning, where even the deepest premises are open to constant revisiting and restructuring, will be more.

Stopper

In terms of its appeal to the fans, slide tackle tops the repertoire of moves performed by defenders in the effort to stop the opposing attackers from advancing with the ball. The story, however, goes that the famous Italian and AC Milan central defender, Paolo Maldini was once asked to recollect his graceful slide tackles, to which he responded by noting, humbly, that whenever he had to slide tackle, a prior error had been made (Willis 2018) (Figure 2), meaning that slide tackles are nothing to be proud of.



Figure 2. Brazil vs. Italy 0:0, Pasadena, California, USA, 1994 World Cup Final. In this still from the first half, the AC Milan legend, Paolo Maldini slide tackles by the edge of the penalty box the São Paulo right-back, Cafu in this first of his three consecutive World Cup finals, after Cafu pulled a simple Cruyff turn and dribbled past Maldini.

The instructiveness of this point is, like that of all the other ones listed here, multifold, but one context in which this story can be invoked is that of biomedical research to which I have been committed for nearly two decades now. Namely, what Maldini tried to say and what can be translated to the biomedical realm is that the merits of preventative medical research and technologies are to be highlighted relative to those of their therapeutic analogs more often than they are. Saving a life struck by a disease through a therapeutic approach is rewarding for everyone involved directly in this act, but preventing the disease from happening in the first place represents a much more salient approach. If the former method is symbolized by a person who jumps into the lake to save a drowning child, the latter is represented by the safety measures of building the fence around the body of water to prevent such and similar drowning accidents. Yet, as Francis Scott Fitzgerald pointed out, “Show me a hero and I'll write you a tragedy”

(Fitzgerald 2009), and one key problem with our culture is that most everyone wants to be remembered as a heroic actor rather than be a prudent person who prevents the need for heroism in the first place and fights for peace in peace, with peace, through peace, with as little drama as possible, albeit receiving no laurels or timeless accolades for

his achievements when all is said and done. All in all, this is to say that in sciences there is research that is not attractive, but is more correct to commit to than its attractive, headline-filling counterparts.

Traditionally, defensive strategies have been divided to zonal, man-to-man and pressing, which are space-focused, player-focused and ball-focused, respectively. However, teams in modern soccer switch between these three types of defense or even combine them in intricate ways. For example, corner kicks and other set pieces are most commonly defended with man marking, whereas open play defense is most frequently zonal. However, since inswing deliveries, which create more goal-scoring opportunities than the outswing ones (Taylor *et al.* 2005), place the ball nearer to the posts, teams may adopt man marking to respond to them and switch to zonal marking for outswing deliveries during set pieces, if not simply alter the timing of the movement of the offside line, making it early for the inswing deliveries and late for the outswing so as to prevent the exploitation of space in front of and behind the line, respectively. Teams may also decide to defend zonally in the center, but press when the ball drifts to the flanks, or have specific players act as destructors by consistently pressing the ball carrier while others mark well-defined zones. Depending on whether the offside line is broken or not, teams may also enter the man or zonal marking mode. Some teams also follow Valeriy Lobanovskiy's classical method (Tossani 2016) of finding out first what the opponent is up to before conceiving of a plan how to dismantle it by starting off zonally and then converting gradually to man-marking, either all around or in some parts of the pitch. Then, since man marking can be manipulated more easily to create space for shooting at the goal from distance, teams may choose to play zonally against teams with good shooters and otherwise adopt the man marking defensive strategy. Clearly, therefore, this ability to switch from one mode of play to another is the trait of a good defender. One, in other words, has to be reactive to the movements of opposing players, but also dictate the play by contributing to the maintenance of a strategically thought-out defensive structure. In science, likewise, following preplanned proposals will not get one far in research unless one is ready to react vigilantly to the findings derived on the spot. Searching for treasure by looking at the map alone, in other words, without paying attention to the signs given out by natural and social milieus in real time, will hardly ever be able to lead one to the desired destination.

Sweeper

In the post-World War II era, when playing with four in the back started slowly emerging as a norm, the Yugoslavs consistently played with three in the back. In the historic win against West Germany in the quarterfinals of the 1962 World Cup in Chile, for example, the Yugoslavs played with three in the backline, namely Đurković, Marković and Jusufi (Figure 3), in contrast to the Germans, who came out with five in the backline, including Erhardt,

Giesemann, Nowak, Schnellinger and Schulz, and Szymaniak dropping in under pressure to add up, nominally, to six defenders on the pitch. Sacrificing a defender and going from four to three players in the backline is, in fact, an effective way of promoting vigilance amongst the players, which can be traced to perplexity invoked in them. Namely, with less teammates in the defense, the players are likely to be confused as to what exact role they are supposed to be playing and whom they are supposed to be marking now that they have more choices open before them than when they were relying on tighter defense and more strictly defined positioning. For example, they may question at a particular moment if the central defender is to be on the left or on the right, or is he to be a sweeper in the center? Are the backs going to shift deeper to fulfill a central defending role or drift forward as offensive backs? Moreover, will they be running wide or deep, given so much space that they are about to cover? Clearly, therefore, in this method, communication errors are more prone to happen than with more players in the backline. On the flipside, to prevent this miscommunication from occurring, the team dynamism is incentivized, alongside alertness, but also creativity in the bigger picture, albeit at the perpetual risk of the formational dissipation. This principle is crucial for any creative scientific conduct, given that it starts from perplexity, a key driving force that prompts the scientists, young or old, to question things and open everything to a selfless and unbiased inquiry from which outstanding ideas and findings can emerge. Another ethical and aesthetical point that this principle demonstrates is how losing a defensive piece and compromising the integrity of one's structures can amount to an indispensable sacrifice needed to propel one's work to higher and more creative vistas.

Further, as the result of this plasticity of playing with the back three, freedom is being given to the full backs to penetrate along the flanks, with the general idea being to overload the wings together with the false forwards, pin the defenders of the opposition and thus create space in the center, where the attacking midfielders could engage in displays of technicality, which has always been a strong mark of the Yugoslav school in lieu of running. Therefore, because of the traditional shortage of classic wingers among Yugoslavs, this system benefitted them because wingers would, effectively, be false and used to spread the formation instead of providing an attack along the sidelines. Another effect by which the back three allow for the displays of technicality in the central areas of the field is by spreading the space in the vertical direction too and evading the squeezing of the space with a high defensive line. Such lines are normally employed to create offside traps and the more players are in the line, the less of a chance for the trap to fail and a goal to be conceded. One example of a failed offside trap when three players are in the high backline may come from Cameroon's trailing 1:3 against Serbia at the 2022 World Cup and then scoring two goals in four minutes from, ironically, counter-attacks, by penetrating the three-player line posed whole 45 yards from the Serbian goal, first centrally and then from a

flank. Playing with three in the back in a more traditional way, however, allows the opponent to come closer to the box (Figure 3), but at the cost of freeing more space in the deeper areas of the field. In all, just like skilled tacticians in chess prefer open positions with a lot of space on the board, the same principle applies to soccer: good and agile technicians favor space, whether it is gained by spreading the formation to the wings so as to combine in the deeper areas of the field, by avoiding high lines and the resulting contraction of the midfield, or by some other positional trickery.



Figure 3. Yugoslavia vs. West Germany 1:0 (0:0), Santiago de Chile, 1962 World Cup. Yugoslavs play the characteristic setup with three in the back, namely Fahrudin Jusufi (top) from Partizan Belgrade on the left, Vladimir Durković from Red Star Belgrade on the right (only shadow is visible) and Vlatko Marković (leaping) from Dinamo Zagreb centrally, as the Hamburger striker, Uwe Seeler shoots from the edge of the penalty box arc and hits the post in this still from early on in the game. The only goal scorer, Petar Radaković from NK Rijeka tracks back alongside Helmut Haller of BC Augsburg in the lower right.

Meanwhile, the central of the three defenders would normally assume the role of a sweeper or a libero, of the likes of Velibor Vasović, Franz Beckenbauer, Gaetano Scirea, Lothar Matthäus, Ronald Koeman, Fernando Hierro, Siniša Mihajlović or Miroslav Đukić, who would engage in man marking during defense, but then carry the ball forward during the attacking phase, capitalizing on the space opened up by the laterally moving stoppers and wing-backs. The all-encompassing benefit for the team here, of course, ties to the fact that this central positioning of the holder of the ball in this initial phase of the attack creates more passing options and possibilities for advancing the ball forward, which favors teams that are improvisatory, versatile, unpredictable and creative. In any case, with three in the back, defenders are no longer used to fulfill static and predefined roles alone; rather, they have an active say in guiding the attack, oftentimes acting as the deepest playmakers on the field. Translated to the scientific universe, this principle that liberates the wings, both literally and figuratively, hints at all the many benefits emerging from the effort to engage everyone in creative thinking and tasks, even those anchored to the rock bottoms of the hierarchies of academic or other scientific organizations. If this anarchic principle gets to be implemented in real scientific practice, this may eventually shatter the traditional pecking order in sciences. As per this

order, which has taken today a purely capitalist, exploitative form, heads of the big labs have virtually no direct touch with research, yet reap all the recognition and the rewards. Instructed by the evolution of the soccer playstyle and strategy, however, a more humane version of scientific practice could be foreseen and, eventually, created.



Figure 4. Partizan Belgrade vs. Queens Park Rangers 4:0 (2:0), Belgrade, 1984/85 UEFA Cup. Partizan management noticed (FK Partizan Beograd 2020) prior to the game that QPR played a static setup with four in the back consistently, without adjusting it to the opponent, and so the plan was made to disrupt it with rotations and attacking runs behind the defenders. In this still preceding Partizan's first goal of the night, Dragi Kaličanin (out of view) has sent a 50 yard long pass to Dragan Mance (top player in the image) as he penetrates the first line of defense along the right flank while the ball is in the air. Radanović would be late for the ball sent into the box by Mance, but the Partizan skipper, Nikica Klinčarski would get to it, send it back in, where Mance would score. Outrunning and tactically outsmarting an opponent is now a relic of the past in Serbian soccer, as is illustratable by the fact that had games at the 2022 World Cup in Qatar lasted only for the first half, Serbia would top its group ahead of Brazil, Switzerland and Cameroon instead of being the last in it. Partizan's 4:0 win annulled the 6:2 loss in the first leg at Highbury in London and is to this day the biggest deficit comeback in the history of the international European soccer competitions along with Barcelona's 6:1 win against PSG in the 2017 UEFA Champions League after the 4:0 loss in the first leg.

Holding midfielder

One of the first advices I give to inexperienced soccer players is to run as much as possible without the ball and as little as possible with the ball, knowing that the instinct of the absolute beginners at this game is to do the exact opposite. Hence the adage often invoked by the soccer coaches and pundits, saying that "run makes the pass" (Smyth 2018). This advice does not apply to any position better than, ironically, that of the holding midfielder, who must anticipate the passes and read the game in defense, but also constantly try to uncover himself and send a prompt forward pass when the ball is in possession. Likewise, whenever the opposition assumes an excessively static setup, outrunning it without the ball, not with it, presents the recipe on how to establish the positional dominance and eventually emerge as a winner (Figure 4). What this advice also effectively does is that it prompts the young player to understand that soccer is a thinking game and that a holistic viewpoint, with the help of which one would coordinate oneself ceaselessly with respect to all 22 players on the pitch, must be constantly nurtured. By positioning oneself precisely within a collective, during both defense and the attack, one can exert a key influence on the play without touching the ball at all. On a side

note, this demand to ceaselessly engage one's attention and adjust the moves to an overall situation on the field and to a myriad of expectations, past events and many other contextual effects, regardless of how far the focus of action is, endows a sport such as soccer with the ability to impart onto the players a meditative mindset, as in agreement with the Latin roots of the word "sports", meaning "to be carried away" (Eauclaire 1984), and allow one to forget the mundanities of the world outside the soccer pitch for a little while. Together with this merging with a collective, the skilled midfielder has his side vision constantly turned on, be he in or out of possession, which is where the merits of holistic consciousness further lurk from. Ironically from the etymologic standpoint, once again, players that most commonly block and enable critical passes during defense and the attack, respectively, by their mere movement off the ball are usually holding midfielders. In the scientific research context, there can never be enough of this holistic intelligence that is persistently aware of the greater systems to which one belongs. Another point that this advice conveys is that urging the scientists to expect essential ideas and insights to dawn on them nonstop, especially when they are least expected, and not only when one is in possession of the ball and in charge of all the attention.

Another segment of play where holding midfielders play a crucial role without holding on to the ball is the transition from offense to defense and *vice versa*. As the team attacks in the final third, for one, holding midfielders normally command the so-called rest-defense and are ready to counterpress as the ball is being lost and thus allow the defense to condense and structure itself under the opposing team's pressure. Then, when their team is on the defense and the ball is won back, they provide a vital link from the central lines to the so-called rest-attack (Davies 2022), which rushes forward. Because the ball is moved faster along the half-space than along the flanks, most counterattacks utilize the former, narrower path (van Zoelen & Baker 2021), which explains the important role of centrally positioned holding midfielders in them, especially as per the reactive, anti-possession ideas implemented by Jose Mourinho through Claude Makélélé at Chelsea in the mid-2000s and later on by Liverpool under Klopp and Manchester City under Guardiola. Accordingly, the tactics of transitioning oftentimes presents the key to crafting a winning team, in just about the same way as phase transitions in physical systems are events of crucial importance for explaining their current states and properties (Uskoković *et al.* 2018; Uskoković 2019b; Uskoković & Rau 2017). To elucidate the structure, the properties and the functional performance of materials, for example, the phase transitions leading to their formation must be understood; likewise, to control the performance of a soccer team, its transitions to and from defense and attack must be carefully analyzed.

Polutka

To engage in prolific research is to be prepared to make

an error after error and only after a series thereof hope for success. This explains, for one, why straight A students, who have gotten themselves accustomed to success and success only rarely make up for prolific investigators in the lab (Uskoković *et al.* 2020; Uskoković *et al.* 2023), given that failure in research is a norm and success but a rare exception. One example of how creative scientists must be accustomed to making errors may come from soccer. Namely, unlike the creative midfielders, who must make repeated attempts at delivering a killer pass to the striker many times before they succeed, defenders are required not to make a single mistake throughout the game, yet creative moves are not expected to be delivered by them at all. In other words, the creative capacity and the liberty to err go hand in hand in both soccer and science. It is for this reason that the Italian coach, Alberto Zaccheroni said once that "if we deprive players of the freedom to make mistakes, we should better close the shop and take up fishing instead of playing soccer". Besides, it is a general systemic principle that only through mistakes and repeated cycles of failure can we evolve and have the chance to become flawless one day (Uskoković 2009b).

The Yugoslav soccer school was traditionally based on prodigal players who nurtured soft touch and nimble non-chalance, the traits that made them recognized globally. In comparison with the prefabbed Soviet school, the Italian *catenaccio*, the industrial German soccer, or the physicality of the English approach to the game, "the unique style of the beautiful game was developed... based on technical abilities, short passing and most importantly – improvisation" (Piskor 2015). What followed was the breakup of Yugoslavia, but also, more significantly, the unprecedented commercialization and popularization of the game globally, where the increasing emphasis on the score promoted ever lesser freedoms for such exhibitions of imagination and ingenuity due to their putting this score and the enormous profit margins tied to it to risk. Out of all the post-Yugoslav soccer schools, the demise of the Serbian soccer began the moment when the freedom to make mistakes on the pitch was abandoned and swapped out for a fear of errors, which had a stiffening effect and was obstructive for the flow of creative impulses. This loss of freedom to make mistakes coincided with the handing of the key role in the national team to defenders such as Nemanja Vidić, Bane Ivanović and Aleksandar Kolarov, and defensive midfielders, including the likes of Dejan Stanković (Figure 5) and Nemanja Matić, whose every last attacking instinct was stifled during their stints at José Mourinho's Inter Milan and Manchester United, respectively. The term *polutka* as a combination of the Serbian words for "half" (*pola*) and "doll" (*lutka*), referring to the type of midfielder that plays sleekly and elegantly, like a doll, around the halfway line or in the half-space, is thus something that nearly vanished from the Serbian soccer dictionary and reality alike as the 21st century rolled around. While the Croatian national team built their style around the authority of more constructive and versatile central midfielders, such as Luka Modrić, Ivan Rakitić

and Ivan Perišić, this provision of defensively minded players as centerpieces of the Serbian national team effectively buried the era of creative players who could always pull a trick or two from their pockets, irrespective of the cost, in the distant past. Naturally, as the freedom to make errors was abolished, the room for such displays of imagination was abandoned too. The intrinsically bold and risky playstyle ceded its place to a sluggish web of “alibi” passes, motivated mostly by the fear of losing the ball, albeit being vain and ineffectual most of the time, promoting a long series of defeats, particularly against the strong teams. The lesson for scientists here is that the rewards in terms of extraordinary research ideas and findings belong to those who are willing to risk the most and stay true to the inner calls for the displays of inventiveness and creativity, notwithstanding the cost.



Figure 5. Serbia vs. Ghana 0:1 (0:0), Pretoria, South Africa, 2010 World Cup. In this still from early on in the game, the Serbian skipper, Dejan Stanković, the winner of the UEFA Champions League with José Mourinho's Inter Milan less than a month earlier, is shown trotting leisurely on the Serbian half of the field despite playing the supposed trequartista, No.10.

Regista

A good midfield playmaker, especially the one who plays from the deep, does not put himself in the limelight, but makes everybody else around him play better instead (Figure 6), whereas his subpar counterpart does the exact opposite. Hence the title of *regista* imparted on one such playmaker, hinting at his semblance to a movie director, who is invisible to the viewers despite having the decisive role in directing the play. Despite this ostensible modesty, *registi* are usually endowed with extraordinary technical skills and with superb intuitive understanding of the game, demonstrating more than any other profile of the player that kinesthetic intelligence amounts to much more than mere eye-and-body coordination. Passing the ball at the first opportunity and in a manner that fluctuates between safe and bold but is nearly always imaginative is the hallmark of this type of player. In contrast, only under the severest of pressures do they engage in dribbling, knowing that dribbling in the midfield is a type of action that inherently disrespects both the opponent and the teammates. Passing, of course, is a key element of effectual play, as exemplified by the fact that nearly 70 % of goals in soccer that result from an active play are scored directly after an assist of a teammate, without any prior contact with the ball, while 18 % are scored after a ball reception and only around 12 %

after dribbling the ball (Durlík & Bieniek 2014; Gonzalez Rodenas *et al.* 2020). What this teaches the natural scientists in the making is the building of the collaborative spirit, but also the free and uninhibited expression of ignorance, which is the precondition for any scientific inquiry to commence and discovery, eventually, to be reached. This is because a player who plays humbly, by making controlled and opportune passes, contributing to the building of an organized and patient attack, is analogous to a scientist who freely expresses one's ignorance and thus gives an opportunity to his fellow mates in the lab to shine. If narcissism and pompous egos have been the key issue with science ever since it became institutionalized in the Age of Enlightenment, then this accentuation of humility is its greatest remedy. To a scientist who is truly overwhelmed by the beauty of natural wonders, however, the adoption of such humble attitudes comes natural and easy, just as well as their emanation does.

A marvelous *regista*, like a prolific scientist, freely employs his intuition during play, making passes that reposition the players to optimal spots and distances from one another. One common weakness of tika-taka tactics is the exceeding proximity of players, which contradicts the classical principle of expanding the active area of play when in possession and narrowing it when defending, making it very challenging to penetrate through compact defenses (Osmanbašić 2018). In those situations, *registi* can play a pivotal role in spreading the players apart so that the ball transfer between the lines becomes more feasible. This profile of players does this naturally, without much overthought, using mere passing as the language. The timing, the angle and the pace of the passes all matter, and so does the elevation from the ground. As for the latter, a fundamental principle can be recollected: the higher the ball and the more time it spends in the air, the more difficult it is for the player's brain to assess its trajectory, meaning that scanning of the field must be renounced and eyes must be kept on the ball instead. This is when long balls can be used as a weapon for diminishing the field of vision of the opposing players and expanding their blindside (van Zoelen 2020), which can be further exploited through rapid structural rearrangements of the segments of the team. Similarly, when it comes to sharing scientific ideas, the closer to the clouds they are, the less immediately comprehensible to their recipients they are, too. Ideas that are down to earth can thus be shared casually, whereas those that have a high degree of fancy in them and that are mesmerizingly creative and sublime can often be misunderstood and rejected, together with their promulgators.

In fact, one can even argue that it is in the nature of a good *regista* to confuse. Why? Because to penetrate a patient and disciplined defense, a sense of confusion has to be seeded throughout it, from which a disarray in the defensive structure will be provoked and the opportunity for scoring created. Hence, during the buildup, *registi* conduct the teamwork via sleek and principled passes, but once the buildup is over, they move on to the high-risk mode.

Whether it is an aggressive pass that splits the defense, an unexpected switch (Amatria *et al.* 2023), a witty layoff, a chip into the blindside, a deliberate turnover (in future) or something else, it is always “a dark forest where $2 + 2 = 5$ and where the path leading out is only wide enough for one” (Ashley 2005), if we were to use the metaphor popularized by the former chess world champion, Mikhail Tal. To convert a static equilibrium into a dynamic imbalance wherefrom one’s creativity can flourish in full force, albeit at the cost of placing oneself into an objectively disadvantaged position, is indeed a method applicable in every human game, discipline and profession, sciences and sports included.



Figure 6. Tottenham Hotspur vs. Liverpool 4:0 (1:0), London, Premier League Season 2011/12. Luka Modrić, in the days when he was still confused for the more famous Mancunian, Shaun Ryder of Happy Mondays, conducting the orchestra of the Hotspur squad with the baton of his foot in dismantling FC Liverpool at White Hart Lane. In this still from the second half, even though Liverpool is down 1:0, no midfielders (Downing, Henderson, Lucas, top to bottom) dare to press Modrić because space would open behind them for a potentially deadly pass.

Box-to-box midfielder

Passing is an art and the player who makes creative passes on the soccer field is nothing short of an artist. One rule that governs this art is the so-called “space rule”, which instructs the player to send the ball not directly to the teammate, but into a space in front or behind him (Figure 7). In fact, the farther one moves from the defense to the offense zone, the greater the distance from the player that an ideal pass is to be sent to. Choosing this distance, along with the ball speed and spin, is one of the key aspects of creative midfield play because the dynamics of the entire team can be dictated by it. The same principle applies to the sharing of ideas in the scientific multiverse. An idea sent to the exact semantic spot where the recipient is located is bound to solidify him in place, and the forward-moving impulse for oneself and for the team will be, consequently, lost. For the messages to propel the recipients forward, heuristically as it were, they need to be sent out into a space in front of them, meaning that they will lose some of their perfect resonance and clarity, forcing the player to make an effort to grasp them, but the gain, in return, can be immense. Hence, although ideas expressed in scientific media may often sound incomprehensible to an untrained mind, this may be for good, because an enormous intellectual and collective benefit can result from an active effort to catch them.

Another reason why passing can be considered the crowning skill of a soccer player may come to view from a

simple observation that defense can theoretically always adjust its positioning to neutralize the threats emanating from a single player’s holding the ball, when in contrast, as the ball starts to be passed, the same adjustment becomes theoretically impossible, especially for rapid ball transfers across wide distances. In those cases, space will always open to enable the forward movement of the ball and an opportunity to score. This is the underlying principle of tiki-taka and also of the play based on constant and fluid circulation of the ball that has been insisted on by Željko Obradović, the most laureled European coach in another sport, basketball. Hence, when in doubt, pass, and this is something that a scientist in search of success cannot remind oneself in excess. That is to say that when one comes across a wall in one’s attempts to cope with a scientific challenge, the best one could do is to change a point of view and pass on the torch to either oneself in a fresher state of mind or to a fellow scientists. This is because when two disparate perspective in sciences cannot resolve a single issue by themselves, their combinations often can. This is, in part, why in recent years natural sciences in particular have witnessed a rise in interdisciplinary research, although at levels that are still modest and far from extraordinary (Uskoković 2019a).

Box-to-box midfielders who track back and forth between the two penalty areas, usually both inside and outside, are of particular significance for employing this passing game that is proactive, involving neither the aimless sending of long balls toward target men nor little fruitful short-pass tiki-taka. One example evocable here may be that of Bobby Robson’s employing the sweeper for the first time in his career in England’s second match at the 1990 World Cup, against Netherlands, to avoid being crushed like in the previous encounter between the two nations, at the 1988 EURO tournament, where the English lost all three games while the Dutch were crowned the European champions. For the first time since this ignoble defeat, Robson brought into a team the Derby County defender, Mark Wright and made him play the sweeper, between Butcher and Walker as stoppers and Parker and Pearce as wing-backs. This setup served as a rope-a-dope strategy of tempting the Dutch forward and forcing the play on the flanks, something that an offside-trapping line defense would not be able to achieve so easily. By sweeping the ball, more space became open through the midfield partially vacated due to the traditional 4-3-3 setup of the Dutch. This open space was utilized for the fast and precise passing to the forwards motorized by Gazza and orchestrated by the English skipper and box-to-box expert, Bryan Robson, who played with an Achilles tendon injury and had to have David Platt be subbed for him mid-second half (Wilson 2009), at which point the integrity of the strategic concept was shaken, allowing the Dutch to regain some of the initiative.

Nevertheless, the inability to build the attack out from the wide became somewhat of an Achilles’ heel for the Dutch in the two decades that followed and can be even blamed for their limited success at the international stage in this period (van Zoelen 2022), in which sense this World Cup game can

be considered a strategic milestone with far-reaching repercussions when analyzed in the historical context deep enough. To close down the center and force the buildup via fullbacks, but then to press after the ball has advanced farther along the sideline, utilizing the idea that players in the wide zone are easier to press than the centrally positioned ones, thus became a common way of neutralizing the setup traditionally employed by the Dutch. One way of solving this problem came in the form of frequent rotations along the flank, so that wingers a la Robben or Kuyt or fullbacks would move inwards to allow the pass to be received diagonally near the sideline. The triangular shape thus adopted reminds of an effect from chemical kinetics aka catalysis. Namely, by sending a direct vertical pass along the sideline from the fullback to the winger, the latter finds himself at an unfavorable angle and is prone to being pressed. However, by passing the ball between these two players through a central mediator, the receiver's field of vision becomes more favorable and the attack has a greater chance to continue building up. In catalysis, the mechanism is similar: by adding a catalyst into a reaction, the reaction path is extended, but with a more favorable net energy expense.



Figure 7. England vs. Italy 2:0 (2:0), Nantes, 1997 Tournoi de France. The Manchester United legend, Paul Scholes sends a long ball in front of the Arsenal striker, Ian Wright, who outpaces the Juventus defender, Ciro Ferrara and volleys the ball into the net for England's lead, which would be increased 17 minutes later through Scholes' first international goal.

Further, although Pearce's direct goal from an indirect kick in the extra time was disallowed and the game ended 0:0, the game is now one of many scoreless draws that may be considered the landmarks of soccer history, alongside Yugoslavia's outplaying Brazil at the opening of the 1974 World Cup (Anon. 1974); each of the four Ivory Coast's finals at the African Cup of Nations, goalless but then topped with over 14 goals on average from the penalty spot; or the last display of beautiful teamwork chaos at the World Cup stage, by Trinidad and Tobago in the scoreless game against Sweden at the Olympiastadion in Berlin in 2006. One take-home point that an aspiring scientist can draw from this analogy is that each individual scientific problem must be approached with a whole new strategy, as, conversely, no two identical approaches will ever prove

themselves suitable for coping with two distinct challenges. Also, even when the research proceeds in a scoreless fashion, there are always meaningful instructive points to be derived from the findings. Moreover, as insinuated by Bryan Robson's box-to-box play devoid of any displays of showmanship, yet essential for the teamwork conception, the universality of style sooner or later pays off, even though it is being greatly underappreciated by today's popular seekers of the best players of the game, putting names such as Lionel Messi or Cristiano Ronaldo on the pedestal, but ignoring the fact that a hypothetical team composed of 10 all-around box-to-box players would defeat with relative ease a hypothetical team made up of 10 Messis or 10 Ronaldos, raising the question as to who, really, is better at the end of the day?

Mezzala

Passes on the soccer field can have a varying degree of verticality. Fully vertical passes, however, work well on very rare occasions, usually during counterattacks. In most cases, though, the receiver of a vertical pass stands with his back to the opponent's goal and can get tackled before he gets to turn with the ball. For this reason, diagonal passes present most commonly a better choice, as their receivers then have a more convenient field of vision. This is particularly true when they are positioned in one of the inside channels, halfway between the center and the sideline, that is, neither too deep nor too wide. This explains why midfielders in the 4-4-2 formation are usually arranged in a diamond-shape configuration. This analogy gives an example to the scientist as to why moving directly toward the target, be it empirical or theoretical, is not the best way to reach it. Rather, in order to reach these destinations efficaciously, the scholars have to follow an indirect or zigzag path, just like the one that midfielders are made to traverse between cones at most every practice. In such a way, the scientist preserves the views of both the foundations of his models in the rearview and the goal toward which he streams. Students who think along tangents are often disparaged for this habit by their academic advisers, but that is a big mistake because this sideways thinking is the route to some of the most inventive ideas that could be derived in sciences.

Moreover, while he was coaching Barcelona in the 1980s and the 1990s, Johan Cruyff recognized that the midfield diamond in the 4-4-2 formation is futile unless it constantly transitions from the 1-2-1 diamond to the 2-2 box or the 1-3/3-1 triangle and back (Davies *et al.* 2021) (Figure 8). Concordantly, our conceptual stances must endlessly fluctuate and never stay in a single state for too long if we are to escape the blind spots of dogmas lurking from the backs of our minds and retain the ability to flex our thoughts to their farthest limits. Hence, if the understanding of the midfield formations in soccer can teach the budding scientist one thing, it is the need for the flexibility of one's models and outlooks and the fosterage of free flows thereof in lieu of getting locked inside fixed, dogmatic positions and worldviews.

Moreover, considering the volatility of formations in soccer, the assignment of fixed number formats thereto, such as 4-4-2 or 3-5-2, can be said to comprise one of the biggest blunders in the science of this sport. This is because the description of a formation with, say, 4-4-2 does not mean much unless it is accompanied with the annotation of its alterations *per se* and in response to the arrangement of the players of the opposing team. For example, the formation of Guardiola's Manchester City has been usually presented as 4-3-3 during live broadcasts, even though it is initially closer to 3-2-5, after which it changes depending on the opponent's formation and playstyle. Thus, against teams that tend to sit in patiently and form a defensive block with five players in the back line, the 3-2-5 formation transforms through a clockwise rotation to a 2-2-6 structure, where each of the six vertical channels in the final, offensive third, namely wide left, inside left, central left, central right, inside right and wide right, get to be occupied by a single player (Turnbull 2020). Against teams playing with four in the back, the five vertical channels get populated with five players before the overload begins in the attempt to create a chance for a combination. Moreover, the full back, the winger and the inside forward on each flank form triangles that incessantly rotate, making the formation impossible to pinpoint as a single static one.

Against more proactive defenses engaging in man-marking and/or pressing, the team typically resorts to ball circulation between free men in a way that requires flexible adjustments of the formation to that imposed by the opponent. Finally, when defending, Manchester City commonly engages in standard 4-3-3 or 4-2-2 midfield presses where the two inside forwards cover the pivots while center-backs are pressed by the striker and the winger. Even Arrigo Sacchi's AC Milan side, the epitome of solid 4-4-2 and famous for its structural coherence, had this formation flow in and out of related numbering, as when the team transitioned to a 4-2-4 setup to apply pressure when out of possession or to a 4-3/3-4 block when defending patiently by setting the off-side trap and blocking the passing lanes while freeing the wingers, primarily Roberto Donadoni, for a counterattack opportunity following the turnover of possession. Still, none of these numbers are descriptive of the fine vertical and horizontal positioning of players with respect to one another and to neighboring lines. In fact, considering Sacchi's request from every player to adjust his movements to four reference points, namely the ball, the space, the opponent and his own teammates, the constant coming out of position and back into it present natural consequences of the flow of the game. This means that more visual ways of describing the formations than the use of a couple of digits alone should always be sought. Even with such visual representations of formations on the board, however, some players will always be difficult to pin down to a well-defined structure because of the dynamism and fluidity of their movements.

One of such types of players, alongside *liberi*, many *requartisti* and players in "false" roles, are *mezzale*, that is,

midfielders such as Kevin de Bruyne, Sergej Milinković-Savić or Aaron Ramsey, who have played centrally in a formation but also engaged in vigorous diagonal runs into half-spaces to assist in the attack. In any case, what this suggests is that adding numbers for numbers' sake need not make portrayals of physical systems any more scientifically rigorous, when more qualitative, picturesque descriptions often provide a more effective means of understanding and utilizing the given systems for practical purposes.

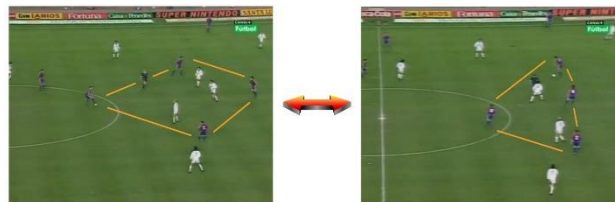


Figure 8. Barcelona vs. Real Madrid 5:0 (1:0), Barcelona, La Liga Season 1993/94. The midfield formation is shown transitioning back and forth between the diamond and the triangle. By creating a European champion and what is often deemed a "dream team" out of modestly technically gifted individuals, in this case Bakero, Amor, Guardiola and Goikoetxea comprising the midfield four of the Barcelona team, Cruyff demonstrated how a good method can turn even relatively poor players into an invincible squad.

Winger

The ability to improvise moves in feedback with the signals from the environment is an essential prerequisite for exhibiting every skill in life. In science, for one, researchers often give in to meticulously planned proposals for research as if they were algorithms to be executed step by step, by a machine, as it were, without paying attention to the subtle signs given out by the physical systems subjected to investigation. A better way of performing research, however, is to always keep an eye on these fine signals and be free to alter the course of research even by 180 degrees if needed. This is what brings us to the famous line uttered by the Inter Milan manager in the 1960s, Helenio Herrera: "You have the tactics, you score a goal, and all the tactics dissipates" (Kuper 2003). This adage is to remind us that tactical ideas must always conform to every littlest perk that can influence the game, not to mention the skills of the players to start with.

The same demand to take note of the conditions of play at every given moment and adjust our own play thereto applies to soccer. Playing in the rain, for example, oftentimes prompts the managers to instruct the teams to build play on long passes, just as well as playing under tropical weather calls for shorter passes to avoid the players' exhaustion from running from one end of the field to another. At another level, skillful dribblers always observe the footwork of the defenders in front of them and direct their own movements in response to them, spontaneously, nearly faster than their brains could think. For this reason, the most skilled dribblers need rely not on an assortment of attractive moves that please the crowds, but rather on the simple swing of the center of gravity relative to the footwork of the opposing player (Figure 9). Even though defenders, to avoid this intrinsic weakness of any stride, try to hop in alternate directions, the leg secured in place, even for a segment of a second, is the weak spot around which the dribbler maneuvers. To do so, he need only change the direction of his run and of the ball at

the right moment. Only so much is required to exploit this inescapable weakness of the stationary leg.



Figure 9. Yugoslavia (Serbia and Montenegro) vs. Spain 1:1 (0:1), Belgrade, 1998 World Cup Qualifier. In this still from the first half, the Montenegrin and former Partizan Belgrade player, Peđa Mijatović, then a Real Madrid forward and the Ballon d'Or runner-up, adjusts his footwork to that of the Spanish and Barcelona left back, Sergi Barjuán, before dribbling past him effortlessly.

One trick that defenders employ to compensate for this intrinsic fallacy is to intentionally slow themselves down in order to give out the impression of trailing behind the attacker whom they should be marking, but only so as to rouse the confidence in the latter and then leap and block the shot or a pass, all of which happens on the temporal scale of tens to hundreds of a millisecond usually. As for the attackers, they, themselves, try to outsmart the defenders by running at a slightly slower pace too and occupying less than the most optimal positions on the field. Diego Maradona, for this reason, considered his adjustment of the speed to the optimal dribbling skill level the greatest improvement he had to make to reach the level of the best footballer on the planet at his position (Kapadia 2019). One lesson from this for the scientist is that slowing down and thinking thoroughly through the research problematic makes up for a better approach than rushing to plan, perform, interpret and report the experiments in as short of time spans as possible. As Nietzsche formulated it, “slow is the experience of all deep fountains: long they have to wait until they know what hath fallen into their depths” (Nietzsche 1883). In fact, watching soccer in slow motion can produce some of the most instructive insights regarding the game. This is, for example, when we could observe with a greatest ease how a seemingly superb pass or a run could have been even better if their angles were changed by, say, 10 ° or how formation “breathing” would have been improved with subtler repositioning of players. Likewise, resisting to rush in research and performing each step with careful oversight is a method that is rewarding for everyone involved in it, from the hands-on to the administrative levels.

Fantasiista

The heart and soul of nearly every extraordinary soccer team are *fantasisti*, who usually play in the roles of central midfielders and are the creative centerpieces of the team. One important feature of these central figures is their rebellious, rule-breaking tendency, which helps them find

moves surprising to everyone on the field and beyond. In this, they are guided by an intuition stemming from their meditative dreaminess and detachment from any palpable physical motives. To counterbalance this drift through the clouds, the successful team, however, needs grounded and pragmatic individuals as well.

The intense research I have conducted in the field of drug delivery using nanotechnologies has taught me that the design of drug carriers for controlled release requires a tradeoff between their physical robustness and degradative propensities. Release upon degradation and structural stability represent a pair of antagonistic properties, yet they must be combined in a prospective drug delivery carrier (Uskoković *et al.* 2012; Uskoković & Desai 2014). On a similar note, materials endowed simultaneously with high strength and high ductility have been the dream of most every mechanical, structural and civil engineer. The same principle calling for the blending of order with disorder applies to any soccer team, where dissipative dreamers must be counterbalanced with obedient fighters in order to ensure its success.

Countless illustrations of this balance can be found in the history of the game. One of the examples can be the Brazil squad that won the 1994 World Cup by employing tough and cohesive defense and granting forwards a complete freedom to orchestrate the attack. Another example may be that of Pep Guardiola’s Barcelona from the early 2010s, where a clear line was drawn between the players who were given the task of maintaining the structural integrity of the team and the dynamic and versatile players who were allowed to traverse the field with a great degree of freeness, which was for Lionel Messi and Andrés Iniesta, complete, as was that at times for the likes of Luis Suárez Miramontes, Garrincha, Gianni Rivera, Allan Simonsen, Maradona, Dragan Stojković Piksi (Figure 10), Roberto Baggio, Eric Cantona, Wayne Rooney, Francesco Totti and Ronaldinho before them. Further, Fabio Capello, the AC Milan manager in the early 1990s, renowned for insisting on the complete submission of each player to a predefined tactical role, learned his lesson too with respect to this need for freedom for *fantasisti* in the team. Namely, after two years of persistent struggles with the attitude of the Montenegrin prodigy, Dejan Savićević, later named *Il Genio* by the popular press, and with what he deemed the “Yugoslav style”, where the player “is the star and the others have to run for him” (Winter 2010), involving also the legendary exchange at the center circle of the training pitch translated by Zvone Boban (Vuković & Đurić 2013), Capello would start assigning everyone on the team specific tasks, but tell Savićević to go out and, literally, play, the way children do.

His giving the Montenegrin *fantasista* the full creative freedom as a counterbalance to the rigid submission to the predetermined tactical directives of the rest of the team paid off and resulted in the successful streak at both national and international levels. The pinnacle of this method came with the 4:0 drubbing of the abovementioned “dream team”, that

is, Cruyff's Barcelona in the final of the 1993/94 Champions League, when Capello was forced to employ a more flexible defensive setup than usual because of the suspensions of Baresi and Costacurta. This, however, gave even more freedom to Savićević, who would end up being the best player on the field, assisting for the opener, constantly disarranging the Barcelona defense, and then outsmarting Nadal and lobbing Zubizarreta for the third goal and the highlight of the match.



Figure 10. Yugoslavia vs. Argentina 0:0, Florence, Italy, 1990 World Cup. The encounter of two fantasisti, Piksi and Maradona, yielded no victor, as no one in their teams scored and they both further missed from the penalty spot in the decisive shootout. Yugoslavia outplayed the defending world champion with only 10 players on the field, but Argentina won the shootout and advanced to the semifinals. In this still from the second half, Piksi pulls a few tricks from his footwork repertoire that toss Oscar Ruggeri of Real Madrid to the ground and leave Basualdo and Simón far behind before passing to the third fantasista on the field, his Red Star Belgrade teammate at the time, Dejan Savićević, who fires wide from the close range.

In science, likewise, such outstanding creative mindsets are, as a rule, disobedient dissenters, at odds with everything and everyone, but enormous rewards can be reaped if they are given freedoms and integrated cleverly into a system functioning according to firm sets of rules and principles. By these rules these creative spirits will never abide, yet this is the only way for them to produce something outstandingly inventive for everyone's benefit. Still, the prevalence of reactionary, right-wing philosophies in all existential spheres, even those that swear by liberal values, has ensured that such creative thinkers are weeded out from virtually every scientific research institution, in just about the same way that they have been wiped out from the soccer world. For, *fantasista*, in the true sense of the word, is an extinct species in modern soccer at the professional level. We do know today that chaotic physical movements of soccer players and their displays of creativity go hand-in-hand (Freire de Almeida & Molina Saorin 2021), yet this indulgence in chaos is all but being nurtured by the contemporary culture of this sport. Although there are players that can pull a fantastic move here and there, players who live the life of fantasy in soccer at the highest level are no more. The pervasive conformity of the players to the interests of the capital hovering over both science and soccer, clearly, is one major reason for this extinction of the most creative spirits from both of

these social domains. The likes of Lilian Thuram and myself have done fair shares of encouraging soccer players and scientists, respectively, through published work (Thuram 2021; Uskoković 2023c; Uskoković 2023e; Uskoković 2021a), interviews (Doyle 2021; Uskoković 2021b; Kovač 2015) and public addresses (Thuram 2018; Uskoković 2012; Uskoković 2023a) to raise their voices against unjust political and economic premises that hold soccer and science in their clutches, yet for as long as these sorts of effort are exceptions among current or former soccer players and scientists rather than rules, the wind in the sails of change will be faint and ineffectual. Another crucial factor here is the culture of inflated egos governing both of these professional worlds, given that egocentrism acts as a steady barrier to the refutation of the old principles and the introduction of the new ones, which is, in turn, the hallmark of all progressive ideas and movements, in science and sports alike.

Striker

Not everyone is born to be a striker, the player of the final ball. Insolence, ego, trickery and stamina are all combined in a great striker, which is less of an artistic combination than that endowing a creative midfielder. Whereas the latter can simply play, for the beauty of the game, the striker ostensibly always plays for the goal. Symbolically, this is to tell us that creativity is tied to no destination at all. It is the road that is seldom traveled - a road whose only goal is the road and the only purpose traveling on it. And yet, the culture of our times is such that scorers of goals are celebrated most, far more than those whose creative skills have enabled these final strikes to be made. That is the tragedy and the truism of our times.

And yet, in the midst of this composite of strikers' traits, one extraordinary feature lies dormant, enfolded by all the others: the intuition. Thanks to this intuition, the final shots of the world's greatest strikers do not target precisely the most optimal spot, yet they appear unmistakable in execution (Figure 11). Savo Milošević's receiving a pass from the Partizan Belgrade forward, Zvonimir Vukić, sensing Paul Jones' swing of the center of gravity and, without delay or any run at all, toe-poking the ball gently and sending it into the net for the lead of Serbia and Montenegro in Cardiff against Wales in 2003, Luis Figo's hitting the upper left corner of David Seaman's goal from 30 yards through the legs of Tony Adams during the meeting of Portugal and England at EURO 2000 in Eindhoven, and Milko Đurovski's chipping the ball from nearly the endline of the field over the Groningen keeper, Patrick Lodewijks - which I watched live from the stands behind the goal - for Partizan Belgrade's lead in the return match against the Dutch side in the 1989/90 UEFA Cup Winners' Cup can be but a few examples where the intuition of the striker came before any elaborate mental calculus. This intuition does stem from an immense wish to net a goal, but this wish, however, is not to be confused for sheer ambition or mulish willpower. This, instead, is a wish that got sublimated into a finer vapor in the striker's heart, allowing him to ride naturally on the waves of intuition, an

art that is difficult to explain to one who tries too hard to accomplish a goal, whatever the goal in question may be. This takes us to the frame of mind described eloquently by Rok Petrovič, a Slovenian skier from the 1980s: “Beware of the personal wishes because they affect intuition by objectivizing the mental space, which resists objectification; if you give in to such wishes and ambitions, you might lose the inner sense, which is why you must retain a nullified mindset in order for the power of intuition to be active” (Anon. 1986). Therefore, Basho’s verse, “Journey is home” (Killion & Snyder 2009), applies well to soccer, as it reminds that the superficial struggle to score a goal only rarely leads to success. Rather, a mindset that is unconditionally immersed in the moment appears to be most effective. Here is where a key paradox of a sport like soccer lies: namely, those who do not submit to the aspiration to score end up having the privilege of scoring. This is to say that journey for the sake of journey instead of the one made for the sake of profiting through recognition and rewards is the attitude to nurture, in sports and sciences alike. Scientific research driven by the goals, be it publication in a high-end journal, tenure, grant funding or a Nobel prize, leads to toxic social scenes and is detrimental for the quality of research *per se*, when the liberation from all these clutches is quite simple: it lies in the egoless immersion in the wonders of Nature and in devotion to research for the research’s sake.



Figure 11. France vs. Brazil 1:1 (1:1), Guadalajara, Mexico, 1986 World Cup. Albeit not a classical striker à la Luis Suárez, Ronaldo Nazário, Gary Lineker or Pippo Inzaghi, Michel Platini was known for his composure before the goal and is considered as one of the best finishers in the history of the sport. In this memorable game, which “should be on the wall in a gallery, on the school curriculum; have its own television channel – it should have everything, because it is everything” (Harris 2020), the game which ended the Brazilian and the world’s most beautiful, free-flowing approach to this sport to this date, Platini scores his last international goal on his birthday by sending the ball slowly, with his weaker foot, across the goal line, having sensed that neither the Botafogo defender, Josimar nor the Corinthians keeper, Carlos could stop the ball.

Last but not least, many, if not all, of these eleven positions of choice in the modern era tend to be fused together into a total soccer conception, where each player plays in multiple roles on the field. This transition to total soccer has made the evolution of soccer drastically different from that of other popular team sports where the degree of fixedness of the player roles has changed to a lesser extent, if any, since the mid-20th century. This is the point I often use to instruct teams of students that traditional hierarchies should be gotten away with and anarchic, constantly fluctuant structures should be sought after. As per the total soccer philosophy proponed by Johan Cruyff, himself a versatile

player ahead of his times, everybody strives to be rendered a utility player, who can play everything and everywhere fluidly and flexibly instead of being locked in a single position and assigned a limited set of tasks. The human race owes its survival throughout the evolution to its exceptional adaptability (Antón *et al.*, 2014) and it is this very same essential trait that is being trained in students by enacting this total soccer philosophy in the context of scientific conduct.

Substitutes

Soccer players acting as substitutes for prolonged periods of time often describe their moods and states of mind as TNT, which hints at their readiness to explode, but is, in fact, the acronym for “Train, Not play, Train” (Stanić 2003). Furthermore, how emotionally devastating one’s permanent relegation from the pitch to the bench is depends on one’s personality to such an extent that it can be used as a mirror to judge the degree of one’s creative predispositions. Namely, players who are in it for the money tend to be touched by this relegation the least and those who live to shine on the big stage most. Since the latter players are usually most prone to become creative wizzes, their disappointment and grudgingness should be taken by coaches as a sign of their immense potential rather than *vice versa* (Figure 12). The same, naturally, applies to sciences, explaining why scholars with the greatest potential are also the first to come in conflict with the authorities. And yet, to be able to view the game from a whole new angle, even if it is the bench, can be a privilege, if only the viewer arrives at precious insights about the nature of the game. Although most soccer coaches were formerly players, this is only a matter of tradition and the outcome of a network of mutual support that is currently in place. In a fully meritocratic system, freed from these ties of sport politics, more coaches would share the paths of Arrigo Sacchi, José Mourinho, Arsène Wenger, Carlos Alberto Parreira or André Villas-Boas, all of whom are very successful managers who built practically their entire knowledge about the game by watching it from the bench, sticking all the while onto Sacchi’s proverb that “one need not have been a horse to be a jockey”. In support of this motto, we could also recognize that the most successful managers who did play in top clubs were not extraordinarily talented players, but rather those who compensated their lack of this talent with an exceptional understanding of the physical and psychological aspects of the game, as exemplifiable by the likes of Alex Ferguson, Marcelo Lippi, Carlo Ancelotti, Fabio Capello and Pep Guardiola. In short, this is to say that thinkers who are outsiders to the mainstream scientific organizations should be encouraged in aspiring to fulfill their research dreams outside of these conventional circles, if we only follow this analogy with soccer.

In fact, at this very mention of substitutes in soccer, of players who did not get the chance to display their drive and their talents and exert a tangible influence on the progress and the outcome of a game, it may be time to assert that crucial insights into the nature of creativity, of human

thought and of existence may come from watching any soccer game, that is, not only those attracting thousands or millions to stadia or TV screens, but even those played by children or elderly in Brazilian favelas or Siberian steppes or dusty terrains of sub-Saharan Africa, in as amateurish settings as it can be imagined. To a trained eye, in fact, soccer games played at lower skill levels can be even more insightful and interesting to watch than the top tier games, primarily because of a greater variety of aptitudes and the entertaining abundance of imperfections in them. Observing such imperfections is also an excellent opportunity for referring to them as cases in educational settings. In science, likewise, inspirational studies need not only relate to subjects that fall within the spotlight of popular attention, but can come from obscure sources as well. In fact, out there, where everything is mostly a fad, a greater tendency of the community to churn out conceptual copycats that dilute the originality and quality of research abides too, whereas topics that are not attractive to the mainstreamers are those from which very often the most precious insights are derivable, be it directly or via analogies, such as those explored here, albeit moving in a different direction, that is, not from a remote field, in this case soccer, to science, but from science to innumerable other aspects of human existence. On top of this, it must be remembered that smaller leagues offer best grounds for experimentation with new concepts, whereas profit-driven clubs playing in top-tier competitions must rely on approved ideas for implementation in practice. The same dichotomy we see in sciences, where massive labs are usually dedicated to perfecting the paradigms, while smaller labs, distant from the spotlight of the popular scientific attention and the sphere of interest of the major funders who eagerly anticipate short-term returns, are where the discovery of groundbreaking new concepts, which may take decades or centuries to develop into commercial applications, if any, is expected to come from (Uskoković 2023d).

This ability to learn from those who were dropped behind more than from those who have always followed a streamlined path to prominence and success evokes the aforementioned straight A students, who, as the unwritten rule goes, tend to perform poorer in research than the students who have gotten used to failure, simply because doing research, day in, day out, is mostly dealing with failure. At another level, if only those subjects that always give predictable and anticipated experimental results were chosen for research, only the paradigms could be reaffirmed and nothing truly valuable and original could ever be discovered.

This is what brings the discussion to the adage that “winning is for losers” (Smyth & Eriksen 2009), which evokes numerous soccer generations that provided valuable contributions to soccer, but without lifting any of the major trophies along the way.



Figure 12. Yugoslavia vs. Argentina 0:0, Florence, Italy, 1990 World Cup.

Yugoslav bench looking more like a congregation of punks than regular sportsmen, considering that this was a match of the quarterfinals of the World Cup, played against the defending champion. From left to right, seated, are the Montenegrin reserve goalkeeper, Dragoje Leković, the Macedonian striker, Darko Pančev, the Croatian striker, Alen Bokšić, the Slovenian defensive midfielder, Srečko Katanec, the Montenegrin trequartista, Dejan Savičević, the Croatian defender, Andrej Panadić, the Croatian left wingback, Robert Jarni, the Bosnian reserve goalkeeper, Fahrudin Omerović, the Macedonian right-back of Serbian descent, Vujadin Stanojković, and the Croatian striker, Davor Šuker. The only substitute missing from the image is the Bosnian defender, Mirsad Baljić. The experience of sitting on this bench proved indispensable for some of the players, including young Jarni and Šuker, who would both score in the quarterfinals of the first following World Cup in which Yugoslav nations were allowed to compete, as members of the Croatian national team against Germany, winning the game 3:0 and the bronze medal at the competition. Right after the poor penalty shootout performance of Yugoslavia in this World Cup match against Argentina, the Yugoslav soccer federation instituted penalty shootouts after each league game that ended in a draw, and this decision paid off only a year later, when all five Red Star Belgrade players scored in the penalty shootout of the final of the 1990/91 UEFA Champions Cup against Olympique de Marseille, including Pančev, who would score the final goal and bring Red Star Belgrade the title of the European club champion. Other players on this bench who would bring their teams the titles of European champions include Bokšić, who would be the top scorer along with Franck Sauzée for Olympique de Marseille in the 1992/93 season and then win the title again with Juventus in 1996, and Dejan Savičević, who would win the European champion title with Red Star Belgrade in 1991 and repeat the feat with AC Milan after being the best player on the field in the final of the 1994/95 Champions League. Unlike the Yugoslav nations less than a year later, ethnicities on this bench were homogenized and no two players from the same nation are seen sitting next to one another. Naturally, this homogenous order was spontaneous and no external forces imposed it on the players. The squad appeared unshaken, too, by the infamous Dinamo vs. Red Star match day riots that happened a month and a half earlier, giving an early sign of the civil war that was to come. As the Bosnian coach, Ivica Osim, who chose four players from Bosnia (Hadžibegić, Šabanadžović, Sušić and Jozić), four from Croatia (Ivković, Vulić, Vujović and Prosinečki), two from Serbia (Spasić and Stojković) and one from Montenegro (Brnović) to represent Yugoslavia in the starting lineup that day, commented two and a half decades later, “the team was far, far better than the country...in my private illusion I wonder what would have happened if Yugoslavia had played in the semifinal or the final, what would happen to the country. Maybe there would have been no war if we’d won the World Cup. I don’t think really things would have changed in that way, but sometimes you dream” (Wilson 2014).

This includes over three decades of perfection of total soccer in Ajax under Jack Reynolds, leading up to Rinus Michels and the culmination of this philosophy in Cruyff’s generation of Dutch players who lost two consecutive World Cup finals to host nations, first in 1974 and then in 1978, despite revolutionizing the soccer playstyle.

The same can be said for the Hungarian generation of the 1950s, which invented a number of new tactical ideas, but failed to win a major tournament, as well as for Victor

Maslov's Dynamo Kiev, which is considered the first team to have implemented zonal pressing and 4-4-2 formation (Wilson 2008). Then there is the case of Brazil in the 1980s, when the national team, led by doctor Socrates, played more creatively than possibly any Brazilian generation before or after them, yet it never reached even the semifinals of the World Cup. In contrast, the successive generation of 1994, the year when Yugoslav nations were at the peak of their potential but also banned from competing, won the World Cup despite playing averagely. Even worse, winning this World Cup had a decimating effect on the style of Brazilian soccer; namely, whereas Telê Santana's Brazil of 1982 and 1986 was an offensive-minded, classical Brazilian team, to whom flair and style mattered most, Carlos Alberto Parreira's Brazil of 1994 was the side of sturdy defense and discipline, modeling itself for the first time in history after the European style of play. Because the latter suddenly proved more successful for the Brazilians, their soccer started adopting a style that was simply yet another European way of playing, which is to this day disappointing to many who see in soccer a search for beauty and *l'art pour l'art* more than a search for wins for wins' sakes. Finally, England's win at the World Cup it hosted, in 1966, created a wrong impression that Alf Ramsey's wingless 4-4-2 formation was the only valid approach to the game and set this school back against more progressive soccer ideas for the next couple of decades at least. All these examples demonstrate how victories can be equivalent to losses and losses to victories. Opening our eyes wide enough to see this is neither an easy task nor an impossible one, but is necessary before truly creative engagements in any discipline can begin. At one such point, namely, we get liberated from the burden of any career or professional goals and simply begin to play for the beauty of the game, be this game that of scientific research, of a sport or of anything else. This is when showers of fresh ideas begin to fall on us and we begin to glide in unforeseen new directions, unattached to any goals, completely, utterly free.

Referee

Other than the 22 players starting for two teams in a professional game of soccer, there is one more person on the field, along with two or more by the sideline, and they are all collectively known as referees. The role of referees in directing the flow and the fate of a match cannot be underestimated, even in the current age of video-assisted reviews, and one sign of this comes from the symptomatic complaints and laments of players, coaches and spectators about certain referees' decisions, including, at times, those that happened a century ago. One such case is that of an array of controversial decisions made by referees at the inaugural World Cup, in Uruguay in 1930, including that of disallowing a goal with which a group of players from Belgrade that played under the Yugoslav flag would have equalized to 2:2 in the semifinal match against the host due to an alleged offside.

The referees' influence on the evolution of the soccer playstyle is also definite, but rarely addressed. One example of this influence comes from the referees' having tolerated rougher body contacts in the preceding century than they do in the current one (Figure 13). This transition served as an important means for protecting the lighter and technically more gifted players and should be thanked for the surge of technical play in Spanish soccer, where the aforementioned era of technically mediocre players from the 1990s and earlier ceded place to an era of technical virtuosi of the likes of Andrés Iniesta, Sergio Busquets, Xavi, David Silva and whole generations of new players from the year 2000 on. In England, likewise, this change retired the players of Vinnie Jones or Ron Harris kind and promoted lighter and nimbler individuals, such as Raheem Sterling, Marcus Rashford, Phil Foden, Dele Alli, Theo Walcott and others. Even one Frank Lampard would have surely been told by the coach in an era of Leeds United's Norman Hunter and other intimidating, "bite yer legs" tacklers that it was his fault whenever he got fouled and advised to avoid an extra touch and pass faster, which is, by the way, exactly how one doctor Sócrates, a "positively skeletal... antithesis of an athlete", developed a unique one-touch playstyle (Downie 2017).

With the introduction of video-assisted technologies, players have become even more cautious against physicality, yet, as it happens with the popularization of every new technology, especially in the digital age, some life has vanished from the game with the adoption of these new refereeing tools, as in instances where players restrain their joy after scoring, knowing that the goal could be disallowed at any moment. Understanding these changes calls for analyses of the intersection of science and soccer on grounds not surveyed in this essay.

The logical question for the seeker of parallels with science is who the analogues of referees in the world of science are, but the answer will be stunning, for it is none. If each critical decision pertaining to the rules of the game was made by players, themselves, it would create a chaos on the pitch, yet this is exactly what the peer-review system in place in sciences is about. In one such situation, the most powerful, not the most righteous on the soccer field would impose their decisions onto everyone else and those creative types of players, who are, as a rule, dexterous and agile but also feeble and touchy, would be quickly forced out of the game. In science, therefore, the ongoing exile of the creative thinkers can be linked to an ample degree with this inherent corruptness of a system where experts whose expertise was approved by other experts determine who will be accepted to the world of experts and who will not. Thinkers who are creative are also those who will be the first to clash with the dominant paradigms in the field and have their voices stifled by many of these experts. Stepping onto the territories of paradigms on which these experts have built their careers, simply, prompts a retaliatory defensive response, which is more often than not ruthless given the un

bridled power of authority that they hold in their hands. The end result for this creative breed of scientists is collective exodus, but also hope that one day, when natural sciences embrace their artistic and humanistic brethren, the exiled will make their way back to the kingdom of science and be allowed again to practice the wizardry that is so dear to their hearts.



Figure 13. Netherlands vs. Yugoslavia (Serbia and Montenegro) 2:1 (1:0), Toulouse, France, 1998 World Cup. Around the turn of the century, refereeing became less tolerant of physicality and also more accurate than in the past, but many decisions continued to be controversial. Within less than 10 seconds of active play, the Spanish referee, Jose-Maria Garcia-Aranda called a penalty against Netherlands for the light jersey pull of Vladimir Jugović by Jaap Stam and ignored to sanction David Bergkamp's stomping over Siniša Mihajlović, who played with the bandaged chest due to rib injury, in plain sight of the Swiss assistant referee, Laurent Rausis. Two years earlier, Jugović won Juventus the title of the 1996 European champion by scoring the last penalty in the shootout against Ajax in the final, against the same goalkeeper: Edwin van der Sar. However, Mijatović, who won Real Madrid a month earlier the first title of the European champion since 1966 – when Partizan Belgrade, Mijatović's former club, lost 2:1 in the final at the Heysel stadium – by scoring the only goal in the final match against Juventus, took the penalty kick and chose to shoot high, with full force, straight through the middle, with white boots. In this penalty kick, the emotion of a nation sanctioned and prohibited to play internationally due to the civil war and due to faults that were mostly politicians' and least people's was sublimated, yet the ball hit the post and bounced back, to the ground and then to the air, live. This historical moment marked the end to a time, to a generation, to a dream, and the beginning of something new.

Future directions for research

Because the cross-disciplinary connection between soccer and science proposed here is formally new, there is, naturally, a limitless room for further elaboration of this intriguing alliance. One interesting avenue for further research would build upon the effort to integrate the analogies discussed here in real-life scientific practice. Since the pivotal effect to look after here is that on scientific creativity, which is difficult, if not impossible, to quantify, any assessment of how productive this cross-fertilization of soccer and science is would have to be derived solely from qualitative observations. Still, it is likely that the seminal use of soccer ideas in teaching scientific creativity would not only promote the latter, but also incite the scientists' curiosity about soccer, which would begin to be approached even more scientifically than today. The result of this curious marriage of disciplines would be the opening

of whole new perspectives on both sports and sciences over time. In the long-term, the founding of entire institutes may be foreseen, where a sport such as soccer would be played and analyzed alongside the nurture of creative research in sciences hard and soft, ranging from physics to chemistry to biology to humanities and other disciplines. After all, just as centers for combining scientific and artistic practices are badly needed in today's society, there is a similar need for the scholarly sites where sports and sciences would be studied and practiced, not only side by side, but also synchronously, in any of the innumerable cross-disciplinary ways imaginable.

Conclusion

Because they put the reflective mental tasks to rest and activate both the body and the more primitive forms of intelligence, sports such as soccer are excellent daily complements to engagements in scientific studies. In addition, simple analogies should never be underestimated for their potential to cross-fertilize distinct fields of inquiry and create whole new interdisciplinary branches of knowledge. Concordantly, all of the examples compiled here in support of the ties between the philosophy of soccer and the philosophy of science are not to serve as a testimony to one teacher's straying into exotic interdisciplinary territories in search of analogies to illustrate points at hand, but rather to inspire the readers to consider building entire academic courses around such intersections of a sport such as soccer and natural sciences.

This would, ideally, lead to sportier and more spirited communities of scientists, but would also increase their awareness of the intellectual aspects of the game, which could start to be viewed with a fresh new eye. Such more scientific ways of watching and playing soccer would yield ideas directly implementable in the conduct of scientific research, the culture of which is today in dire need of rejuvenation.

Last but not least, whenever two remote disciplines are brought together, there is an opportunity for their mutual humanization. In this essay, the ideas were shared as to how the understanding of the tactical and technical subtleties of soccer can enhance the quality of the practice of science, but this positive effect may extend to the sports universe as well, which may be in an even greater need of humanization than that of sciences. Currently a profession where voracious and oftentimes unscrupulous business principles abide, where gigantic inequalities are supported and where competition often spills into devastating displays of cruelty and violence, with a little bit of input from science, arts and humanities of the kind proposed here, it may be converted to a holy game, aka *joga bonito*, such that its animalistic competition would be suppressed and artistic elements accentuated. If so, soccer would turn into an entertaining source of insight to the scientist and a game that brings only joy and happiness to its players and spectators.

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