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Sport: A Scientific Experiment?

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Science plays an increasingly important role in sport. Innovative high-tech equipment and research-based exercise regimes are vivid examples. In more subtle forms, scientific ways of thinking impact how sport is understood and practiced. I examine the possibilities and limits of scientific rationality in the set-up of competitive sport. Standard scientific requirements on reliability and validity make sense in sport to a certain extent, among other things in the quest for equal opportunity to perform, and for fair and impartial evaluation of performance. However, whereas the instrumental aim of science is 'certified' and relevant knowledge, I argue that sport has primary meaning and value in itself. Analysing the normative structure of sport, an alternative ludic rationality emerges with a combination of predictable meritocratic elements and elements of chance and luck. I argue that sport is structured to cultivate not only athletic but human excellence. I conclude that an emphasis on scientific rationality can be a threat to sport as we know it. Upholding ludic rationality, operationalized in norms for fair play, is crucial for realizing sport's characteristic values.

Key words: Sport, science, rationality, performance, values, fair play

Introduction

Scientific insights and applications play an important role in sport. To an increasing degree, training and exercise are based on research within physiology, biomechanics and psychology. Scientifically developed equipment, from shock absorbing running shoes via lighter and better bicycles to high tech smart watches, have become part of everyday sport activities.

Competitive set ups are impacted as well, among other things by increasing the accuracy of performance measurements. In sports such as track and field and swimming, timing devices measure inequalities down to 1/1000 of a second. In ball games and net ball

games, video assistant and so-called Hawkeye technologies are implemented to review referee decisions and enhance fairness. In training and preparation, bio-medical technology such as nutrition regimes, hypoxic chambers and even potent drugs, is used to an increasing degree.

Although science serves many important goals, its impact in sport is by no means uncontroversial. Some technological innovations, such as the full body swim suit developed in the early 2000s, or 'efficient' Polara golf balls that 'forgive' lack of player technique, are considered by critics to 'technologize' and 'de-skill' sport (Fouché 2017). The quest for accurate hi-tech refereeing tools is by some seen as a challenge to the 'human factor'. Sport is turned into 'a prison of measured time', to use a phrase from sport critic Jean-Marie Brohm (1978). The perhaps greatest challenge comes from applied bio-medical science: performance-enhancing drugs and genetics. In his history of doping, John Hoberman (1992) talks of 'the science of performance and the dehumanization of sport'. Will future athletes be turned into guinea pigs in great scientific experiments on limitations of human performance?

In what follows, my interest will be not so much in what Fouché (2017) calls sport's techno-scientific revolution, but rather in the impact from scientific ways of thinking, or scientific rationality, on the very set up of sport.[1] Potentially, scientific rationality exerts a more fundamental kind of impact as it concerns the definition and understanding of what sport is all about and thereby, more or less directly, sport policies and practice. I concentrate on competitive sport exemplified by Olympic sport disciplines. This is its hegemonic form with a global following, and this is where the most heated debates on the impact of science take place.

Rationality can be conceptualized in various ways.[2] I will understand rationality in functionalist terms as a consistent system of norms and values that characterizes and guides action and development in human institutions and practices. More specifically, rationalities are expressed and operationalized as normative structures, that is, as formal and informal rules and regulations. In his classic analysis of science, Merton (1973: 269) defines a normative structure as a system of 'prescriptions, proscriptions, preferences, and permissions' when it comes to action and conduct, and justified by 'institutional values'. A main institutional value of science is the 'the extension of certified knowledge' (Merton 1973: 270). In up-dated terminology, 'certified knowledge' refers to rigorously tested knowledge based on main methodological norms of reliability and validity. Sound methodology is the premise for trusting scientific knowledge with explanatory and predictive force, and hence for its value to society. [3]

The article is structured as follows. Firstly, I will test out whether scientific rationality understood as norms on reliability and validity makes sense in sport. Does the metaphor of sport as a scientific experiment hold water? Secondly, I will look for potential discrepancies and contradictions and alternative rationalities. In this way, the essay is an exploration into the normative structure and nature of sport.

Reliability

Sporting games are defined by their rule systems. The core rules, that is, the constitutive rules, define what counts as performance and what is allowed and not allowed. The world of sporting games is diverse. Soccer rules ban the use of hands and cancel goals scored by players in off side positions. In European handball, kicking the ball is prohibited. Track and field tests athletes on the basic bio-motor abilities and skills of running, jumping, and throwing.

In spite of this diversity, however, all sports share a particular, social logic. What I have called the structural goal of competitions is to measure, compare, and rank competitors according performance of the relevant athletic skills (Loland 2002). To a certain extent, then, sport represents a quest for knowledge. Who is the better performer? What are the relative inequalities in performance among participants? How can we rank competitors according to performance in sound ways?

This is where scientific rationality enters the picture. One key characteristic of scientific measurements is the quest for reliability. In simple terms, reliability tests are estimations of random errors in a measurement; they are tests of consistency and repeatability (Thomas et al. 2015). For example, if the same performance is measured again by the same measure, reliable measures would give identical scores, or at least scores with a strong positive correlation. And, if another but identical performance takes place in the same sport and is measured in the same way, the outcome should be more or less the same.

Do sport competitions meet requirements on reliability in this respect? In some sports, with track and field as the obvious example, performance is measured in exact physical-mathematical entities such as meters and seconds. In weight lifting there is a similar approach with exact measurements in kilograms. Strict standardization regimes are implemented to provide all competitors with equal external conditions. Runners run the same distance and on the same surface, jumpers and throwers have the same number of attempts, throwers throw more or less identical objects (javelins, discuses, hammers, and shots) within their discipline.

These are almost experiment-like set ups. In fact, in running races, measurements and comparisons are done at the accuracy of 1/1000 of a second. Requirements on consistency and repeatability guide practice.

This does not mean that reliability cannot be improved. In the long jump and in throwing events, measurement can be fine-tuned even more to the level of millimetres. In throwing events, precision can be improved by replacing human judgment of landing points with electronic sensors in the landing area. The perhaps greatest reliability problems are found in outdoor events. Inequalities in wind, temperature and light conditions are unpredictable and difficult to control. Ski jumping is an obvious example. Two athletes can perform identically in the in-run and take off but experience different outcomes due to variable wind conditions. To improve reliability, an advanced technological system has been installed in which points are added or withdrawn based on wind conditions during flight. If reliability is the overall aim, however, the ideal solution would be to move outdoor sports such as ski jumping to indoor facilities.

Other sports measure performance in other ways: in what I have called sport-specific units (Loland 2002). In ball games, performance is operationalized as the ability to score goals or points, in net ball games there are points, games and sets. Some sports combine various kinds of measurement. In gymnastics, ski jumping and figure skating, clearly defined performance criteria are combined with aesthetic judgment. What can be said of reliability in these respects?

Again, outdoor sports are problematic. Once in a while, and due to weather and light conditions, identical performances give different results. A beautiful shot in soccer may hit the outside of the pole due to a sudden blow of wind. Under other circumstances, the identical shot might end up with a goal. As with sports with exact measurements, the obvious solution is to move indoor.

Another challenge is linked to subjectivity and fallibility of human judgement. Most ball games include referees judging whether points and goals are scored in legitimate ways. In most games, many of these calls can be challenged. In some situations, referee decisions (such as offside calls in soccer) are simply mistaken and wrong. In sports with aesthetic judgment there are regular debates on reliability of measurements. Vague operationalization of what is considered aesthetically valuable opens for subjectivity, multiple interpretations, and for partial judgment and unfairness. Although intersubjective consensus among experienced judges is common and a sign of (inter-rater) reliability, requirements on consistency and repeatability are under constant pressure.

The elimination of measurement errors due to human subjectivity and fallibility is one of the hallmarks of science. Technologies such as Hawkeye in tennis and video assisted refereeing in ball games correct obvious referee mistakes and can be considered improvements. When it comes to aesthetic sports, a solution could be to abandon aesthetic judgment completely and concentrate on what can be operationalized in more or less objective ways: the number and height of vaults and spins in a gymnastic or figure skating exercise, the length of a ski jump, etcetera.

These are radical proposals and will change the nature of the sports affected. Reliability requirements will conflict with common practice and understanding of what these sports are all about. It is difficult to take a stand here as we have not yet defined the 'dependent variable' in the 'sport experiment': athletic performance. For instance, it can be argued that aesthetic expression is a constitutive element of performance in gymnastics and figure skating. Removing aesthetic criteria would simply render our measurements irrelevant. We move now towards discussions of validity.

Validity

In simple terms, questions of validity refer to whether one actually measures what one is trying to measure. Valid results should reflect reality in some sense. Reliability of measurement is no guarantee. As is illustrated by the example from sports with aesthetic criteria, we may have reliable measurements but still produce invalid results. Popular interpretations of the possibilities of genetic insights provide other examples. Sometimes one gets the impression that the existence (or non-existence) of a particular genetic set-up is the critical variable explaining and predicting athletic performance (Loland 2015a). Although a test can provide precise genetic information, this is nothing but one among an almost infinite number of factors involved in human performance. Scientific reductionism, at least in its vulgar and popularized version, is expressed in the conflation of validity questions to questions of exact operationalization and reliability.

In scientific work, standards and tests of validity are complex and include discussions on external and internal validity with respective subcategories.[4] Our question concerns whether performance measurements in sport actually measure and compare what we are after: athletic performance. The question is one of construct validity referring to the degree with which inferences can be made legitimately from operationalization to the theoretical construct upon which the operationalization is made. Do measurements in a competition really relate

sufficiently to the construct ‘athletic performance’? Do results measured in time units in running races and goals in soccer really reflect actual performances in these sports? Validity questions go straight to the core of competitive sport, they are ‘nothing less than an evaluative summary of both the evidence for and the actual – as well as potential – consequences of score interpretations’ (Messick 1995, 742). What is an ‘athletic performance’? How can ‘athletic performance’ be defined?

A first look at the world of sports does not provide direct answers. Sporting games are of great diversity and test participants on multiple and different abilities and skills. Moreover, the value of sport is interpreted differently between individuals and groups and in different social and cultural contexts. Sometimes sport is considered to have instrumental value primarily. Sport is a means to enhance health, or self-esteem, or collective identity and prestige, or profit. In other contexts, sport is seen as a source of meaning and value in itself. The dedicated athlete strives for perfection in his or her sport, the amateur looks for joy and friendship, the dedicated supporter ‘lives’ with his or her athletes and teams and follows them loyally in victory and defeat.

A closer look at the normative structure of sports however indicates common features. Most outdoor sports have rules to eliminate or at least compensate for inequalities in weather conditions. Varying weather conditions are considered confounding variables. Moreover, in many sports, competitors are classified and matched according to age, biological sex, and body size. Classification schemes indicate what kind of individual inequalities are considered non-relevant and sources of measurement errors. They provide insights into how athletic performance is understood. What is the rationale behind classification schemes?

One obvious rationale is a quest for exciting competitions with open outcomes. According to Elias and Dunning (1986), the growth of modern sport can be understood as a ‘quest for excitement in unexciting societies’. This however provides no explanation of current classification. If open outcomes were the goal, we could imagine competitions between mediocre men and elite women, we could handicap the best athletes to give athletes of lesser skills better winning chances, or we could organize competitions between humans and animals, or between humans and machines. Although having significant potential for entertainment, such contests do not typically categorize as sports.

A better explanation can be found by examining sport in the context of more general social and moral norms such as ideals of fairness. The set-up of a 100-meter sprint race between an elite male and elite female sprinter is considered unfair as the female sprinter, statistically speaking, have other genetic predispositions to develop speed than her male

counterpart. To a boxing connoisseur, a fight between a fly weight and a heavy weight boxer does not catch the same interest as the heavier fighter has a significant advantage due to greater body mass.

Typically, by eliminating or compensating for inequalities that athletes cannot control or influence in any significant way, classification cultivates abilities and skills developed by hard efforts and training. Even more generally, the attempt in sport seems to be to tie performances to performers and to test particular qualities in athletes and teams for which they can be held responsible. Sports are meritocratic practices.

There is a link here between sporting games and core ideals and values of the culture and societies in which they have emerged and developed. Classification in sport expresses a commonly held normative view referred to as the fair equality of opportunity principle, FEO, (Arneson 2015) which can be formulated as follows:

> *It is unfair to treat individuals or groups differently in significant matters based on inequalities upon which they exert little or no control and for which they cannot be held responsible.*

In a sport specific version, FEO prescribes the elimination of or compensation for *inequalities with impact on performance upon which athletes exert little or no control and for which they cannot be held responsible.*

Now, then, we can return to questions of validity. With this interpretation of 'athletic performance', and with the reliability reforms suggested above: Are performance measurements in sport valid? Can inferences be made from operationalization to the FEO-construct of 'athletic performance'?

The FEO seems to give support to the conclusion of moving outdoor sports indoor. Climatic inequalities are out of control of athletes. When it comes to sports in which performance is measured in exact physical-mathematical entities, certain modifications are needed as well. If it can be shown that 1/1000, or even 1/100 of a second is beyond the possibility of human control, these measurements are invalid. If there is evidence that expert performers can differentiate between margins down to 1/10 of a second, this should be the critical lower level of accuracy.[5]

When it comes to sports with sport-specific units, more significant challenges arise. From the FEO perspective of validity, one of the world's most popular games, soccer, has

perhaps the most challenging measurement unit of all: soccer goals. A goal is a goal no matter how it is scored. It can be the result of superior technical and tactical play, it can be a failed hit on the ball, or even the outcome of a player putting the ball in own goal. From the perspective of FEO, there is no accurate differentiation of performance quality. Hence, goals scored do not always relate in a clear manner to soccer performance. Validity problems prevail. In other ball games, measures are taken to compensate for this inaccuracy, among other things by differentiation. In basketball, penalty shots give one point, shots from within the three point-line give two points, shots from outside three points.

For similar reasons, netball games such as tennis and badminton have validity challenges, too. Imagine the following situation. A tennis player attacks beautifully with a brilliant shot to the far corner. The opponent is completely outplayed but stumbles and hits the ball by accident so to speak with the frame of the racket. The ball enters a high loop and ends on top of the net before finally dropping down on the other side. The point goes to the player with the unintentional frame hit, that is, to the inferior performance.

Can these validity challenges be met? A mild reform in soccer could be to follow the principle of basketball and differentiate according to degree of difficulty of the goal (in basketball: the point) scored. Sending the ball in own goal could give one half goal to the opponent, regular shots within the penalty area could give one goal, long shots two goals, and so on. Even more accurately, and including all ball and netball games, one could abandon sport-specific measurement units completely. Objective units could be constructed that relate more directly to the FEO-construct of performance. In soccer, for instance, a committee of experts could define critical technical and tactical skills and operationalize with the use of advanced movement analysis technology. Validity would be improved.

Are these reasonable solutions? Should FEO and ideas of responsibility for performance be the regulative ideas in defining 'athletic performance'?

The Limits of Scientific Rationality: Merit, Chance, and Human Excellence

Testing these ideas against the way sport is understood and practiced, the answer seems to be no. In track and field, there seems to be acceptance of 1/1000 of a second as a decisive inequality. In sports with sport-specific unit systems, measurement units do not seem to be controversial. Actually, soccer, with its ‘inaccurate’ goal measurement, is one of the most popular sports in the world. Converting goals into more accurate measurement units is not

even up for discussion. Moreover, neither track and field nor soccer seem to have serious discussions of moving indoor. In fact, indoor championships tend to have less prestige and are given less attention. The important events are outdoor competitions.

How can this be understood? Should we accept 'inaccurate' measurements and 'confounding variables' as parts of sport? Are there complementary or contradictory forms of rationality at play here? Is the FEOs-construct of 'athletic performance' too narrow? Are we making the mistake of 'construct underrepresentation' (Messick 1995)?

On closer examination, non-meritocratic elements that are accepted in sport seem to share a key characteristic. Inequalities in external conditions, and 'inaccurate' measurement units, open for elements of chance and luck. Chance strikes blindly and is uncontrollable. This is the rolling of the dice, or the outcome of the genetic 'lottery'.[6] Luck, good and bad, refers to events and outcomes that seem out of control from the perspective of the agent but which, at least in principle, can be impacted with increased knowledge and improved skill. Due to a sudden blow of wind, a soccer shot hits the pole and ends outside of the goal. Bad luck. A more skilled player could aim with a sounder margin due to experience with unstable wind conditions, and score. Impact of luck, good and bad, is reduced. In elite sport, the sphere of control and responsibility for performance is expanded. As the saying goes among athletes, 'the more I practice the luckier I get'.

However, chance and luck are never eliminated completely. Even in tight games at the highest level, marginal events can lead to the decisive 1/1000 of a second inequality in the running race, or the decisive point or goal in the final second that determines the outcome. Still, as long as elements of chance and luck do not exert systematic and significant impact, that is, as long as sports are not turned into games of chance but sustain a clear meritocratic structure, these elements seem to be valued.

This is not necessarily a validity problem. Rather, it demonstrates that our idea of athletic merit might be too narrow. So far, and based on FEOs, merit relates to whatever is within the sphere of impact and control of the individual or team. Chance and luck are seen as confounding variables. In an alternative interpretation, suggested by among others Simon (2007) and Loland (2015b), athletic merit is understood as mastery of a combination of elements that can be under athlete control, *and* of chance. Good athletes have the ability to calculate unpredictability and relate in rational ways to events and outcomes that are outside of their control. Not only do they reduce the impact of luck: They accept that they can never be in full control, and they continue with their best efforts even in moments where chance and luck are not on their side.

This perspective can be extended even further. From the individual perspective, probably the most important chance event of all is 'the natural lottery': the moment of conception in which genetic predispositions are determined. Indeed, in sport as in other areas in life, these predispositions exert significant and systematic impact.[7] Starting at the moment of conception, there is gene-gene-environment interaction in which chance and luck play their part. An athletic performance is the sum of an infinite number of complex interactions beginning with the very first symbiosis with the mother in the womb and proceeding with impact of the local socio-cultural environment during childhood, general social and cultural impact, sport specific impact in terms of training and quality of facilities and coaching expertise, and all the way up to the day and moment of performance.

In sport competitions, athletes are tested on how they handle these factors. However, as have been argued, and with reference to FEO: If there are significant inequalities with systematic impact that are outside of athlete control such as biological sex and body size, they are eliminated or compensated for by classification. These are what we with Norman (1996) can call absolute biological background conditions. Sport outcomes should not be matters of chance primarily. Relative biological background conditions, such as predispositions to develop strength and endurance, can be impacted and controlled to a certain extent by the individual. Moderate cardio-vascular or strength talent can be compensated for by hard efforts. Great genetic talent can be wasted by laziness. In this way, performances can be linked to the individual athlete, to his or her history and narrative, to ideas of identity and authenticity. A performance is a unique expression of the performer as an individual, as a subject. In competitions, the attempt is to judge athletes and teams on 'true' performance, according to what they can perform at their best, according to who they really 'are'. As Jonasson (2014) comments, sport competitions are 'trials of humanness'. The metaphor of sport as a reflection of life, makes sense.

We approach now an understanding of basic sport values, that is, of sport as a moral field and why 'sports morally matter', to quote Morgan (2006). With the emphasis in sport on factors that can be impacted and controlled by the athlete through his or her own efforts, Murray (2007) proposes the following interpretation: Sport is about the *admirable* development of natural talent towards excellence. What is admired includes cultivation of human virtues such as effort, motivation, strength of will, handling victory and defeat in sound ways, et cetera.[8] At its best, sporting excellence can be seen as an instantiation of human excellence.

Scientific Rationality and Ludic Rationality

As the discussion has moved on, similarities but also clear differences between science and sport have emerged. Firstly, the methodological ideal of reliability makes sense in sport as in science. To a certain extent, measuring, comparing and ranking competitors according to rule-defined performance should meet requirements on consistency and repeatability. Some implications, however, for instance the idea of removing aesthetic criteria from sports such as gymnastics and ski jumping, or of turning outdoor sports into indoor sports, raised critical questions. These reforms would imply radical changes of the way these sports are understood and practiced.

This led to questions of validity. What do we really want to measure in sport? What is athletic performance all about? And, from the perspective of construct validity, how can inferences be made soundly from operative measurement to athletic performance? Looking more closely at sporting rule systems, FEO emerged as a regulative norm on eliminating or compensating for inequalities for which athletes cannot be held responsible. Sport competitions are meritocratic practices. To enhance validity, one reform could be to convert 'inaccurate' sport-specific units such as soccer goals into more accurate ones.

As argued above, however, such reforms contradict the way sports are understood and practiced. It seems to be an expression of 'construct underrepresentation'. Hence, the FEO's interpretation of merit was extended to include coping with elements of chance and luck. This wider interpretation, in which athletes have to relate to a certain degree of contingency, can be seen as reflecting in an embodied and concrete way challenges in human life, and has links to moral interpretations of human excellence.

At this point, it becomes clearer how sporting rationality departs from scientific rationality, at least in a strict experimental understanding of science. In the setup of an experiment, accepting 'unnecessary' elements of chance and luck compromises reliability ideals. For example, a soccer player can perform two identical shots in two different matches. In one match, the shot ends with a goal. In the other match, a sudden gust of wind pushes the ball outside of the goal post. As performances are identical, there is no real consistency and repeatability of measurement.

Validity requirements are challenged as well. An extended construct of 'athletic performance' seems to solve some of the problems. Accepting certain forms of contingency seems to be 'the name of the game'. As long as rule violations or referee mistakes do not significantly impact the outcome, competitions measure what we want to measure. As a

dependent variable in research, however, 'athletic performance' is extremely complex. Its operationalization in competition is rough and simple and does in no way provide ground for nuanced scientific explanation and prediction.

Differences emerge as well when we look at institutional values justifying the normative structures of science and sport. Science exists, in principle at least, for instrumental reasons: producing 'certified' and relevant knowledge. Sport is different. There is no systematic quest here for values outside of the activity. Quite to the contrary, in sport there is a particular non-instrumental logic at play. Instrumentally speaking, constitutive rules such as the rule in soccer on not touching the ball with one's hands, or the rule in steeple chase on jumping and not running around the water jump, seem irrational. Bernard Suits' well-known definition of game playing captures this particular logic: '…to play a game is the voluntary attempt to overcome unnecessary obstacles' (Suits 1978: 54-55). Within sport, however, 'unnecessary' obstacles create skill tests that are interpreted as meaningful and valuable in themselves.

Elsewhere I have elaborated on the particular normative structure of sport in terms of the ideal of fair play (Loland 2002). Norms for fairness are linked to requirements on reliability and validity in terms of FEO. Norms for play relate to experiential qualities in striving to do one's best in the face of uncertainty of outcome. The balance between fairness and certainty on the one hand, and elements of contingency and uncertainty on the other, expresses a particular *ludic*, or playful, rationality.

Ludic rationality is operationalized differently from sport to sport. In track and field, there is an emphasis on exact measurements. In soccer, sport specific units open to a larger extent for chance and luck. A common premise, however, is the primacy of the extensive interpretation of meritocracy, and, in a wider context, an interest in sporting excellence as a particular instantiation of human excellence.

Concluding Comments

As scientific rationality tends to invade the sport world, I set out to examine its potential and limitations. In the discussion, limits were exposed gradually, and a different rationality emerged; that of ludic rationality. Sport is not about production of rigorously tested knowledge, but is characterized by the unpredictable quest for sporting and human excellence within the normative structure of fair play. Whereas science has an instrumental justification, sport exists primarily due to meaning in the activity in itself.

My claim is not that sport is an ideal moral sphere. Typically, sport engages moral emotions and presents its followers to moral dilemmas. What is proper conduct in settings of intense competition? How should athletes relate to opponents? What is fair and unfair? Those involved in sport policy and governance are challenged constantly by external interests and rationalities of many kinds: national, ideological, commercial. What are acceptable and non-acceptable changes in competitive set-ups? How can justice be done and sporting values be realized and developed? How can lines be drawn between acceptable and non-acceptable ways of enhancing performance? Sport is morally contested terrain which, I assume, is one main reason for its global fascination. The argument here is that ludic rationality offers a guide to meet these challenges in sound and principled ways and protect and cultivate the characteristic meaning and value of sport itself.

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1 The main argument is a development of previous work (Loland 2002, 2015a). Similar questions, but from a slightly different Latourian perspective, have been discussed by Jonasson (2015).

2 In most cases, 'rationality' refers to practical or theoretical reason or rational choice theory in which agents' beliefs, intentions and actions are under examination. For further discussion of functionalist and rational choice approaches to social action (cf. Craib 2015: 33-68).

3 Merton (1973: 270 ff) formulates four institutional norms that define what he calls the 'ethos' of science. 'Universalism' points to the validity of scientific insights as independent of partial interests and social, cultural and political contexts. 'Communism' emphasizes the ideal of scientific knowledge as open and shared and never kept secret. 'Disinterestedness' is a requirement on scientific institutions on operating in ways that benefits all, not just partial interests. 'Organized scepticism' deals with the need of critical scrutiny and falsification attempts of scientific findings, and of strict methodological requirements. Norms of reliability and validity can be seen as operationalization of this ethos in the set up and carrying out of scientific research and will be my focus here.

4 Cf. chapter 11 in Thomas et al. (2015) for a thorough discussion of reliability and validity with examples from research in physical activity and sport.

5 Controversies related to increased accuracy of performance measurement are not new. In the 15 kilometer cross country event during the 1980 Winter Olympic Games in Lake Placid, Swede Thomas Wassberg became Olympic champion with 1/100 of a second difference over Juha Mieto of Finland. Wassberg did not accept this a valid difference and insisted on sharing his gold medal with Mieto. After the event, the international skiing federation (FIS) changed its practice and operates currently with the minimum time margin of 1/10 of a second. Jonasson addresses a related point in his reflections upon what is actually measured in swimming events, see http://sportminor.blogspot.no/2011/02/holey-diver_15.html (accessed November 1st, 2017).

[6] This does not mean that chance events cannot be explained. With insight into initial conditions of force, rotation and direction with which the dice is thrown, and with insights into the frictional forces on the surface upon which it lands, the outcome of a dice throw can be explained causally. Similarly, with knowledge of the hydrodynamics of the womb, and of velocity and energy surplus of sperm cells in their race towards the ovum, outcomes of the genetic lottery can be explained. The point is that from the perspective of the individual and team, chance outcomes are beyond the sphere of control. For interesting examples of the role of chance and luck in everyday life (cf. Rescher 1995).

[7] For an overview of the impact of genetics on sport performance, see Posthumus' and Collins' (2015) edited collection of essays.

[8] For a thorough review of virtues (and vices) in sports, cf. McNamee (2008).