TRANSLATING KEY METHODOLOGICAL ISSUES INTO TECHNOLOGICAL ADVANCEMENTS WHEN RUNNING IN-SITU EXPERIMENTS IN SPORTS
AN EXAMPLE FROM SAILING

ADAPTED FROM –


- FIGURE 2.1. A sailor rounding the windward mark and adjusting his trimming lines. Marked by letter a-b: a) the mobile eye tracker; b) the recording device on the chest of the participant worn in a waterproof rucksack.
ABSTRACT

In recent years there has been an increasing interest in capturing and understanding skilled performance by studying complex perceptual-motor skills. In this context, we identify and discuss key methodological issues that are particularly relevant when aiming to translate sport scientific knowledge into practical guidelines for coaches and athletes. These issues are: the representative performance environment (including fidelity of stimuli and type of response), generalisability, and experimental control. After a short introduction of the methodological issues, we first review and critically discuss to what degree past research studying complex perceptual-motor skills in sports has or has not sufficiently taken these issues into account. Second, we illustrate an examination of expertise in sailing as an example of how to address the key issues when performing experiments in-situ. We conclude that the presented example illustrates how the collaboration between coaches, athletes and sports scientists advances the methodological and technological developments to capture skilled performance in complex sports.

KEY WORDS

Expertise;
Field Experiments;
Sailing;
Sport Technology;
Visual Search Behaviour
INTRODUCTION

Skilled athletes outperform their less skilled counterparts due, amongst other things, to superior anticipation skills in changing environments (A. M. Williams et al., 2011). In recent years there has been an increasing interest in capturing and understanding skilled performance by studying complex perceptual-motor skills (Bishop, 2008; Oudejans & Coolen, 2003). In this regard, one of the major aims of sport scientists is to translate experimental research into practical guidelines for coaches and athletes alike (Bishop, 2008; A. M. Williams et al., 2011). Skilled performance manifests itself in finely tuned perceptual-motor responses developed over many years of extensive practice (Abernethy & Russell, 1987b). While motor skills, defined as “a skill for which the primary determinant for success is the quality of movement that the performer produces” (Schmidt & Wrisberg, 2008, p. 4) have been strongly related to the superiority of skilled athletes over their lesser skilled counterparts, the reliance on different perceptual information pick-up that guides the action has only received attention over the last three decades (e.g., Abernethy & Russell, 1987; Ericsson & A. M. Williams, 2007; Ranganathan & Carlton, 2007; Savelbergh, Williams, Van der Kamp, & Ward, 2002; A. M. Williams, Davids, & Williams, 1999; A. M. Williams et al., 2011; A. M. Williams, Ward, & Chapman, 2003). Based on this research, it is undisputed that expert performers are also superior at picking up the most appropriate perceptual information – at the right time – to help inform and guide the most suitable motor responses. One of the key challenges for developing athletes though is that the visual environment typically contains information both relevant and irrelevant to performance (Abernethy, 1996; A. M. Williams et al., 1999; A. M. Williams & Grant, 1999), thereby increasing the importance of efficient information selection processes.

In this chapter, we identify and discuss key methodological issues that in our view are particularly relevant when aiming to translate sport scientific knowledge into practical guidelines for coaches and athletes. After shortly introducing and highlighting the importance of the issues, we first review and critically discuss to what degree past research studying complex perceptual motor skills in sports has or has not adequately addressed these issues. Secondly, based on our current research project into sailing we illustrate how we have addressed these key issues in in-situ experiments. Finally, we argue that the presented pilot work provides a clear example of how the collaboration between coaches, athletes and sports scientists sparks the methodological development to capture skilled performance in sailing.
Differences in Laboratory and Field Experiments

Laboratory and field experiments are the two key research settings, which have been used to further our understanding of how perceptual-motor skills are executed by skilled performers (Xiao & Vicente, 2000). While it is well established that each research setting has its advantages and drawbacks (Abernethy, Thomas, & Thomas, 1993), it is interesting to note that over the past two decades approximately two-thirds of all sports science research in Australian research institutes and universities has been conducted in laboratory settings (S. J. Williams & Kendall, 2007). Recent research, however, indicates significant differences between laboratory studies and representative experimental settings particularly for the measures of visual search behaviour and movement behaviour (Dicks et al., 2010; D. L. Mann, Abernethy, Farrow, et al., 2010; D. T. Y. Mann et al., 2007). For example, Dicks et al. (2010) demonstrated that the visual search behaviour of goalkeepers during soccer penalty kicks significantly differs between video simulation and in-situ conditions (Farrow & Abernethy, 2003). These findings emphasize how experimental conditions can markedly alter an athlete’s behaviour.

With this in mind, we identify and discuss key methodological issues that are relevant when comparing these two types of experimental environments, particularly when aiming to translate sport scientific knowledge into practical guidelines for coaches and athletes: i) representative performance environment (Schmuckler, 2001; van der Kamp et al., 2008; Xiao & Vicente, 2000), ii) generalisability (Berkowitz & Donnerstein, 1982; Green & Glasgow, 2006; Lucas, 2003; Mook, 1983), and iii) experimental control (Dicks et al., 2010; Dicks, Davids, & Araujo, 2008).

Representative Performance Environment

In sailing there is a high level of inter-individual dynamics and the ability of sailors to create uncertainty in the environment for fellow competitors is paramount to successful performance. Sailors can, for example, alter their approach line, gain speed in a squall or vary their heel angle. However, whereas the issue of engaging opponents is typically not considered in laboratory settings, studies in the field provide the opportunity to capture the relationship between the performance environment, including fellow competitors, and athletes’ actions (Passos et al., 2008). Notably, the dynamic situation on the water affords ever-changing opportunities for action (Fajen, Riley, & Turvey, 2009). Hence, a competitive performance environment might give structure to an athlete’s skilled performance, that is, athlete’s perceptual-motor skills to cope with uncertainty of situational constraints, such as fellow competitors and changing environmental
characteristics (Passos et al., 2008). Athletes in representative experimental designs need to be provided with opportunities to establish functional relationships between perception (e.g., visual information) and action (movement). As Pinder et al. emphasise: “Since information regulates actions, an important principle is that the critical perception and action processes that are coupled in a competitive performance environment should be maintained in the design of experimental task constraints” (Pinder, Renshaw, Davids, & Kerhervé, 2011, p. 796). Following Brunswik, a representative design is defined as “the arrangement of constraints in an experimental design so that they represent the behavioral setting to which the results are intended to apply” (Pinder, Davids, Renshaw, & Araújo, 2011, p. 148). In a representative performance environment achievement is based on comparable information sources (i.e. perceptual cues or other stimuli) – and athlete’s responses remain the same – to those in a competitive performance environment. Achievement refers to the adaptation of an organism to a specific environment (Brunswik, 1956). To clarify the effect of a representative performance environment on experimental results, different types of stimuli and responses, used in field and lab experiments, are discussed.

First, the stimuli used across different research settings can vary, for example, the timing of the information or the quality of the stimulus presentation can alter markedly. Participants in competitive environmental settings see, feel, and hear relevant stimuli continuously and unobtrusively (Abernethy, 1996; A. M. Williams & Grant, 1999), while participants in laboratory settings often react (and start their action) from the moment that a perceptual stimulus is presented on a video or computer screen (e.g., Paull, Case, & Grove, 1997). A stimulus may be any form of external information, in particular the direction of the non-kicking leg of a penalty taker in soccer save (e.g., Savelsbergh, van der Kamp, Williams, & Ward, 2005; Savelsbergh et al., 2002), the setter’s initial contact with a volleyball (Starkes, Edwards, Disanayake, & Dunn, 1995), or the back foot contact of a bowler in cricket (Müller, Abernethy, & Farrow, 2006; Müller & Abernethy, 2006). A considerable amount of the research literature on perceptual-motor skills has used video or computer simulations to examine expert-novice differences across a broad spectrum of sports such as soccer (e.g., Savelsbergh et al., 2005, 2002), tennis (e.g., Farrow & Abernethy, 2003; Huys et al., 2009; Rowe, Horswill, Kronvall-Parkinson, Poulter, & McKenna, 2009), field hockey (e.g., Cañal-Bruland et al., 2010) and sailing (e.g., Araújo, Davids, & Serpa, 2005). However, all of these studies are potentially limited by an inability to truly simulate the visual information experienced by athletes in a competitive performance environment (Dicks et al., 2010; Dicks, Davids, & Button, 2009; D. L. Mann, Abernethy, Farrow, et al., 2010). Stimuli on a video or computer screen might not adequately reflect those stimuli that trigger the action of an athlete in the field. For example, three-dimensional information guiding the perception of depth is undoubtedly lost or decreased. Consequently, participants might not show the visual
search and movement behaviours that they would in a competitive performance environment. In other words, achievement in a lab setting is not based on comparable information sources to those in a competitive environment. Therefore, it can be questioned whether the findings from lab research sufficiently transfer to the field (Dicks et al., 2010).

Second, a review of perception-action research reveals that the type of response significantly alters the expert-novice difference typically reported in studies on expertise. In most recent studies within laboratory settings responses are measured in different ways: verbally (e.g., Farrow & Abernethy, 2003; Ranganathan & Carlton, 2007; A. M. Williams & Davids, 1997), with pen-and-paper responses (Huys et al., 2009), by a button press (e.g., Cañal-Bruland, van der Kamp, & van Kesteren, 2010; Sebanz & Shiffrar, 2007), with a simulated joystick movement (e.g., Savelsbergh et al., 2005) with simulated responses (e.g., Farrow & Abernethy, 2003; Shim, Carlton, Chow, & Chae, 2005). In sports, however, movements are not constrained in such a rigid way. Movements naturally vary from trial to trial and may still lead to similar outcomes (e.g., a successful free-throw in basketball) (Oudejans & Coolen, 2003). Laboratory studies often reduce complex perceptual-motor skills to a simpler level and there is an on-going debate that these studies may not adequately simulate the athlete-environment interaction (e.g., Pinder, Davids, et al., 2011; van der Kamp et al., 2008). In particular, participants in laboratory studies were frequently limited in their motor degrees of freedom (Bernstein, 1967), but also in their perceptual degrees of freedom, thereby not being able to perceive or respond to the situation as in a competitive performance environments (Savelsbergh & van der Kamp, 2000). Therefore, several authors support the notion that representative perception-action coupling is essential when conducting scientific sports experiments and thus call for representative task designs (Araujo et al., 2007; van der Kamp et al., 2008). Based on the framework of Pinder et al. (2011) an in-situ design should be based on comparable information sources (i.e., fidelity of stimuli), and athletes’ responses (i.e., fidelity of response) should remain the same compared to those in a competitive performance environment.

GENERALISABILITY

Closely connected to the issues related to the type of stimulus and type of response, the generalisability of conclusions from laboratory studies are often questioned in applied sports science (e.g., Dicks et al., 2010). Generalisability refers “to whether results of a study can legitimately be generalised to a specified broader population” (McTavish & Loether, 2002, p. 133) and whether the results are “not confined to the particulars of time and place” (Lucas, 2003, p. 236). In general, if the objective is to translate sports scientific knowledge into practical guidelines that generalise
to a specified broader population (e.g., sailors with equivalent skill level), then results that are more generalisable are viewed as more desirable than results that are less generalisable (D. L. Mann, Abernethy, & Farrow, 2010). However, experimental findings from many laboratory studies in sports science cannot be generalised to competitive settings and to the specified broader population. In response to this criticism some researchers (Berkowitz & Donnerstein, 1982; Mook, 1983) argue that the set-up of an experiment does not always require settings and participants that project competitive environmental conditions.

They point out that the advantage of laboratory experiments lies within the simplification of competitive situations to only theoretical meaningful aspects, eliminating variables that are not relevant and making generalization more likely. However, Mook (1983) acknowledges the need for generalisability under circumstances in which researchers aim to derive predictions for functional behaviour, such as in applied (sports) settings. During athlete-environment interactions in an applied sports science experiment, achievement (i.e., the adaptation of an athlete to the environment) should be corresponding with functional behaviour as in a competitive performance environment (Araújo et al., 2006; Araujo et al., 2007; Pinder, Davids, et al., 2011). Furthermore, based on Brunswik’s ideas, Pinder et al. recently stated, “just as participants of an experiment must be representative of those to which the study wishes to generalise, the experimental task constraints must also represent the environmental (performance) constraints to which they are to be generalised” (Pinder, Davids, et al., 2011).

EXPERIMENTAL CONTROL

The issue of generalisability also has a direct impact on experimental control (Dicks et al., 2010). On the one hand, it is well known that laboratory tasks commonly allow greater experimental control when compared to field studies. In favour of laboratory experiments, Lucas validly argues that “laboratory experimental conditions allow researchers to examine only elements of the situation that are relevant to a certain theory under test; other elements that may mask or vary with predicted effects are eliminated” (Lucas, 2003, p. 246). However, in field studies experimental control is often difficult to achieve, especially while studying perceptual-motor skills influenced by, and highly attuned to, unpredictable environmental factors. Therefore in in-situ designs sport scientists are challenged to identify and measure all relevant environmental factors, thereby creating the opportunity to categorise trials by environmental conditions afterwards. The preference for simplified research designs in laboratory settings often emphasizes experimental control and therefore disregards the importance of these environmental characteristics (Dicks et al., 2010, 2008). To support generalisability and to improve experimental control, considerable
technical sophistication and careful descriptions of seemingly simple phenomena in the field (i.e., on the water) are required (Araújo et al., 2006).

In summary, the key methodological issues of representative performance environment (including fidelity of stimuli and type of response), generalisability and experimental control have a tremendous impact on how to set up experimental research which seeks to translate research findings into practice. Representative experimental settings, based on the ideas of Brunswik and the insights of Gibson, provide full visual information for participants, and in doing so participants are able to perceive and process varying types of stimuli uninterrupted, and can respond without dealing with unnecessary environmental or task constraints (Brunswik, 1956; Gibson, 1979). In order to study complex perceptual-motor skills, experimental conditions should provide participants with opportunities for action and perception in a representative environment while trying to measure all relevant performance and environmental characteristics. In the following, we illustrate an initial attempt, based on our current research project into sailing, on how to adequately implement these issues into technological advancements when running in-situ experiments.

AN EXAMPLE: A COMPLEX EVENT IN SAILING

If one aims to capture and understand skilled performance in complex sports, several key factors need to be taken into account. For instance, in sailing, sailors have to deal with wind shifts, waves at sea, a changing tide, fellow competitors, and the optimisation of boat settings (Davidson, 2009). The technical skills are therefore an essential component of a sailor’s ability to sail as fast as possible at all times. Furthermore, decision-making at the right time is necessary in order to sail the optimal route (Araújo et al., 2005). The fastest course to reach the finish line is variable, since the wind and waves usually change in direction and speed along the course. These unpredictable environmental factors add to the level of perceptual-motor complexity in sailing.

If the aim of a research project is to inform or translate information into practice, then experimental designs in the field should replicate as closely as possible the perception-action coupling produced in the performance domain in order to extract a full picture of expertise (D. L. Mann, Abernethy, Farrow, et al., 2010; Pinder, Davids, et al., 2011). Therefore athletes must be given the opportunity to detect information-rich areas in the field so that they can direct their attention appropriately and extract meaningful information from these areas (A. M. Williams et al., 1999). In line with this argument, empirical findings have indicated that context-specific expertise effects are exhibited more clearly under representative (in-situ) experimental conditions than in simulation laboratory settings (D. T. Y. Mann et al., 2007).
Moreover, in addition to empirical findings also current theoretical frameworks, such as the two-visual systems model by Milner and Goodale (1995), support the notion that perception and action should be coupled in an unrestricted manner (van der Kamp et al., 2008). So far, however, sailing has predominantly been studied by obtaining data using computer simulation scenarios in which participants were required to react verbally, or by pressing keyboard buttons during dynamic sailing tasks (see Araújo et al., 2006; Walls, Bertrand, Gale, & Saunders, 1998; for an exception, see Araújo et al., 2005). Despite their experimental control, these studies would have been more representative if the authors had included more realistic movement behaviours such as when sailing in a competitive performance environment.

In the remainder of this chapter, we present and discuss our current approach to effectively capture complex perceptual-motor skills in sailing in light of the methodological criticisms raised in this chapter. To this end, we illustrate some pilot work that outlines how the close collaboration between coaches, athletes and sports scientists may advance the methodological development to adequately capture skilled performance in sailing. As an example, our approach to measure complex perceptual-motor skills in the field is demonstrated based on a complex sailing manoeuvre – dubbed a windward mark rounding – in a genuine single-handed Olympic boat. During a sailing regatta many small events within a couple of hundred milliseconds occur that can make the difference between winning and losing. The findings of Araújo and colleagues (2006, 2005) suggest that expertise in perceptual-motor skills may be of great significance in sailing, especially during these critical events. For Davidson (2009), an event refers to a critical moment to win time relative to an opponent, for example by performing a neat start, or a perfect rounding of a mark. Throughout this chapter, the term mark is used to refer to “a floating buoy or other fixed-position indicator of the end of one leg of a racing course and start of the next. Boats must typically turn 2-3 rad (120-180°) as they round a mark” (“Glossary of sailing terms,” 2007, p. 1077). A leg is defined as a length of water between one mark and the next. To demonstrate our approach, data is systematically collected during a relevant but relatively short event in a sailing regatta: the rounding of the windward mark. This particular event was identified as highly relevant and important following formal discussions and questionnaires that were completed by interviewing elite coaches and sailors in the Netherlands.

The aim in rounding the windward mark is to turn the boat from a close-hauled course onto a downwind course while staying as close to the mark as possible. The term windward is used to refer to the side of a boat, or direction of sailing, towards the wind. The rounding of a windward mark is not dependent on wind direction. The rounding may be divided into three main parts and is considered to be a complex perceptual-motor skill: i) the last straight line toward the windward mark, starting immediately after the last tack; ii) the actual rounding of
the mark, starting when the boat turns, indicated by letting the mainsheet out, steering away from the wind, and moving the body outside, causing the boat to heel windward; and iii) the period of time beginning after the rounding as soon as the course is straight, lasting for at least two seconds (Davidson, 2009; “Glossary of sailing terms,” 2007). For the helmsman this is a challenging manoeuvre to master because of the small rudder and powerful rig, which means that a good technique is imperative. The task of the helmsman varies according to the boat class. The boat trim and heel should all be employed to assist turning the boat. Heeling may be defined as tilting a boat away from the wind due to its sideways pressure on sails. This will allow the sailor to maintain maximum tactical options on exiting the mark.

The pilot work is illustrated briefly in the next section by integrating recent technology to capture skilled performance of a sailor throughout the duration of a windward mark rounding.

INTEGRATING TECHNOLOGY TO CAPTURE PERFORMANCE

The rounding of a windward mark is a complex perceptual-motor skill. To unravel the performance of a sailor during a windward mark rounding it is necessary to utilise a variety of testing equipment. The key task is to combine different types of technology in a smart and simple manner to effectively evaluate the overall performance of a sailor on the water. The following set-up functions as an example to systematically collect data while sailors round the windward mark. The set-up can be best considered as consisting four sections which interact to evaluate overall performance: i) visual search behaviour of the sailor, ii) movement behaviour of the sailor, iii) environmental conditions (e.g., wind), and iv) performance of the boat. These variables approximate the competitive performance environment that is under investigation (Pinder, Davids, et al., 2011). For this set-up, an Olympic single-handed sailing boat was used: the Laser. The Laser is the world’s numerically largest class of singlehanded sailing dinghy for adults and has been an Olympic class for men since 1996 (Davidson, 2009).

VISUAL SEARCH BEHAVIOUR

Visual search behaviour is recorded with a mobile eye tracker attached to a pair of safety glasses, in this case using the Applied Science Laboratories (ASL) Mobile Eye Tracker (version 2). The Mobile Eye samples point of gaze at 30 frames per second. With a mobile eye tracker it is possible to record the visual search characteristics of sailors in their performance environment: mean number of fixation points, mean number of areas fixated on, and mean fixation duration for each trial (for more information, see e.g., Dicks et al., 2010). For example, these visual search
characteristics have been addressed in several other situations similar to rounding a windward mark, e.g., in speed skating on an Olympic Oval and when negotiating bends during car driving (Falkmer & Gregersen, 2005; Kandil, Rotter, & Lappe, 2010; Panchuk & Vickers, 2006; Wilson, Stephenson, Chattington, & Marple-Horvat, 2007). Based on these studies we hypothesise that high skilled sailors i) have more control over their boat handling thereby allowing them to gaze more outside the boat in general, ii) gaze more to the tangent point just before - and during – the actual rounding similar to findings from car driving and speed skating studies driving (Falkmer & Gregersen, 2005; Kandil et al., 2010; Panchuk & Vickers, 2006; Wilson et al., 2007), and iii) have less fixation points of longer duration during the mark rounding as occurring in studies in a wide range of sports (e.g., Savelsbergh et al., 2005, 2002). The eye tracking glasses are relatively lightweight and unobtrusive. The recording device is placed in a small waterproof backpack that is worn on the chest of the participant so that it does not hamper the participant in his or her movements (Figure 2.1).

The eye image and scene image are interleaved and saved on a DVCR tape (60 minutes), which are analysed with EyeVision software on a laptop computer using a licence key. In Figure 2.2 several fixation locations during the rounding of a windward mark are displayed. The locations of gaze are utilised to calculate percentage-viewing time for each fixation location (e.g., Cañal-Bruland, van der Kamp, Arkesteijn, et al., 2010; Dicks et al., 2010; Savelsbergh et al., 2005, 2002).

MOVEMENT BEHAVIOUR

The movement behaviour of a sailor is recorded using a waterproof GoPro video camera mounted on the bow of a Laser; an example of the perspective of the GoPro is shown in Figure 2.1. Recording can be performed at 30 or 60 frames per second, providing the opportunity to obtain the timing of key movements in reference to the point where sailors were positioned right above the mark during the rounding of a windward mark (Figure 2.3) (D. L. Mann, Abernethy, Farrow, et al., 2010; Oudejans & Coolen, 2003). The images in Figure 2.3 are screenshots captured and adapted from a DVD instruction video to illustrate a regular windward mark rounding (van Mackelenbergh, 2010). This video was shot from a coach boat nearby. Some examples of key movements during a mark rounding as identified in the literature (Davidson, 2009; van Mackelenbergh, 2010) are i) the release of the outhaul and kicking strap (these are trimming lines) during the approach phase of a windward mark, ii) heeling to the windward side during the actual rounding, and iii) pulling up of the centreboard in the exit phase. The GoPro video – synchronised with the corresponding GPS track
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- **FIGURE 2.2.** Fixation locations of the visual search behaviour of a sailor. Marked by letters a-h: 
a) virtual inner curve of the rounding mark; 
b) interception of the mark and boom; 
c) interception of the horizon and next downwind mark; 
d) in front of the boat; 
e) upwind area; 
f) other sailor; 
g) other boat through sail; 
h) trimming: cunningham.

- **FIGURE 2.3.** Some key movements during the rounding of a windward mark in time. Marked by letters a-g: 
a) cleaning up the mainsheet; 
b) releasing theouthaul and cunningham; 
c) releasing the kicking strap and mainsheet; 
d) sailing the boat to windward side, moving body to behind; 
e) moving body to inside; 
f) possibly releasing the cunningham more; 
g) putting centreboard up; 
Right: The track of a windward mark rounding (top view) with the letters of the corresponding key movements displayed.
– provides the opportunity to obtain the timing of key movements in reference to a point \( t = 0 \) where sailors were positioned right above the mark during the rounding of a windward mark (Figure 2.3). From this point on, key movements were identified 4500 ms before and 4500 ms after \( t = 0 \). On average, key movements were performed within these 9000 ms. Movement responses are coded in milliseconds in reference to \( t = 0 \) and averaged across other trials that were performed in the same wind condition. Wind speed was obtained by multiple iPhone applications, such as Navionics Europe (version 2.5.6), WindGURU (version 2.0) and Windfinder (version 2.0). These applications delivered us information about possible tides, wind speed, gust, and direction per hour. We hypothesise that high skilled sailors are more attuned to differences in environmental conditions (e.g. low versus strong wind) and are therefore more consistent in reproducing successful movements (Araújo et al., 2005). On the water, participants are able to respond without any limitation to every stimulus available in the environment (Dicks et al., 2010; Pinder, Davids, et al., 2011; van der Kamp et al., 2008).

ENVIRONMENTAL CONDITIONS

To control for unpredictable environmental factors such as wind, a wind wand (Tacktick) mounted either on the mast or bow of the sailing boat provides wind information. The measurement of wind speed is a key factor in our attempt to capture environmental conditions in sailing. More specifically, multiple trials from sailors with different skill levels are categorised into one of the following three categories: i) 0-5 knots, ii) 5-8 knots, and iii) 8-12 knots. As a result we can compare trials – from the same wind condition - across participants. These measures, and others like wave strength and strength of currents help us to effectively evaluate performance across different participants. The Technical Support Division of the VU University in collaboration with InnoSportLab The Hague is currently in the process of developing a tool to measure wave strength in metres and currents in metres per second. In future studies this tool is most likely to be integrated to capture relevant environmental conditions. So far, we used multiple iPhone applications like Navionics Europe, WindGURU and Windfinder.

PERFORMANCE OF THE BOAT

The Pi Garda logger, which houses an internal battery, a three-axis accelerometer, and a high performance GPS, is used to log data from on-board sensors as well as the boat’s position and speed via a 5 Hz GPS; that is, the GPS receives a fix every 200 ms. The Pi Garda logger uses NMEA (National Marine Electronics Association) communication protocols to work with other
systems, such as the Tacktick systems. The Pi Garda logger is positioned at the starboard side of the mast. The Pi Garda logger and the Pi Toolbox software is used to track, measure, and evaluate critical elements of sailboat performance (e.g., boat speed, heel angle or course over ground).

The video data from the ASL eye tracker and GoPro are synchronised (by UTC time) and coupled to the GPS track within the Pi Toolbox software package. The software searches the nearest video frame for any given moment in time; using this method it is possible to load and synchronise videos, of any type of video recording equipment, for comparison with any other data feed. As a result, it is possible to simultaneously review synchronised data variables: GoPro video footage, mobile eye video, GPS tracks, boat speed, GPS course over ground, heel angle, and rudder angle. Synchronisation is achieved via a UTC/GMT iPhone application (Emerald & Sequoia LLC; version 1.5) which uses Network Time Protocol (NTP). The application uses these NTP servers on the Internet to obtain a more accurate time than is typically available from a device’s internal clock. A large clock display shows the corrected time obtained from the NTP servers in UTC time; the average round-trip-time (rtt) to the server varies between 50 and 200 ms and is processed in the corrected time. A red, yellow or green light above the UTC time indicates the quality of the server connection in the iPhone application. A green light is on when quality is sufficient. We used the 3G networks for our Internet connection; average Internet speed varied between 144 and 284 Kilobytes per second. UTC time was presented several times during a measurement (e.g., every 20-30 minutes), both to the scene camera of the mobile eye tracker and GoPro to minimize errors when videos were analysed subsequently in relation to other data feeds. In addition, the export of multivariate data from Pi Toolbox to other software packages such as Microsoft Excel or IBM PASW Statistics is convenient. Pi Toolbox is a suitable software option to inform coaches and athletes immediately after a measurement in the field. This tool significantly improves translation from research to practice (Bishop, 2008).

WHY DO WE FOLLOW THIS APPROACH?

With the above procedure we set up an initial attempt to capture and understand skilled performance in sailing to translate sport scientific knowledge into practical guidelines for coaches and athletes. We sought to address key methodological issues outlined previously in an attempt to adequately capture complex perceptual-motor skills in sailing. In our research project we made sure that sailors were able to perform a complex sailing skill in a representative performance environment. That is, we measured sailors’ performances in the field, or one should better say, on the water. Given our aim to translate our knowledge directly into practical guidelines for athletes
and coaches, moving to the water is imperative because laboratory studies may fail to adequately sample the environmental characteristics (van der Kamp et al., 2008). More specifically, no video simulation or similar methods are used and three-dimensional visual information is fully provided (Dicks et al., 2010; Pinder, Davids, et al., 2011). Using an in-situ approach, sailors did not have to wait for perceptual stimuli before an action was initiated (Farrow & Abernethy, 2003; Panchuk & Vickers, 2006), as is the case in laboratory studies. Actions of sailors in this research design are based on similar stimuli that trigger sailor’s action in the field. Hence, the entire natural flow of information from the onset of the trial until the end of the trial can be used to form the basis of an action. By measuring movement behaviour on the water (i.e., the type of response) the sailor’s actions are captured during the whole trial and remain the same compared with a competitive environment (Pinder, Davids, et al., 2011; van der Kamp et al., 2008). That is, sailors are neither limited in their motor nor perceptual degrees of freedom (Savelsbergh & van der Kamp, 2000). Therefore in our project sailors are able to adapt their actions to environmental changes, thereby giving us the opportunity to gain deeper insights into the complex perceptual-motor skills of expert sailors.

Secondly, laboratory experiments are considered to be less generalisable, because the transfer of research findings from one sample to a specified larger population may not be applicable (Lucas, 2003). Our approach is an attempt to generalise research findings in sailing. That is, one of our aims is to generalise specific findings to a specified broader population (e.g., sailors with equivalent skill levels) and to immediately provide feedback of these results to coaches and athletes to improve performance (Dhami, Hertwig, & Hoffrage, 2004; Mook, 1983).

Finally, experimental control in field studies is often complicated to achieve (Dicks et al., 2010; Ericsson & Williams, 2007). As addressed already, laboratory tasks commonly have the benefit of greater experimental control when compared to representative experimental settings (Berkowitz & Donnerstein, 1982; Mook, 1983). This is considered a thorny issue, but should not distract sport scientists from the measurement of complex perceptual motor skills in the field. In the near future technical tools to measure wavelength, wave height, and the strength of currents have the potential to measure environmental conditions for each trial. This allows us to analyse visual search and movement data across trials and participants, categorised by relevant environmental conditions such as wind strength. In this regard, sports scientists might benefit from better embracing new technological developments and close collaborations with other disciplines (A. M. Williams et al., 2011). The recent technological advances in eye tracking systems (i.e., wireless digital recording and improved data collection technology) and remote monitoring sensor systems are examples that provide a practical option to better capture and understand visual search behaviour of athletes in in-situ research designs (Dicks et al., 2009).
For the analysis of gaze data, Dicks et al. (2010) recently suggested that the averaging of data in statistical analyses may have disguised important individual differences in performance (for an alternative approach, Withagen & van Wermeskerken, 2009), and therefore question the existence of an optimal perceptual strategy. Our approach allows us to shed further light on this issue by comparing our findings with previous research results performed in laboratory settings, and to identify both individual and group differences in sailors’ gaze strategies. Elite sailing coaches have an interest in examining complex events in the field, but are commonly eager to study the broad picture, for example, to capture performance during a whole leg or even a whole sailing regatta. As Williams and Kendall conclude: “An elite coach is concerned primarily with sports performance, whereas a sports science researcher is focused on increasing sports science knowledge (both applied and theoretical), based on sound research questions” (S. J. Williams & Kendall, 2007, p. 194). To support the collaboration between sport science and practice, it is of great importance to report useful and concise feedback to experts in the field after the research has been conducted (Farrow, Baker, & MacMahon, 2013). Additionally, findings from sport scientific research could be accepted and adopted more by athletes and coaches at whom they are targeted (Bishop, 2008).

This chapter has argued that our presented approach may be an adequate method to examine skilled performance within changing environments (such as in sailing), both from a methodological and practical perspective. By translating key methodological issues into technological advancements we aim to improve in-situ experiments in the field. Using, for example, waterproof and cold-resistant high-tech equipment, we could use this approach for the future design of experimental and practice tasks to capture and understand the skilled performance of other Olympic sports, such as kiteboarding, BMX racing, mountain biking, or snowboard cross. These sports have received little attention from a perception-action point of view. Note that we use our technology as a means to an end, not to an end itself. From a long-term perspective, a better understanding of skilled performance in the field, and the role of perception-action coupling in varying sports could support the talent identification of young athletes (Dicks et al., 2010). In addition, the knowledge gathered by our approach could contribute to the development of evidence-based perceptual training methods (Savelsbergh et al., 2010). We are currently pursuing our research project in sailing, in close collaboration with (elite) coaches and sailors to examine performance during specific sailing events. These experiments are designed to add substantially to our understanding of key predictors of skilled performance during sailing. An important practical implication when implementing these issues in in-situ experiments is that it allows us to optimise the scientific guidance of athletes, coaches and staff to the desired performance at world championships and Olympics by translating sports scientific knowledge into practice.