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Performance analysis in sport: Contributions from a joint analysis of athletes' experience and biomechanical indicators

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The purpose of this study was to test the usefulness of combining two types of analysis to investigate sports performance with the aim of optimizing it. These two types of analysis correspond to two levels of athletes' activity: (a) their experiences during performance and (b) the biomechanical characteristics of their movements. Rowing served as an illustration, and the activity of one female crew member was studied during a race. Three types of data were collected: (a) audiovisual data recorded during the race; (b) verbalization data obtained in interviews conducted afterward; and (c) biomechanical data. The courses of experience of the two rowers during the race were reconstructed on the basis of the audiovisual and verbalization data. This paper presents a detailed analysis of a single phenomenon of the race experienced by one of the rowers. According to the coaches, it reflected a dysfunction in crew coordination. The aim of this analysis was to identify the biomechanical characteristics of the rowers' movements that might explain it. The results showed that the phenomenon could be explained principally by an amplitude differential between the two rowers' strokes. On this basis, the coaches defined new training objectives to remedy the dysfunction in crew coordination.

Over the past several years, a research program in cognitive ergonomics as applied to sports situations has developed in France, based on the course-of-action theory originally developed in the field of French-language ergonomics (Theureau, 2006). The objectives are both scientific, through the production of new knowledge in sports sciences, and practical, through the conception of new aids for the development of high performance. The program includes a methodology for collecting and processing two types of data: audiovisual recordings and transcribed verbalizations. The audiovisual data are collected *in situ* during ordinary training sessions or official competitions using discreet equipment, mainly digital video cameras and microphones, that is easily adapted to a variety of sports. The verbalizations are collected during self-confrontation interviews (Theureau, 2006), during which the participant is confronted with an audiovisual recording of his or her behavior and is invited by the researcher to make specific comments on it. This methodology has several advantages: (a) sports performance can be studied in real situations; (b) researchers have access to the experiential dimension of performance, including athletes' concerns, intentions, sensations, emotions, expectations, and interpretations; and (c) changes in these dimensions, over the course of the performance, can also be determined.

This research program is original in the sense that sports performance is analyzed at the level of activity that is meaningful for the athletes; that is, the performance is associated with an experience that athletes can tell us about. This means that activity is described as the athletes experienced it, by a reconstruction of their "course of experience". By hypothesis, the "course of experience" is composed of a chain of discrete units of activity that are meaningful for the actor (Theureau, 2006). These units can be actions, focuses of attention, interpretations, judgments, sensations, or emotions. The "course of experience" does not account for all levels of activity organization: it can only be used to describe the activity phenomena that are considered "meaningful for the actor". The choice of this level of analysis is based on two major assumptions: (a) this level of organization can provide scientifically validated descriptions and explanations and (b) these same descriptions and explanations are useful in the conception of performance aids. By gaining access to subjective dimensions of performance, the studies of this research program have provided new insight into the experiences of high-level athletes in sailing, trampoline, table tennis, and basketball (e.g. Durand et al., 2005; Hauw & Durand, 2006; Sève et al., 2006; Bourbousson et al., 2010), and have yielded more transversal data on athletic behavior, such as interpersonal coordination (e.g. Poizat et al., 2009; Bourbousson et al., 2011). Moreover, the results of some of these studies have been used by athletes and coaches to develop new training procedures (e.g. Hauw et al., 2003; Sève et al., 2006).

To date, courses of experience have been reconstructed to study sports performances in which the athlete's activity is considered as an important tactical or strategic component. This method has seemed less well adapted for studying sports requiring the mastery of highly automatic cyclical movements, such as rowing. Yet a recent study of rowers' courses of experience showed that during a race the rowers took their partner's activity into account in a way that was "meaningful for them" (Saury et al., 2010). The need to synchronize their actions required them to adjust to each other and constantly coordinate throughout the race. They did so moment by moment on the basis of judgments about how synchronized their oar stroking was, and their mutual concerns for adjustment were expressed using diverse modalities. Crew coordination was thus revealed to be an unceasing process of *in situ* adjustment in response to the constant threat of falling "out of synch". The analysis of the courses of experience revealed four typical modalities of mutual adjustment, respectively characterized by the following concerns: (a) "Be a stable reference for one's partner" (i.e. focus only on one's own stroking to ensure constant cycles and make it easier for the partner to synchronize with one); (b) "Encourage the partner to adjust to oneself" (i.e. try to influence the other's behavior by giving verbal commands over the course of the race); (c) "Adjust to one's partner" (i.e. try to modify one's behavior in line with the partners' commands or the perception of her implicit expectations); and (d) "Row together to get the best performance from the boat" (i.e. adjust the stroke cycle by staying focused on how the boat is performing). These findings raised questions about some of the main assumptions underlying explanations of crew performance, notably the importance given to a set of relatively stable factors assumed to pre-date the collective activity itself.

Although the study of Saury et al. (2010) presented original descriptions of some of the phenomena inherent to rowing coordination, it was quite difficult for the rowers to account for very fine sensorimotor adjustments. Certain facets of rowing coordination could not be characterized with precision. The results indicated, for example, that at any given moment the rowers had a judgment about how well coordinated they were with their partner based on a variety of sensorial information. However, they described their perceptions of the quality of coordination in a very syncretic manner and were unable to specify the sensations on which the judgment was based. Thus, the analysis of course of experience has limitations to understand accurately sports performances requiring the mastery of highly automatic cyclical movements. It seems useful to combine this analysis of course of experience with objective indicators of subtle behavioral adjustments.

To test the usefulness of a joint analysis, we chose to focus on the coordination of a rowing crew. We made this choice for two main reasons: (a) coordination is assumed to be an essential element of crew performance, as boat speed depends in part on the degree of coordination in stroking, and (b) coordination is well suited to a joint analysis in that mechanical and biomechanical measures are regularly taken in the framework of both research and training (e.g. Wing & Woodburn, 1995; Baudouin & Hawkins, 2004). In most studies, these measures concern boat speed and/or acceleration, the power developed by the rowers, the rhythm of oar stroking, and time gaps in the rowers' stroking (e.g. Baudouin & Hawkins, 2004; Hill & Fahrig, 2008). These measures capture facets of performance that depend on very fine sensorimotor adjustments that may escape rowers' awareness as they recall their experience.

The advantage of a joint analysis is that a wider range of phenomena can be taken into account than would be possible if only one or the other analysis was conducted alone. The goal of this case study was thus to test the usefulness of combining two levels of activity analysis: the course of experience and objective performance indicators. More specifically, we sought to determine how the biomechanical performance indicators would enrich our understanding of the rowers' perceptions during a race and dysfunctions in crew coordination. To our knowledge, only the work of Lippens has investigated coordination in rowing by combining a new interview technique with biomechanical measures (Lippens, 2005). The case study presented in this paper is an extension of this work.

Methods

Participants and situation

A junior women's coxless pair crew from Pole France of Nantes participated in this study, which was conducted in collaboration with their coach. The protocol was explained in full to them, and they provided written consent to participate in the study, which was approved by the university ethics committee. The coxless pair is a boat for two rowers, each having a single oar. Marion, 18 years old, was the "stroke rower" and Lucy, 17 years old, was the "bow rower". These rowers were in the top 10 of their category in France. This was their first season rowing together.

The rowing activity was studied during a 3000-meter race against the clock, which lasted 12 min and 35 s. This race took place at the beginning of the competitive season, while the team had been rowing together for a month. Five months later, the crew placed third in the French championships, and the two rowers were selected to be on the French junior team for international competition.

Data collection

Data collection for analysis of the courses of experience

The rowers' behaviors and verbal communications (both rowers were equipped with high-fidelity microphones) were recorded during the entire race with two video cameras. The race was filmed from a second boat that kept pace with the coxless pair.

Self-confrontation interviews were held immediately after the race. The self-confrontation interview has points in common with the interview technique of stimulated recall, which was developed and tested by Trudel et al. (1996). The interview techniques are based on video recordings of the participants during competition; as the participants then view these videotapes, they are invited to comment. In this study, each rower was separately shown the audiovisual recording of the race and encouraged to "re-experience her race" in order to describe and comment on her experience (what she was doing, feeling, thinking, perceiving) at each instant of its unfolding. The researcher helped the rower in this description with prompts about her sensations, perceptions, focuses of attention, concerns, emotions, and thoughts. Each interview was recorded in full using a digital camera so that the race trial events could be mapped to the comments in the self-confrontation interviews.

Biomechanical and mechanical measures

The biomechanical and mechanical data were collected during the race using the *Powerline* system (Peach Innovations, Cambridge, UK). This system has a data acquisition and storage center connected to several sensors: two sensors measure the forces applied at the pin of the oarlocks (in the direction of the longitudinal axis of the boat) and two sensors measure the changes in oar angles in the horizontal plane (angle formed by the oar with the axis perpendicular to the longitudinal axis of the boat). The accuracy of the force and angle sensors is 2% of full scale (1500 N) and 0.5°, respectively. The calibration of sensors was carefully checked before the experiment.

Data analysis

Analysis of the courses of experience

First, the data from the audiovisual recordings and the interview were fully transcribed. These transcriptions were synchronized on a table: the first column noted the race time; the second, the rowers' verbal communications during the race; and the third and fourth, the rowers' and researcher's verbalizations during the self-confrontation interviews (Table 1).

Second, we reconstructed the courses of experience of the two rowers during the race. A course of experience is a chain of activity units that are meaningful for the actor. By hypothesis (Theureau, 2006), an activity unit results from the articulation of six components that respectively account for the following phenomena of human experience: (a) the actor's concerns at instant t; (b) the actor's expectations at instant t; (c) the knowledge mobilized by the actor at instant t; (d) the elements of the situation taken into account at this instant; (e) the part of the actor's activity that is meaningful to him or her at instant t (action, communication, focus of attention, interpretation, or sentiment); and (f) the construction of new knowledge at this instant (Sève et al., 2007). Analysis consisted of reconstructing the chain of meaningful activity units for each rower on the basis of the audiovisual recordings and verbalizations.

Third, the rowers' courses of experience were time-synchronized so that we could compare the similarities and differences in their concerns, expectations, perceptions, and interpretations at each instant of the unfolding race.

Fourth, we identified the race phenomena that were meaningful for the rowers. This identification was based on a comprehensive analysis of their courses of experience.

Calculated biomechanical parameters

Parameters were calculated from the rowers' strokes to account for each rower's individual performance (stroke speed and duration, stroke amplitude, power produced) and the degree of rowing synchronization (differences in stroke amplitude and time gaps in stroke phases). Wilcoxon tests were performed to assess the statistical differences in parameters between rowers. The statistical significance was set to $P < 0.05$.

Crossed analysis of courses of experience and biomechanical parameters

First, we identified the salient phenomena of the race from the rowers' points of view through an analysis of their courses of experience. This analysis revealed several typical experiences concerning coordination during the race; for example, the sensation of "being in synch" or "not being in synch", the sensation of being just a bit in advance of or behind the partner's movements, or sensations of the boat's speed. Some perceptions were shared by the partners, while others were experienced by only one of them.

Second, we presented these results to the coaches. One salient phenomenon experienced during the race by Marion surprised the coaches: her perception of "being pushed" by her partner Lucy, which made her feel unable to fully carry out her movements. This phenomenon was particularly interesting for the coaches because, according to the pre-established roles, Marion as the stroke rower

Table 1. Extract from the crew's activity chronicle at the start of the race

Time	Rowers' verbal communications	Marion's self-confrontation	Lucy's self-confrontation
0'00" 15"	Marion: "Slow down!"	Researcher: So, at the start. . . for the first oar strokes . . . Marion: Right away the boat started moving. We didn't do it together. I also saw that we weren't in synch because we didn't get our oars into the water at the same time, I felt pushed in fact, I felt like she was ahead of me. Researcher: She was ahead of you. . . Marion: She went into the water before me, her oar went into the water before mine. And there, I felt it from the very first strokes. So there, right from the start I said to myself "Oh boy!" We're going to have to slow down and get ourselves in synch.	Researcher: So there. . . Lucy: The start was OK. Researcher: OK. . . Lucy: We were in synch, the boat was gliding along. And I had good sensations. I thought about really flattening my legs, positioning myself the way Christophe [the coach] told me to

should have been imposing the stroke rhythm, and Lucy as the bow rower should have been following the rhythm set by Marion. From the coaches' point of view, Marion's perception reflected a problem in the coordination of the rowers' actions. In this paper, we present a detailed analysis of this single salient phenomenon. The aim of the analysis was to identify the biomechanical characteristics of the rowers' movements that might explain this dysfunction in crew coordination.

Results

Marion's perception suggested three hypotheses about the biomechanical characteristics of the rowers' movements that might explain it. These hypotheses were tested using the measures of biomechanical parameters recorded during the race.

Test of Hypothesis 1 regarding a time gap in the catch phase

Hypothesis 1 concerned the time gap between the two rowers in the catch phase of the stroke cycle (beginning phase of propulsion): Marion's perception of "being pushed" could have been linked to a slight advance on the part of her partner at that moment (i.e. Lucy put her oar into the water and started the drive phase before Marion). Figure 1a presents a description of the temporal dynamics of the rowing cycle from the changes in oar angles in the horizontal plane (angle formed by the oar with the axis perpendicular to the longitudinal axis of the boat). The drive phase begins with a minimum oar angle (catch) and ends with a maximum angle (finish), and conversely for the recovery phase. With these signals, the beginning of the drive phase for each rower (t1 and t2) and the difference between the two rowers' catches could be timed (t1-t2). Figure 1b presents the changes in the temporal difference between the two rowers' catch phases (t1-t2) during the race. The analysis of the catch times (beginning of the drive phase), which were measured for each stroke cycle and averaged over the total race (Fig. 1b), invalidated Hypothesis 1. In fact, it showed that Marion was more often in advance of Lucy [mean ± SD of t1–t2: –0.026 ± 0.038 s, where t1 and t2 are the beginnings of the drive phase of rowers 1 (Marion) and 2 (Lucy), respectively]. To confirm this result, additional processing was performed to determine the temporal difference between the force onsets of the two rowers based on the method described in detail by Hill (2002). Briefly, force was first set to 0 during the recovery phase. Second, to eliminate the force produced by changes in the oar motion direction, the steepest slopes of the beginning and end of the force signals were extrapolated to the baseline (Hill, 2002). This extrapolated point was considered as the force onset. This last analysis showed results similar to the previous finding: Marion was in advance of Lucy in terms of their respective force onsets, with a mean temporal shift of 0.034 ± 0.038 s (Fig. 1c). It should be emphasized that these results did not agree with Marion's interpretation in the self-confrontation interview of her perception of "being pushed" by Lucy ("I had the impression that Lucy was ahead of me. . .she put her oar in the water before me.").

Test of Hypothesis 2 regarding the differences in stroke amplitudes

Hypothesis 2 concerned the difference in the stroke amplitudes of the two rowers. Marion's perception could be explained by Lucy's generally smaller stroke amplitude, giving Marion the sensation of not being able to perform her stroke with maximal amplitude. Figure 2 presents a description of the stroke ranges of motion calculated from the oar angles in the horizontal plane (angle formed by the oar with the axis perpendicular to longitudinal axis of the boat). The drive phase begins with a minimum oar angle (catch) and ends with a maximum angle (finish), and conversely for the recovery phase. These signals allow the calculation of the catch and finish angles, and then the amplitude of each rower's stroke. The analysis of the overall amplitudes of the oar sweeps showed that Lucy's stroke was less ample than that of Marion by 3.7 ± 2.6° ($P < 0.001$; Fig. 2b). Moreover, a more targeted analysis of the catch amplitude (Fig. 2c) showed that it was 5.1 ± 2.7° greater ($P < 0.001$) for Marion than for Lucy and that the variability of Lucy's catch amplitude measures was noticeably greater than that of Marion (standard deviation of the catch angle: 2.5° and 2.0° for Lucy and Marion, respectively). These results supported the second hypothesis: the measured amplitude differences, particularly during the catch, could explain in part Marion's sensation of "being pushed" by Lucy. This sensation was probably heightened by the high variability in Lucy's catch amplitude (Fig. 2c).

Test of Hypothesis 3 regarding a difference in the speed of the recovery

Hypothesis 3 concerned a difference in the speed of the recovery phase of the stroke cycle (i.e. the return of the rowers toward the back of the boat before a new propulsive phase): Marion's perception could have been linked to Lucy's recovery phase being faster than Marion's, which put pressure on Marion. Figure 3 presents a description of the temporal dynamics of the two rowers' recovery phases. The analysis of the recovery times indicated two phenomena that could be related to Marion's perception of "being pushed".

The first phenomenon was revealed by comparing the recovery times. Figure 3a shows that the recovery times were identical for the two rowers ($P > 0.05$; difference: 0.00 ± 0.04 s). This result is compatible with Marion's perception: the similarity in the recovery times implied that Marion, who had a bigger stroke amplitude, thus had

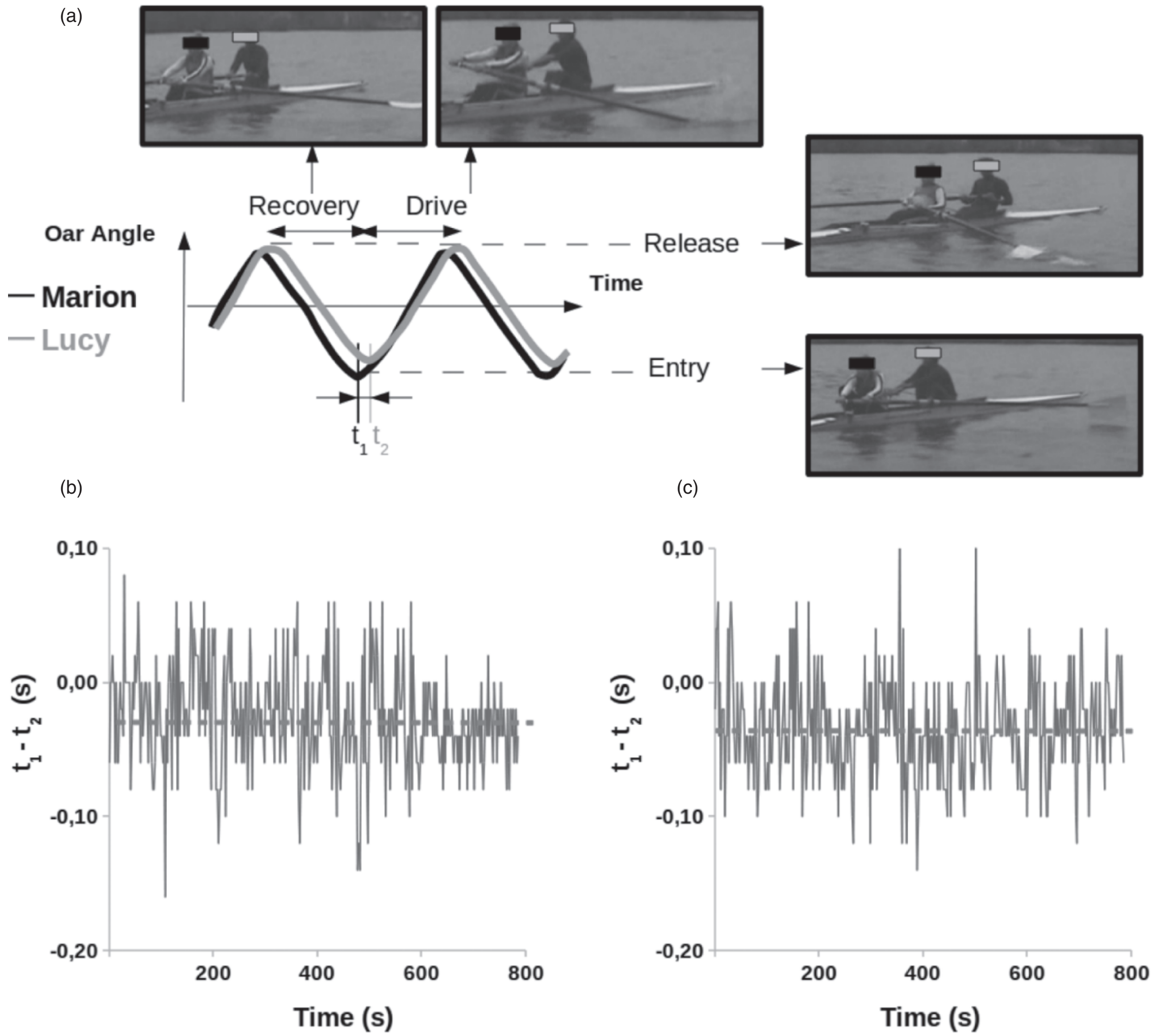

Fig. 1. Testing the first hypothesis. (a) Description of the temporal dynamics of the rowing cycle from the changes in oars' angles in the horizontal plane (angle formed by the oar with the axis perpendicular to the longitudinal axis of the boat). The recovery phase begins with a maximum of the angle of the oar (finish) and ends by a minimum (catch), and conversely for the drive phase. With these signals, the beginning of the drive phase for each rower (t1 and t2) and each rowing stroke can be timed. (b) Graph representing the changes in t1-t2 during the race. The average is represented by the dotted line. A positive value indicates that Marion is late at the catch compared with Lucy. (c) Additional processing to determine the force onset based on the method described in detail by Hill (2002). Briefly, force was first set to 0 during the recovery. Second, to eliminate the force produced by changes in the oar motion direction, the steepest slopes of beginning and end of force signals were extrapolated to the baseline (Hill, 2002). This extrapolated point was considered as the force onset, and the graph shows the differences in onset timing between rowers. A positive value indicates that Marion is late at the catch compared with Lucy.

to move more quickly during his recovery phase ($P < 0.001$; speed difference: $2.7 \pm 3.5°.s^{-1}$, Fig. 3b) in order to "catch up" to Lucy's movement and be synchronized for the catch.

The second phenomenon was revealed by comparing the times of the start and finish segments of the recovery movement (which had been divided into two phases of equal amplitude). Figure 3c presents the average angular velocity of the first part of the two rowers' recovery phases throughout the race, and Fig. 3d the average angular velocity of the second part of the two rowers' recovery phases throughout the race. The analysis showed that the speed in the first part of the recovery was greater for Lucy than for Marion ($P < 0.001$; speed difference: $-2.6 \pm 6.2°.s^{-1}$, Fig. 3c), and that, conversely the speed in the second was greater for Marion ($P < 0.001$). These findings also contribute to explaining Marion's perception: she may have felt "pushed" by her

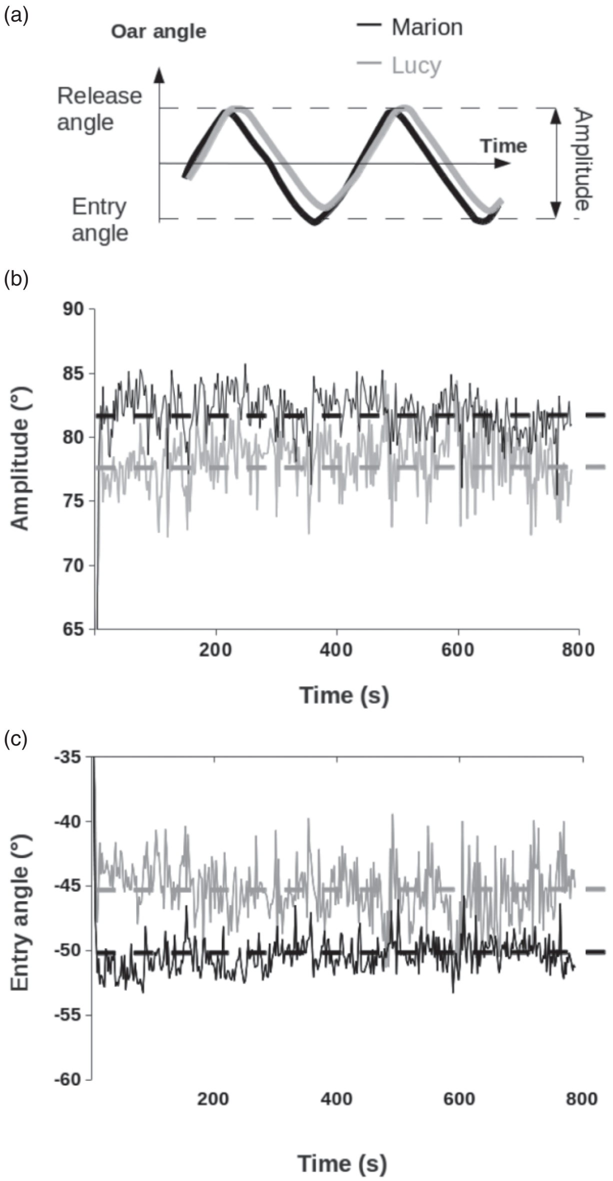

Fig. 2. Testing the second hypothesis. (a) Description of stroke ranges of motion calculated from the oars' angles in the horizontal plane. The recovery phase begins with a maximum of oar angle (finish) and ends by a minimum (catch), and conversely for the drive phase. These signals allow the calculation of the catch and finish angles, and then the amplitude of each rower's stroke. (b) Changes in stroke ranges of motion for Marion (black) and Lucy (gray) throughout the race. (c) Changes in catch angle for Marion (black) and Lucy (gray) throughout the race. The average values are represented by dotted lines. The smaller the catch angle, the greater the catch amplitude will be.

partner in the first part of the recovery, which would have been reinforced in the second part as she had to go faster to remain synchronized with Lucy for the catch ($P < 0.001$, speed difference: $8.0 \pm 7.6°.s^{-1}$, Fig. 3d).

Thus, the sensation expressed by Marion of "being pushed" by her partner could be explained principally by an amplitude differential between the two rowers. The sensation was likely heightened by the lack of stability in Lucy's catch amplitude and by Marion's slower first part of the recovery, which then required her to accelerate to "catch up" to Lucy.

Discussion

The results of this study are discussed in two parts in response to two aims: (a) empirical (contribution to knowledge in sports) and (b) practical (definition of orientations for sports training).

Empirical enrichment by joint analyses of the course of experience and biomechanical parameters

In terms of the richness of empirical detail, the joint analyses of the courses of experience and the biomechanical parameters showed characteristics of the rowers' coordination that were compatible with their perceptions but unsuspected by them and their coaches. The rowers' describable and personally meaningful experiences were put into relationship with largely unconscious adjustments that could be measured using other methodologies, yielding new insights into certain facets of performance. For example, Marion's perceptions of "not being in synch", "being pushed" by her partner, and "not being able to complete her strokes" at certain moments of the race were syncretic descriptions of her experience. Although they served to identify and localize a critical incident from her point of view, they were uninformative as to their source. The sensation of "being pushed" by her partner could in fact have been linked to several behavioral adjustments between the rowers that were not only meaningless for them, but also too subtle to be identified by the coaches by direct observation or by viewing the video recordings. When the biomechanical parameters were mapped to the syncretic perceptions of "being pushed," it emerged that differences in stroke amplitude and the speed in the first and second parts of the recoveries had a notable impact on the global dynamics of the collective activity.

The results also indicated an interest of indexing an objective performance analysis to a prior analysis of athletes' courses of experience. The wide range of objective performance indicators makes it difficult to choose the most relevant. An initial analysis of athletes' courses of experience makes it possible to (a) formulate hypotheses that will guide the choice of the objective parameters relevant to exploring specific performance phenomena and (b) give "experiential meaning" to some of these objective performance indicators. This perspective has not only found favor in some of the technical and scientific literature on rowing, but also in the broader field of sports sciences.

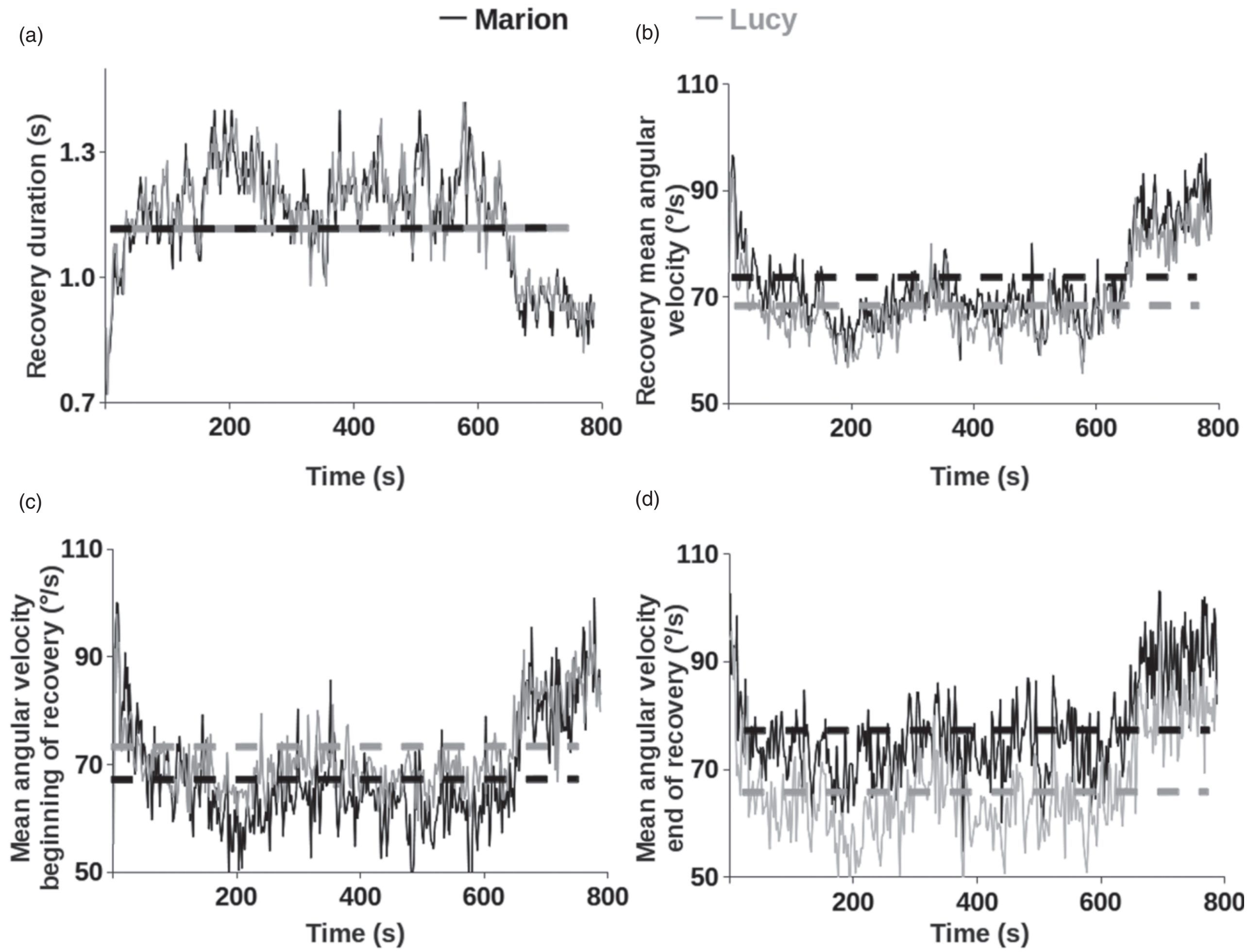

Fig. 3. Testing the third hypothesis. (a) Duration of the recovery phases throughout the race. (b) Average angular velocity of the recovery phases throughout the race. (c) Average angular velocity of the first part of the recovery phases throughout the race. (d) Average angular velocity of the second part of the recovery phases throughout the race. The average values are represented by dotted lines. Note: The decrease in recovery duration at the end of the race was due to an increased stroke rate at the finish.

Contributions to the conception of training aids

Development of shared resources

By focusing on the level of activity that is meaningful for athletes, course-of-action analysis is close to the reflexive practices often used in high-level athletic training (performance analysis by the athletes during debriefings with their coaches, spontaneous expression of their sensations, etc.). However, self-confrontation interviews prompt athletes to express aspects of their activity that would not be evoked in the framework of the classic training practices, because the researcher uses a specific mode of questioning, does not make judgments on the performance, and helps the athletes to reveal their experience in a continuous manner as it originally unfolded. Athletes are shown audiovisual recordings of their performance and are invited to give a step-by-step and highly detailed description of their actions, perceptions, emotions, preoccupations, interpretations, and focuses of attention. The researcher helps them to describe their lived experience by giving prompts designed to (a) elicit greater precision from them (e.g. “So you’re saying that you were feeling out of synch. . .”, “It seems like you’re saying that she goes in the water before you. . ..”), and (b) obtain supplementary information about their preoccupations, thoughts, interpretations, and emotions (e.g. “And there what are you trying to do?”, “What are you thinking?”, “How are you feeling here?”). This form of stimulated recall immediately enriches study participants cognitive and reflexive resources for training and competition (Gilbert & Trudel, 2001): it helps them to become aware of certain aspects of their activity that they were not aware of during the actual performance (Sève et al., 2006). This perspective has thus been incorporated into the framework of high-level athletic training in several sports, notably trampoline (Hauw & Durand, 2006), table tennis (Sève et al., 2006), and sailing (Durand et al., 2005).

The research materials shared with the rowers and coaches who participated in the study presented in this paper were quite diverse: audio and video recordings, transcriptions of self-confrontation interviews, and biomechanical and mechanical measurements. These materials, in addition to the researchers' comprehensive analyses, served as resources for shared reflection between coaches and athletes. This type of analysis, conducted for the first time in rowing, had a positive impact. First, athletes' experiences were mapped to "objective" measures that provided detail on certain facets of their performance. This had the merit of helping the athletes to better understand and evaluate the "reliability" of their sensations during an unfolding performance. Second, this approach facilitated the sharing of experiences between crew members and between coaches and athletes, and it allowed them to exchange points of view and interpretations about crew functioning and performance variations. This type of exchange expands the number of reference points held in common by coaches and athletes, and a strong common base of understanding is an essential factor for all collective performance (Gréhaigne et al., 2001).

Definition of new training directions

The course-of-action approach facilitates the generation of knowledge useful to coaches because its level of analysis can reveal hidden dimensions of athletic activity. For example, course-of-action studies conducted with the collaboration of coaches and high-level table tennis players revealed the importance of skills in inquiry and dissimulation, which had never been addressed in training sessions (Sève & Poizat, 2005). The coaches took these findings into account and were able to develop new exercises for the players that were geared toward developing these skills as a means to enhance effectiveness during matches (Sève et al., 2006).

In this rowing study, our analyses were shared with the coaches and rowers within a few weeks of data collection. This led to adaptations designed to optimize the performance of this coxless pair crew. The analysis of this case identified the elements underlying Marion's perception of "being pushed" by her partner. This in turn led to a consideration of how training objectives could be defined in subsequent training sessions to remedy the dysfunction in crew coordination. For Marion, the objective was to transform her recovery dynamics by higher speed in the first part. For Lucy, the objective was to develop greater stroke amplitude by making small adjustments to the boat settings, with specific focus on the amplitude in the catch phase. Thus, the rowers' coaches considered the results of this case study as very interesting and constructive for the improvement of the crew performance. Unfortunately, since no longitudinal follow-up was performed, the influence of this performance analysis was not quantified, but it represents a very interesting perspective for future research.

Perspectives

Although empirical studies that articulate different approaches are still fairly rare in sport, several authors have begun to underline the interest of doing so to better account for the complex character of performance and to uncover new phenomena (e.g. Adé et al., 2009). This example in rowing underlines the value of joint analysis using methodologies that generate diverse research materials that can be exploited by both the researchers and the study participants. In this case study, the analyses of the courses of experience and the biomechanical parameters were crossed by giving "first place to the course of experience"; that is, within a framework that subordinated the biomechanical analysis to the findings of the course-of-experience analysis. The course-of-experience analysis determined the salient phenomena of the race from the rowers' points of view. The analysis of biomechanical parameters aimed to characterize the biomechanical elements in order to better understand these phenomena. This analysis brought new understanding to the coaches that helped them to define new designs for training and performance optimization. One limitation of this study is that it only concerned the detailed analysis of a single phenomenon reflecting a dysfunction in crew coordination in rowing. It is therefore necessary to complete this first study by other crossed analyses in other sports to clarify how the data from two types of analysis can be articulated in order to provide new insight into sports performance and how to optimize it.

Key words: rowing, training device, interpersonal coordination, course of experience.

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