XIIth International Symposium on Biomechanics and Medicine in Swimming, AIS, Canberra, Australia, 2014

How competitive swimmers adapt their inter-limb coordination to drag perturbation?

Ludovic.seifert@univ-rouen.fr

Seifert L.[1], Schnitzler C.[1,2], Komar J.[1], Dovgalecs V.[1], Button C.[3]

[1] CETAPS - EA 3832, University of Rouen, Faculty of Sports Sciences, France
[2] Faculty of Sports Sciences, Strasbourg Marc Bloch University, France
[3] School of Physical Education, University of Otago, Dunedin, New Zealand

Introduction: Expertise in swimming

Competitive swimming mostly focus on “swimming fast(er)”

However, understanding **expertise** goes beyond the "how fast can you swim" question.

Adaptability, considered as the capacity of expert to modify their behaviour to respond to subtle modification in the constraint acting on them, might also be a key concept of expertise to investigate *(for a review, Seifert, Button, & Davids, 2013, Sport Med).*

By artificially generating perturbation to the swim stroke, it can be explored how expert swimmers adapt their limbs movements and limb coordination pattern to constraints, brought about by a subtle blend between behavioural **stability** and **flexibility**.

Objectives:

Stability corresponds to the capability and the time an individual takes to resist to a perturbation or to recover his initial motor behaviour after perturbation (e.g., assessed by the relaxation time (*Kelso, Scholz, & Schöner, 1987*)).

Flexibility relates to the fluctuations within a coordinative pattern to continually adapt to a given set of constraints.

From there, **adaptability** corresponds to the ratio between behavioural stability and flexibility, in the sense where an adaptive swimmer is stable when it's needed and is flexible when it's needed, supporting **functional** movement and coordination **variability**.

The aim :
to examine the **adaptability** of the limbs movements and coordination pattern in expert swimmers when a drag perturbation is artificially applied.

Protocol

6 competitive swimmers performed an intermittent flume test composed of three randomized stages (60, 70, 80% of their maximal speed).

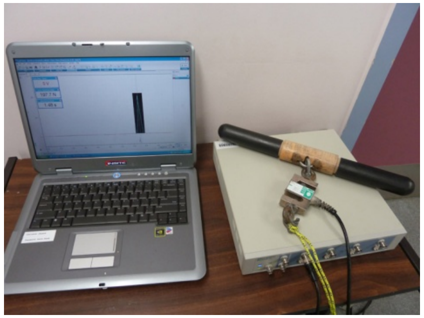
Each stage consists of swimming 15 cycles at the given speed up to a black mark,

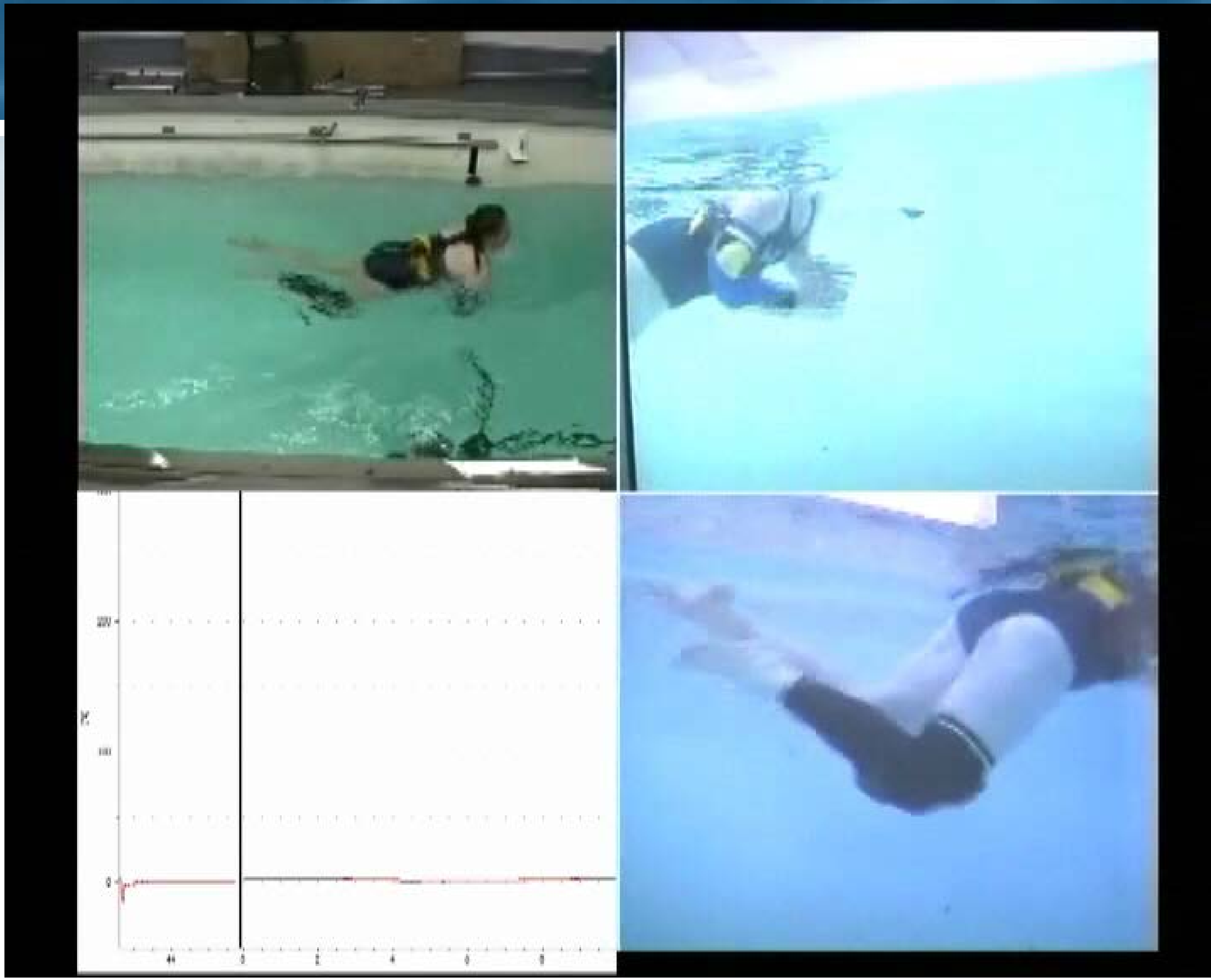
then the swimmer was towed with a cable 1m backward from his initial place,

immediately after, the swimmer had to return as fast as possible to his initial place,

before continuing to swim for 15 further cycles.

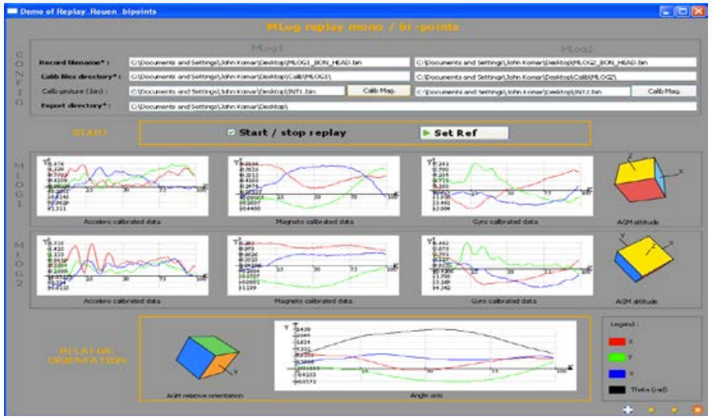
The cable was attached to a dynamometer in order to control the applied towing force.
One lateral camera recorded the number of cycles to recover to the line after the perturbation.

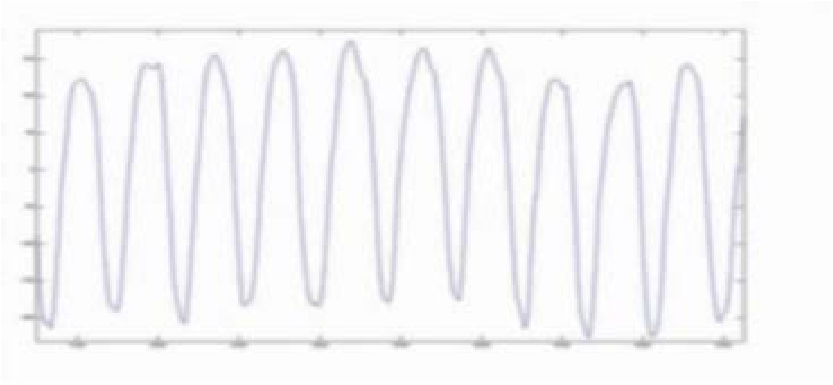




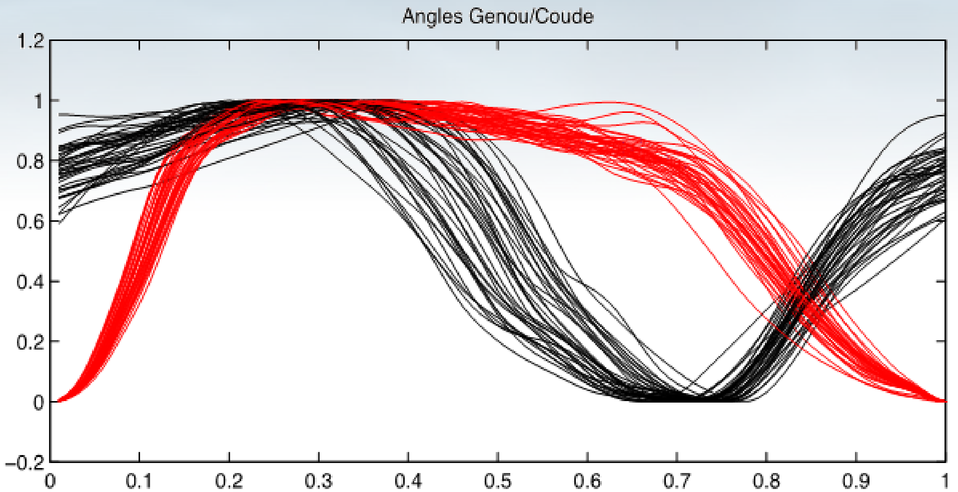
Data Collection

- Motion Sensors: inertial measurement unit combining 3D accelerometer, 3D gyroscope, 3D magnetometer to assess times series of knee and elbow angles





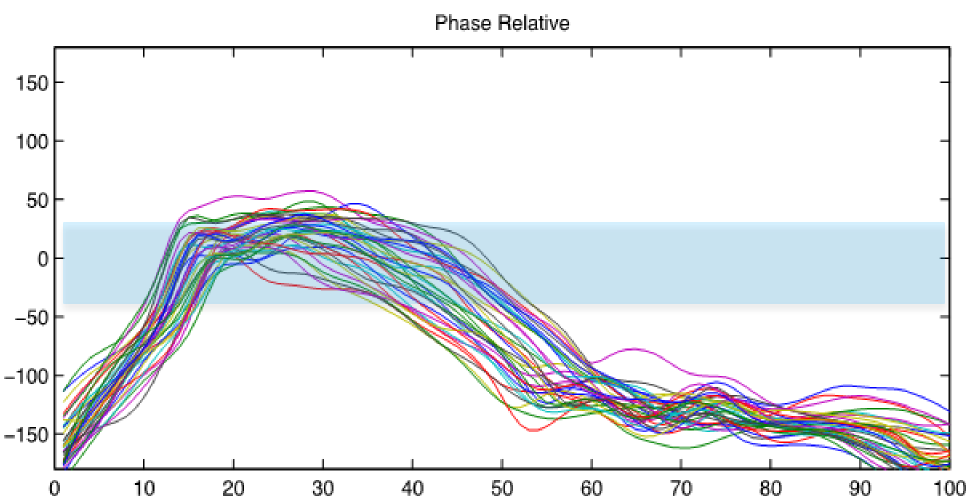
Data Analysis



Time series of knee angle (red curve) and elbow angle (black curve) for each trial.

Time series of phase angle

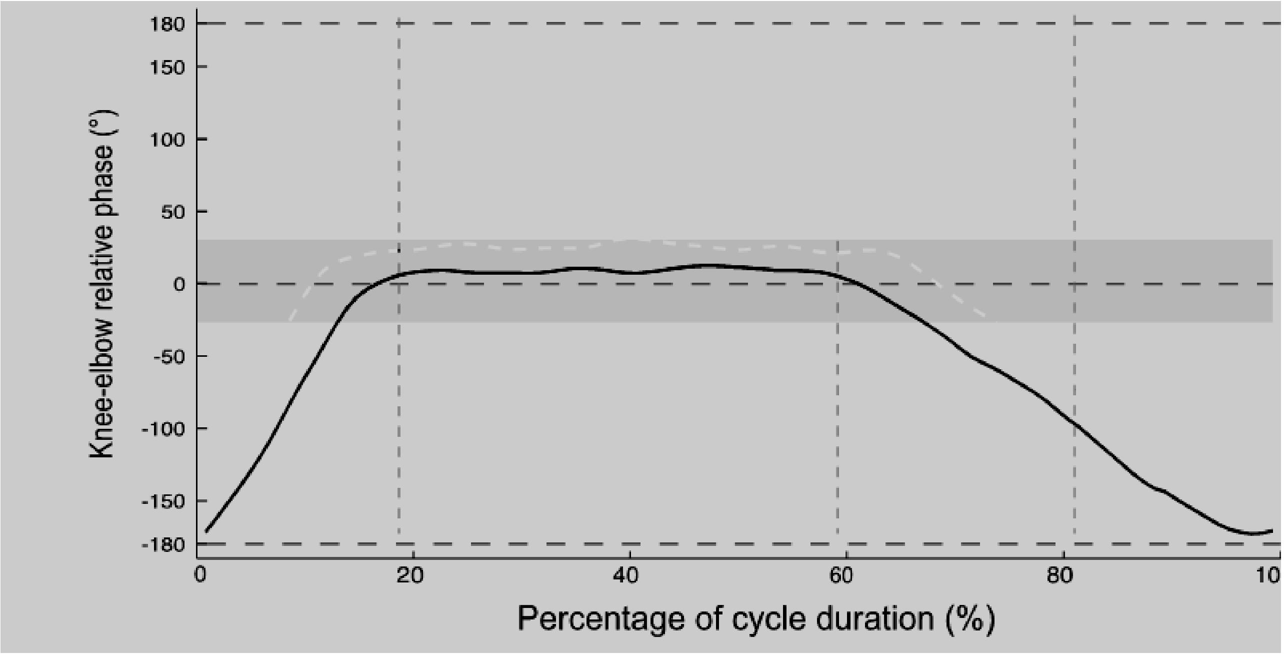
(for more details see, Seifert et al., 2011, Hum Mov Sci)



Time series of Continuous Relative Phase (CRP) for each performed trial:

2 patterns:

in-phase / out-of-phase coupling



Knee-elbow relative phase (°)
180
150
100
50
0
-50
-100
-150
-180
0
20
40
60
80
10
Percentage of cycle duration (%)

Data Analysis

The **stability** of elbow and knee angles, and elbow-knee coordination was assessed by the relaxation time(Kelso et al., 1987)

i.e., the number of cycles needed to recover to:
(i) the line (informing on the task-goal outcome),
(ii) the initial pattern after the perturbation (informing on the behaviour outcome).

The recovery of the initial angle and coordination pattern was assessed by comparing each cycle after the perturbation to the average cycle (computed on ten cycles prior to the perturbation).

When the cycle was in the confident interval of 95% (i.e., average cycle ± two standard deviations), it was not considered as perturbed.

Results

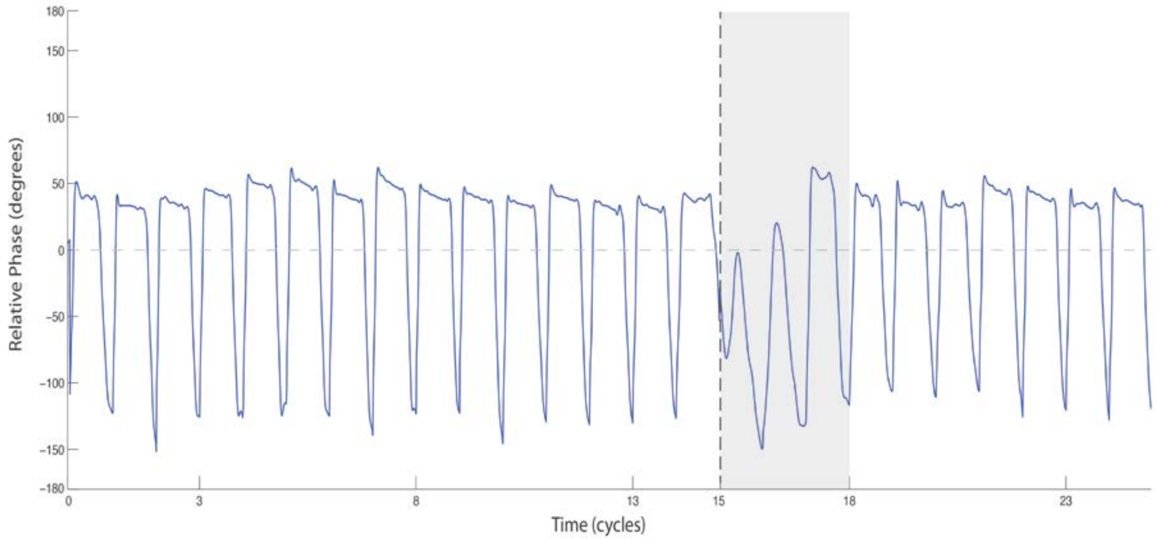
Significant change in stroke rate during perturbation / before and after perturbation showing capability to recover initial stroking parameters:

Speed	Before	During perturbation	After
60% Vmax	0.43	0.72	0.45
70% Vmax	0.49	0.76	0.51
80% Vmax	0.62	0.79	0.66

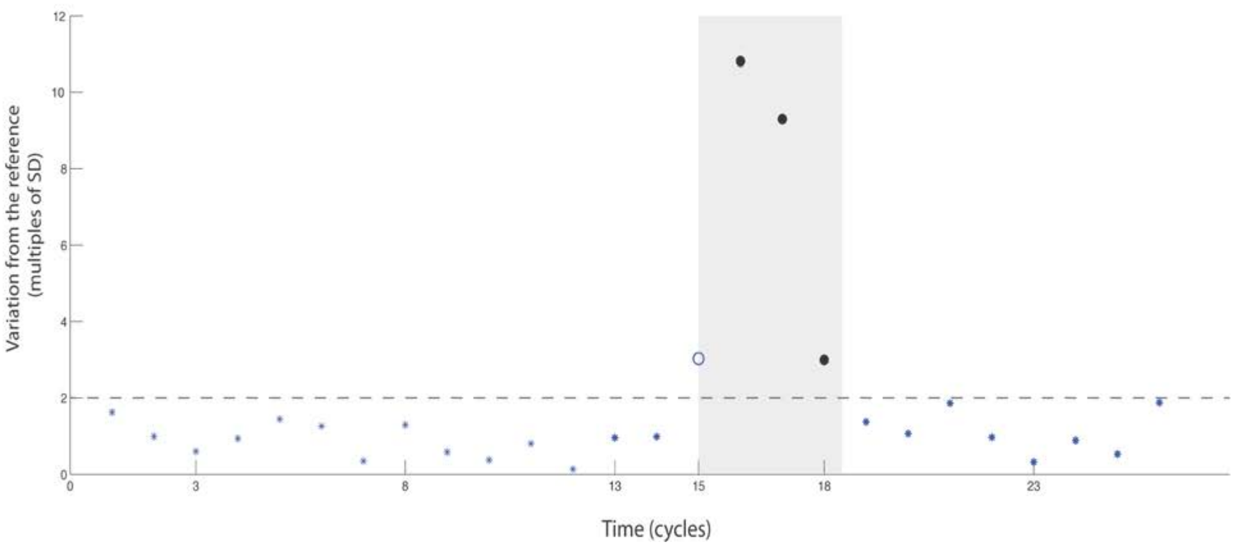
Perturbation led to significant behavioural adaptation that involved more or less relaxation time, which is not similar for arms, legs and their coupling:

	Number cycles needed to recover			
Speed	black line	initial coordination pattern	initial knee angle pattern	elbow angle pattern
60% Vmax	3.3 ± 0.5	3.5 ± 1.4	4.2 ±1.7	5.0 ± 2.5
70% Vmax	4.8 ± 1.2	5.0 ± 1.1	6.3 ± 3.5	3.8 ± 1.8
80% Vmax	7.8 ± 3.2	9.2 ±6.7	6.0 ± 4.3	7.2 ± 4.8

Results: Example for one individual



Modification in elbow-knee CRP when the perturbation is applied (dash line). The grey zone highlighted the perturbed cycles.



Cycles in / out the confident interval (dash line) for elbow-knee CRP.
The perturbation was applied at the 15th cycle (white circle) and led to 3 perturbed cycles (black circle out of the confident interval).
The perturbation ended when the cycles recovered in the confident interval.

Discussion / Conclusion

Competitive swimmers seemed to adapt very reactively to the perturbation, by generating high acceleration.

Large inter-individual variability suggested that some swimmers adapt their elbow-knee coordination by further changes in their knee movement while other swimmers mostly modified their elbow movement.

Adaptability to drag perturbation seems thus to be an interesting candidate to investigate behavioural skills in swimming at different speeds, and offers promising potential applications to test inter-limb coordination stability during learning and training.

Thank you …

…. and welcome in Normandy

Ludovic.seifert@univ-rouen.fr