



**What do we have to learn in alpine skiing technique training? – Task variation as a crucial point in technique training**

The concept of Differential Learning / Variable Practice in Alpine Ski Racing



Dr. Josef Kröll  UNIVERSITY of SALZBURG

**Task:  
Single – Leg - Stance**



Stabilization through destabilization

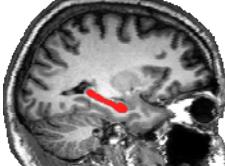


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**Differential Learning**

  
(Schöllhorn ab 1999)

**How do we learn?  
(our brain)**



**What do we have to learn?  
(in Sport / in Skiing)**

  
Nikolai Alexandrowitsch  
**Bernstein**  
1896-1966

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**Differential Learning / Variable Practice**

  
Jürgen Birkbauer  
Module der Motorik, 2006

**Application to Alpine Ski Racing**

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How do we (our brain) learn?

Toni et al. 1999 (Nature 402)

Dendrites

Axon

use it or lose it

Computer ≠ Brain

„ There is a remarkable ability of human brains to extract rules. For the knowledge of facts, the brain is only limited dedicated

What do we have to learn?

### Task

## Extend the right elbow

M. triceps brachii

ANTAGONIST

AGONIST

Galileo Galilei

Sir Isaac Newton

What do we have to learn?

Bernstein's approach of coordination and regulation of movement

**1967**

## Bewegung

complex System / many Degree of Freedoms

Muskelinnervation

- + Gravitational Forces
- + Inertia Forces
- + Stored Forces

Reactive Phenomena

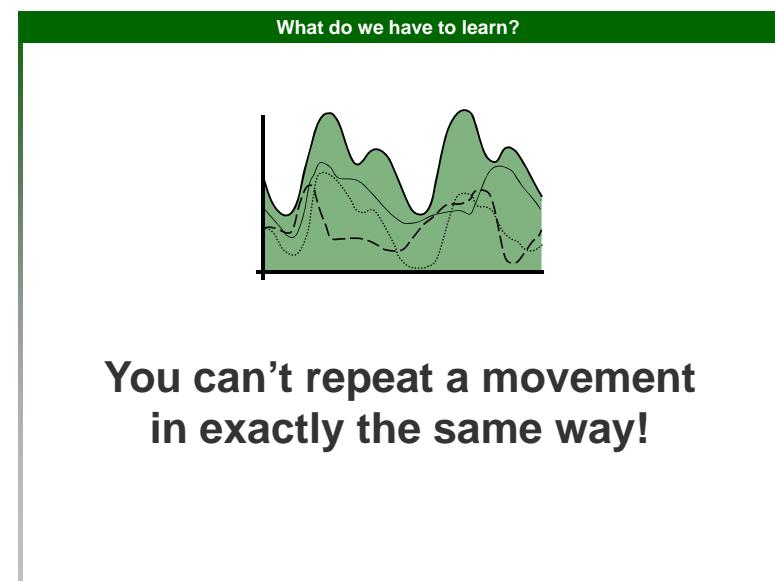
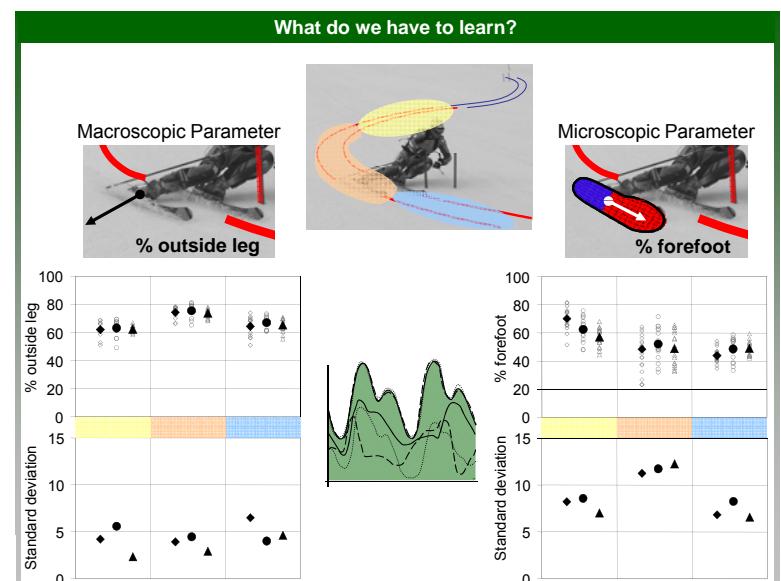
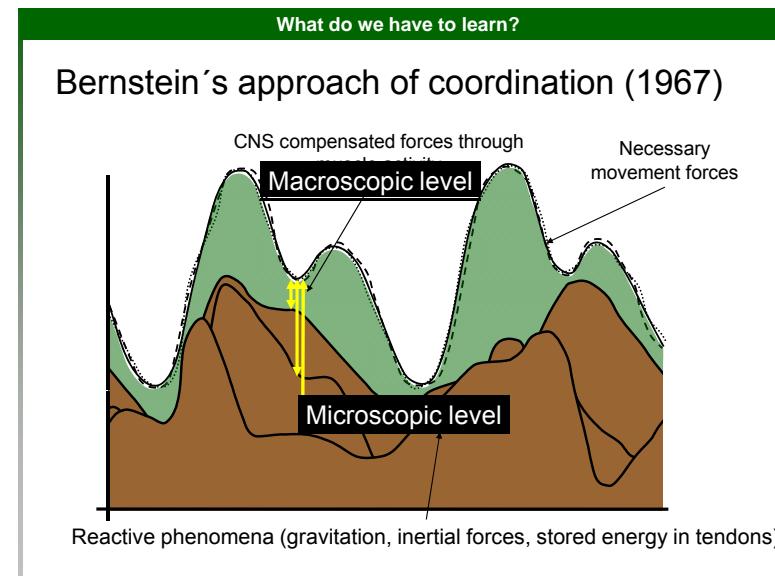
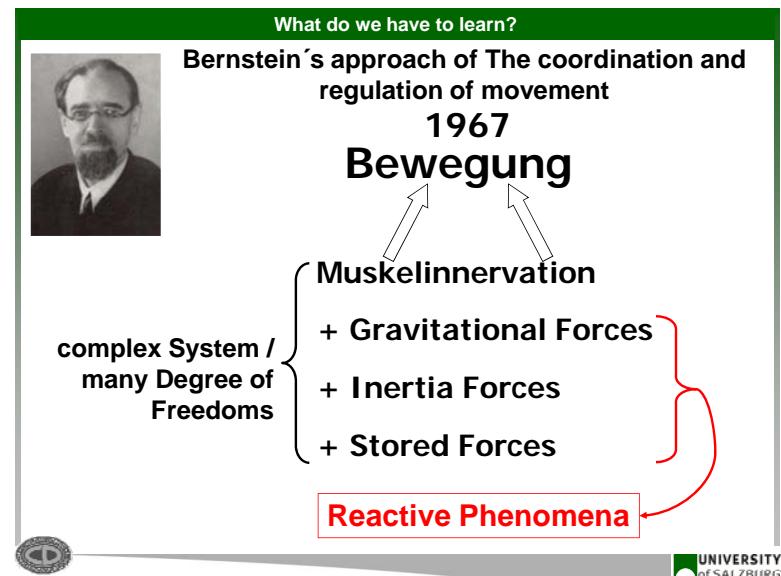
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What do we have to learn?

### ‘From Freezing to Freeing’ (Bernstein)

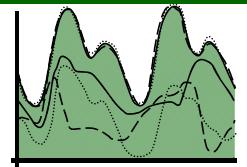
- 1: Fixing DOF
- 2: Freeing of DOF
- 3: Optimal Use of DOF / reactive Phenomena

Videos:  
CD CARVEN,  
Wallner & Wörndl  
2006



**What do we have to learn?**

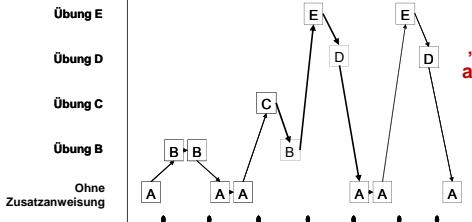
Take home messages

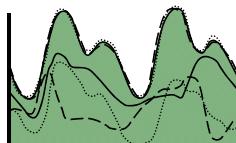



1. You can't repeat a movement in exactly the same way
2. Macroscopic stability and microscopic Variability
3. Compensation function of CNS on occurring reactive phenomena
4. Highest level of coordination = to use reactive phenomena
5. A standardized ("grinded") program can per se not exist

## How to train?

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Consequences for technique training		Differential learning / Variable practice
<b>Classical „Grinding-In“-Training</b>		
without additional instruction		
<b>Differential learning / Variable practice</b>		
Zusatzanweisung		<p><b>„Training with altered reactive phenomena“ (Bernstein)</b></p> <p><b>„Tasks which produce noise around the target movement“ (Schöllhorn)</b></p> <p><b>Not the facts, but the underlieng rules are important to know (Birklbauer)</b></p>

Consequences for technique training	Differential learning / Variable practice
<b>Methodological Concept</b>	
	
<ol style="list-style-type: none"> <li>1. Requirement Profile of the Task = general and individual guidelines of the Technique</li> <li>2. To Provoke as much as possible perception differences and movement differences (experiences are important!!)</li> <li>3. „Interpolating exercise progression / exercise character</li> <li>4. Decreasing differences</li> </ol>	

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Consequences for technique training	Differential learning / Variable practice
<b>1. Requirement Profile of the Task = general and individual guidelines of the Technique</b>	
	
<p><b>Teil 4: Disziplinspezifische Technik Der Race-Grundschwung</b></p> <p><b>Steuerphase 1</b></p> <ul style="list-style-type: none"> <li>Aufzähler des neuen Ausfalls durch eine leichte Kippbewegung</li> <li>Fehlsteuerung durch leichten Knie-/Wadenruck</li> <li>Druck auf die Schatzen des neuen Ausfalls</li> <li>Neuen Ausfall belasten, Innenski wird mitgeführt.</li> <li>Ende des Drucks durch leichtes Beugen</li> <li>Durch angepasstes Kippen Knicken wird der Aufkantwinkel verhindert</li> <li>Weiterer Druckaufbau über den AußenSKI</li> </ul> <p><b>Steuerphase 2</b></p> <ul style="list-style-type: none"> <li>Zusätzliches Knicken ermöglicht die Erhöhung des Kantenwinkels</li> <li>Der Druck befindet sich zum größten Teil auf dem AußenSKI</li> <li>Beide Skier stehen sowie die Schuhlen gerade (horizontal)</li> <li>Phase des größten Drucks (Steuern)</li> <li>Initiieren des aktiven Belastungswechsel und „Jettig fahren“ bis zur neuen Fahrtrichtung herstellen des Aufkantwinkels</li> </ul> <p><b>Auslösephase</b></p> <p>Erstellen der Steuerphase 2 und Vorbereitung für den nächsten Schwung</p> <ul style="list-style-type: none"> <li>Allmähliches Auflösen der Kippbewegung durch aktives Drücken</li> <li>Durch die „Vor-Jetzt-Schick“ Bewegung und eine gleichzeitige Verlagerung des Kippenschwerpunktes werden die Ski klar gestellt</li> <li>Belastbarkeit vom Takt auf den Bergski</li> </ul> <p><b>Timing - Taktik beim Schwungwechsel</b></p> <ul style="list-style-type: none"> <li>Ski werden nach gefordert spät, am besten spätestens</li> <li>Überkopfpositioniert sich in die neue Fahrtrichtung</li> <li>Überkopf und Schuhlen bleiben gerade</li> <li>Im Bewegungsrhythmus und unter angepasster Körpermitzung werden die Ski im idealen Zeitpunkt aufgestellt.</li> </ul>	

52 Technik → Ausbildung

Consequences for technique training      Differential learning / Variable practice

**2. To Provoke as much as possible perception differences and movement differences (experiences are important!!)**  
->especially on microscopic level!

**Stabilization through destabilization**

Consequences for technique training      Differential learning / Variable practice

**3. „Interpolating exercise progression / exercise character**  
**4. Decreasing differences**

Consequences for technique training      Differential learning / Variable practice

**Methodological Concept**

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**Differential Learning / Variable Practice**

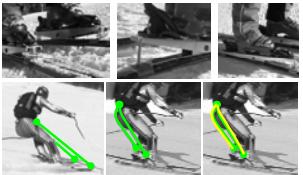
Jürgen Birkbauer  
Module der Motorik, 2006

**Application to Alpine Ski Racing**

Dr. Josef Kröll      UNIVERSITY of SALZBURG

**Practical Application to Alpine Ski Racing**

START technique → Pozzo et al. 2000, Raschner et al. 1991: Biomechanical analysis



TURNING technique → Kröll et al. 2009 & ICSS 2006



GLIDING technique → Kröll et al. 2004



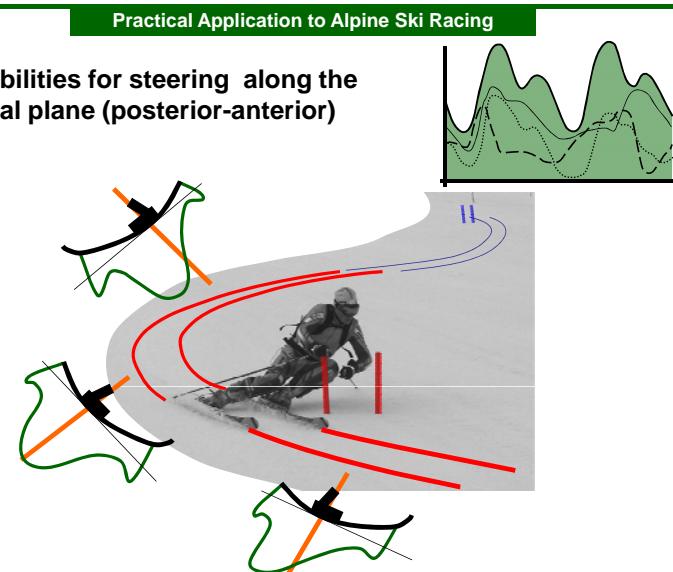
Passing finishing line →





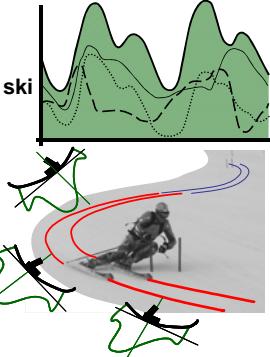
**Practical Application to Alpine Ski Racing**

Possibilities for steering along the sagittal plane (posterior-anterior)



## SensoWip

A 'see-saw' based plate between binding and ski

Spring (SP)

Backward (BA)   Forward (FO)



- Many variations through combinations
- Easy to handle (change) on the slope

**Practical Application to Alpine Ski Racing**

Which exercise was used?

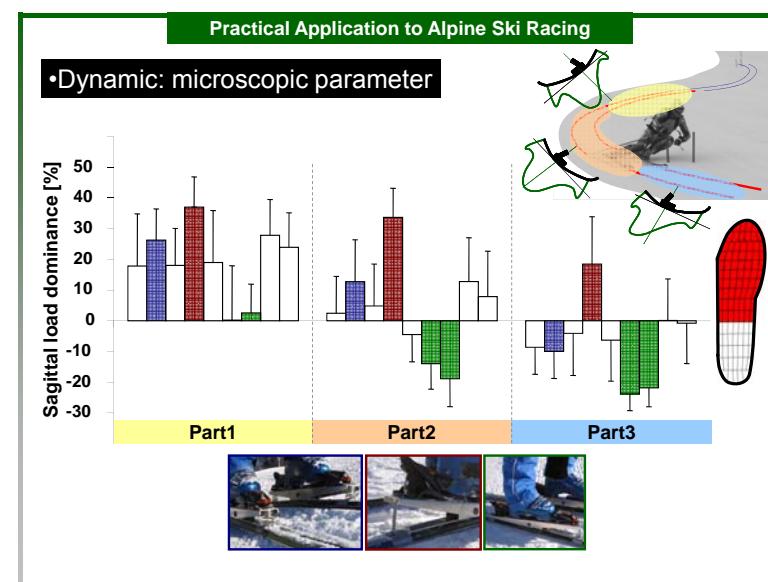
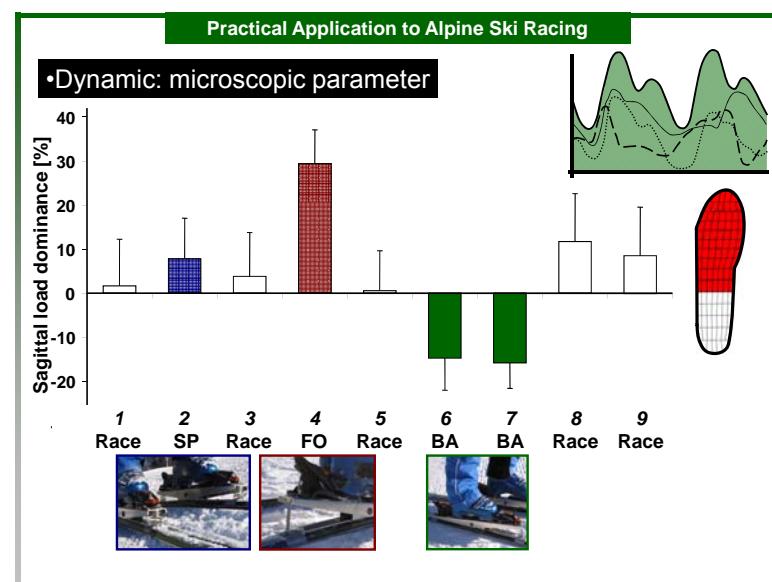
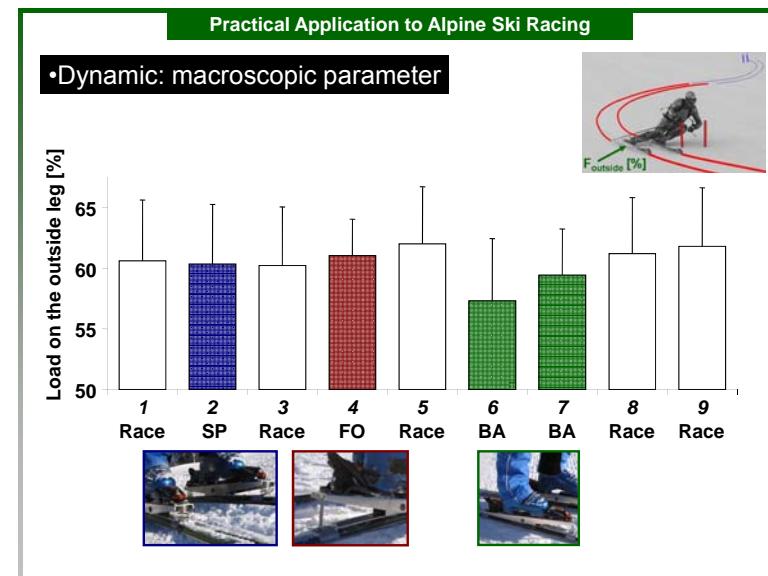
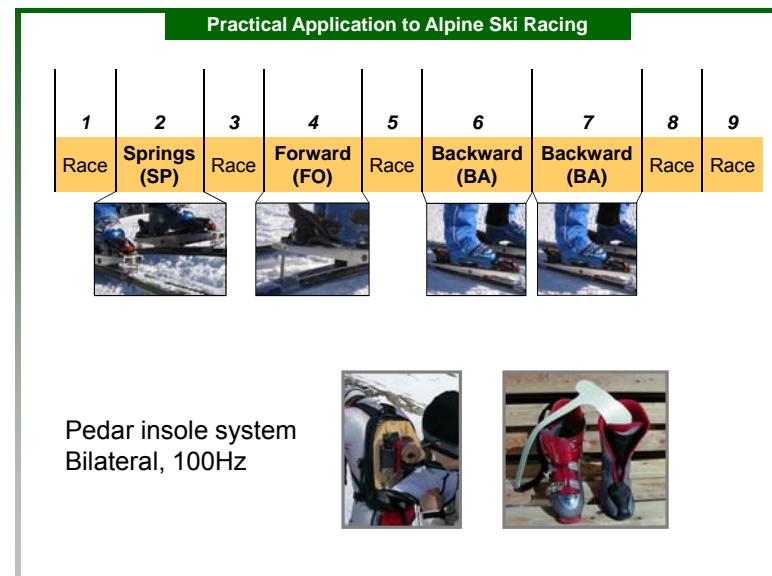
Race Setup



(Kröll et al. 2007)

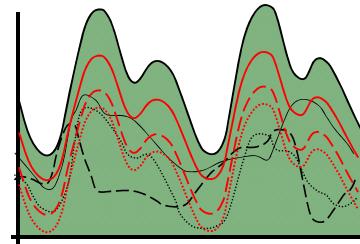


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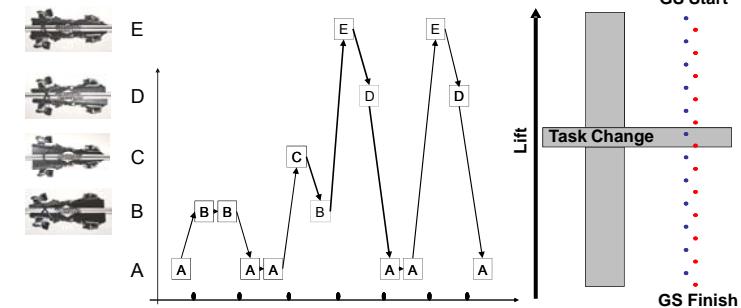
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(useful) variations on the movement  
seems to be possible



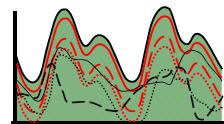
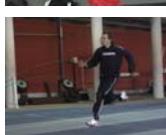
## Practical Application to Alpine Ski Racing

Example of a Training session with Sensowip:



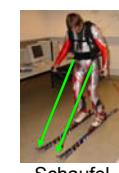
## Practical Application to Alpine Ski Racing

### Tendybelt



## Differenzielles Lernen / variables Üben in der Praxis

### Basisübungen



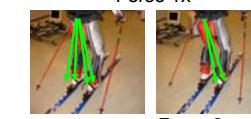
Schaufel



Ferse 1x

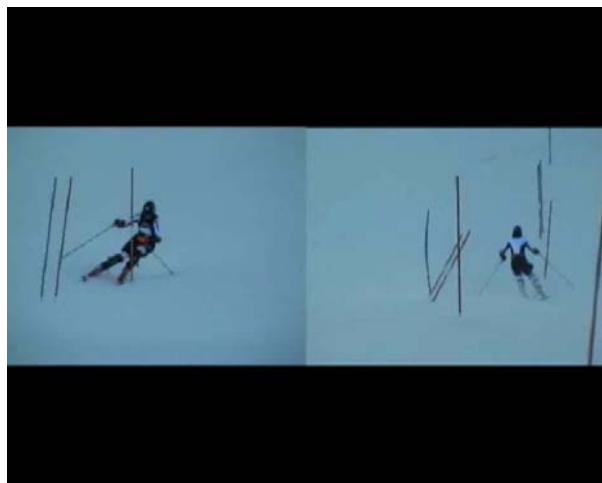


zentral



Ferse 2x      Ferse 2x uni

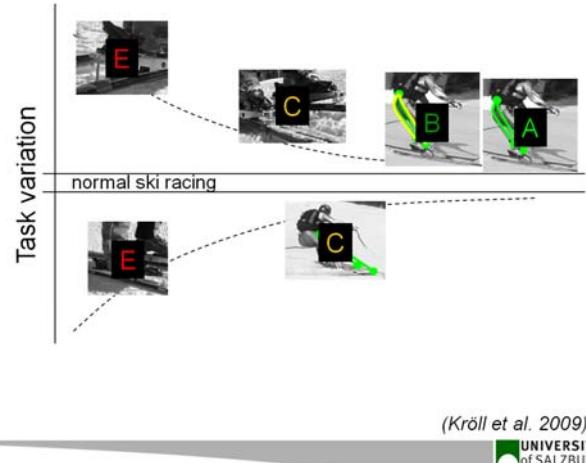
### Practical Application to Alpine Ski Racing



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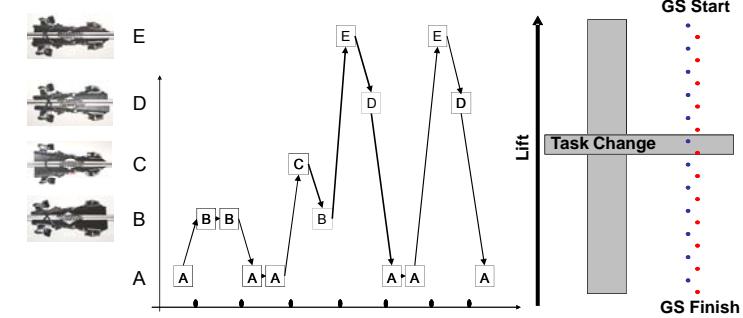
### Practical Application to Alpine Ski Racing



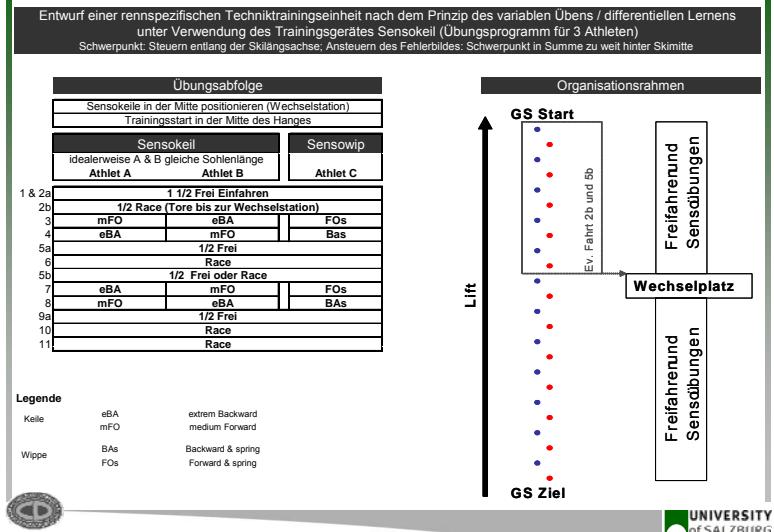
### Practical Application to Alpine Ski Racing



**Example of a Training session with Sensowip:**



## Practical Application to Alpine Ski Racing



## Starts in Alpine Ski Racing

### Starts in Alpine Ski Racing

- Functional analysis of the target movement to add appropriate task variations

Gate push off  
+ first acceleration step



Acceleration phase



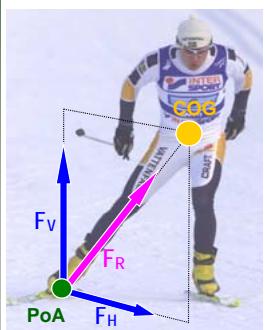
- Analogy to XC skiing techniques

(Kröll et al. 2010)

## Starts in Alpine Ski Racing

### Analogy to XC skiing techniques

Optimal Skating Push-off (Lindinger et al. 2009)



#### Methodological Consequences:

- GLIDING
- ROLL ON EDGE
- PUSH-OFF



## Starts in Alpine Ski Racing

### Complex start technique

Gate push off  
+ first acceleration step

Basic elements

Specific techniques

Acceleration phase

Basic elements

Specific Techniques

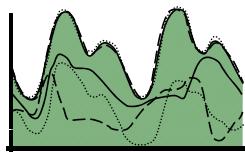
Theoretical confrontation  
with the topic  
90°  
Videofeedback

25  
45  
Inline skates

- 123 structured task variations, 7 "real" starts, 90° "education"
- separated into 14 Trainings sessions; in addition to ski training

(Kröll et al. 2010)

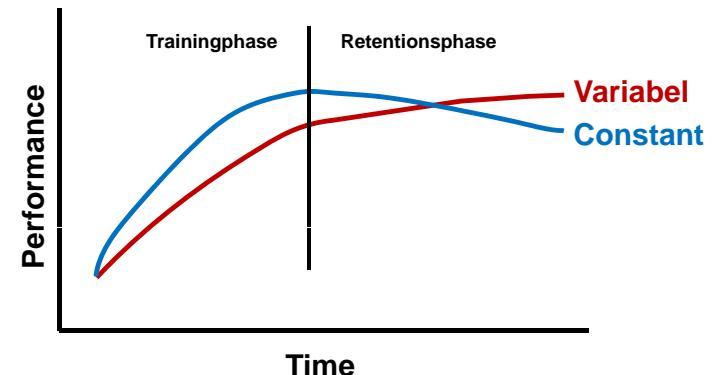
## Methodological Concept



1. Requirement Profile of the Task = general and individual guidelines of the Technique
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## Study Results: Constant Practice vs Variable Practice



hundreds of a second may decide...

1997 World championship SG 4th	0.06 s
1998 Olympics GS 4th	0.02 s
<b>1999 World championship SG 3rd</b>	<b>0.01 s</b>
1999 World championship DH 4th	0.02 s
<b>2003 World championship SG 2nd</b>	<b>0.03 s</b>

5 Races

0.14 s



What do we have to learn in alpine skiing technique training?  
–Task variation as a crucial point in technique training

