Pedagogy Saturday

Music Teachers National Association 2018 National Conference March 17–21, 2018 Disney's Coronado Springs Resort

The neurobiology of healthy practicing:
What neuroscientists can tell music pedagogues

Eckart Altenmüller

Institute of Music Physiology and Musicians ' Medicine (IMMM)
Hannover University of Music, Drama and Media

eckart.altenmueller@hmtm-hannover.de
www.immm.hmtm-hannover.de

Structure

1.) The performing brain

2.) Three studies on motor behavior in musicians

3.) Why and how to practice

4.) The “optimal theory of motor learning”

5.) Summary and Outlook

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What is difficult?

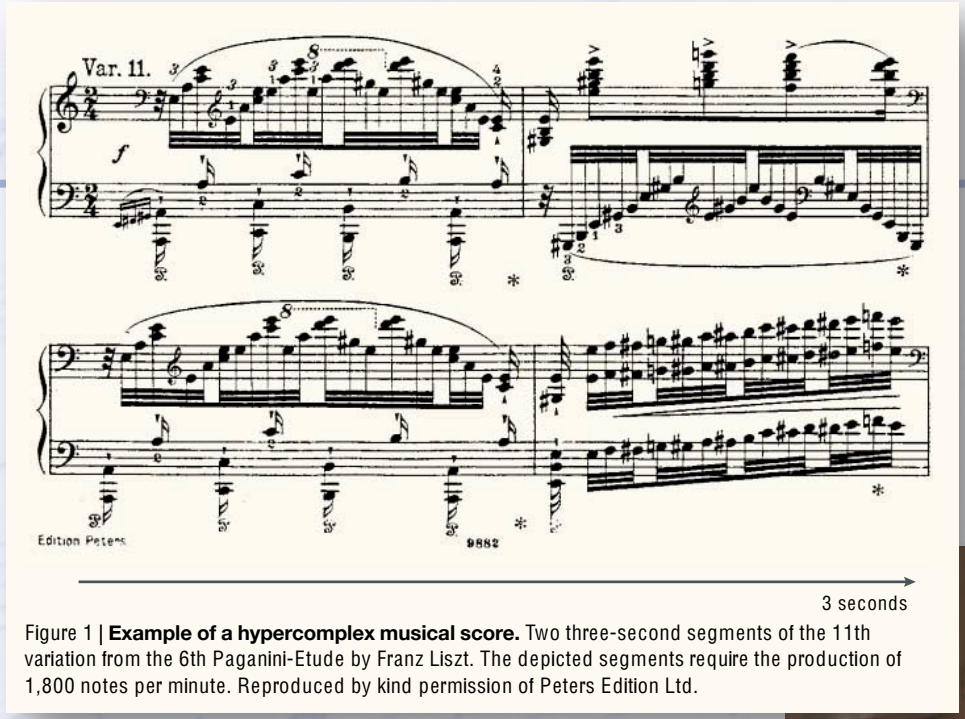


Figure 1 | **Example of a hypercomplex musical score.** Two three-second segments of the 11th variation from the 6th Paganini-Etude by Franz Liszt. The depicted segments require the production of 1,800 notes per minute. Reproduced by kind permission of Peters Edition Ltd.

1800 key-presses per minute

Münte, TF, Altenmüller, E. & Jäncke, L. (2002). The musician's brain as a model of neuroplasticity. *Nat Rev Neurosci. 3*(6), 473-478.

Alexander Lubyantsev, age 22

Neurophysiology of Practicing
The whole brain is involved:

Cerebrum
Planning, Anticipation
Voluntary Movement
Hearing, Perception

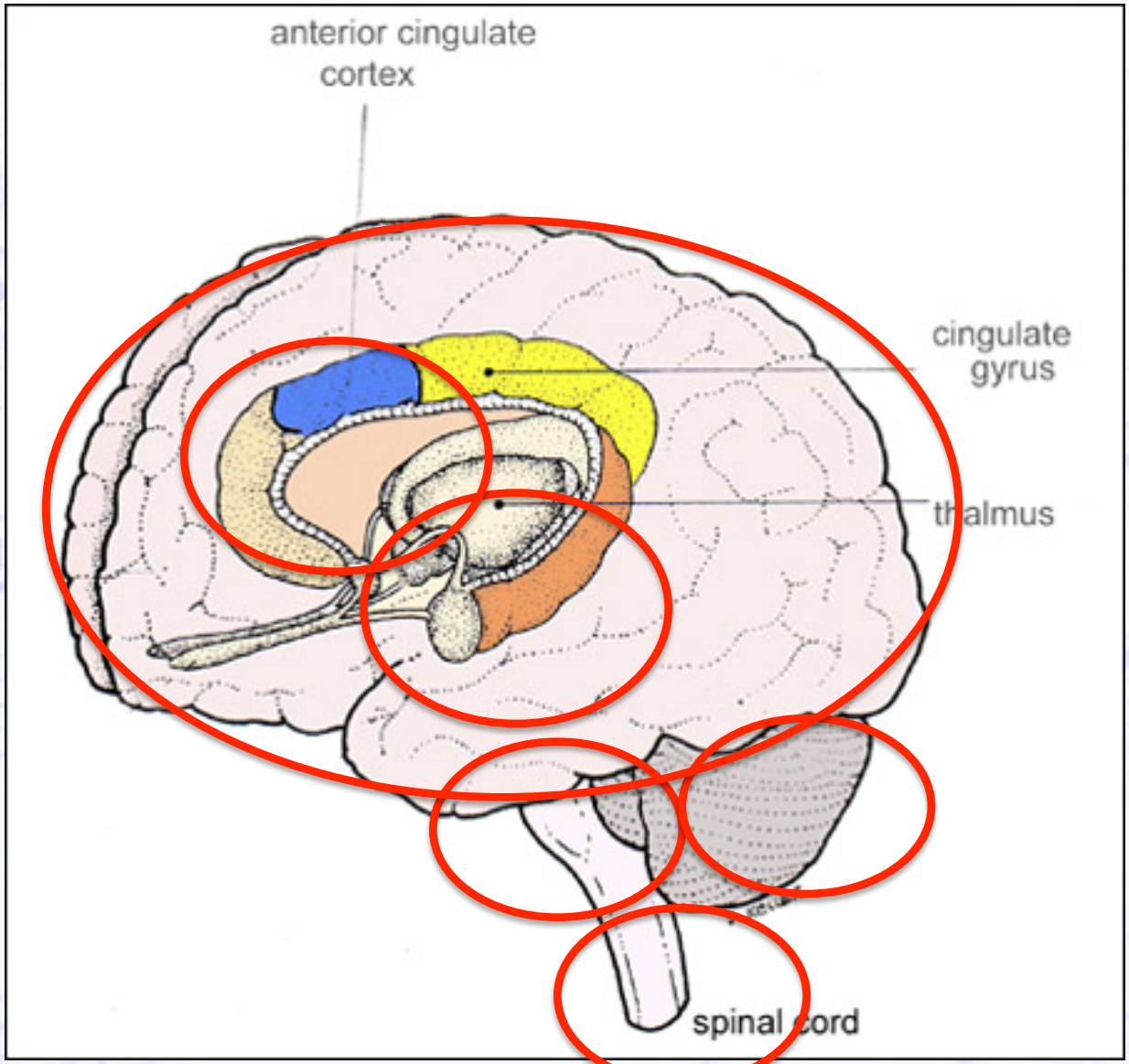
Cingulate Gyrus
Emotional evaluation
Error Monitoring

Basalganglien
Automation
Emotional “labelling”

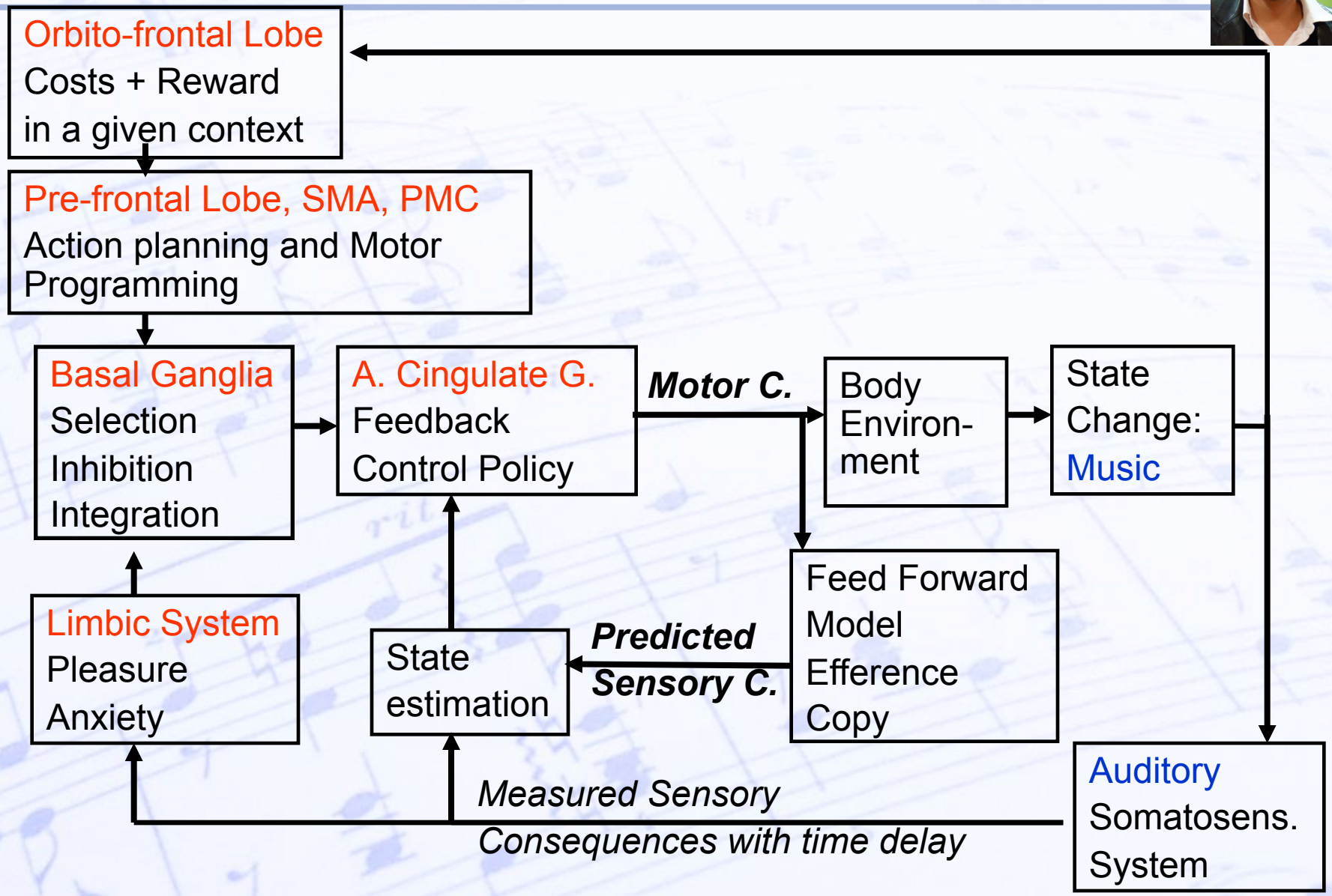
Brain stem
Posture, Reactions, Breathing

Cerebellum
Coordination, Timing
Learning

Spinal cord
Reflexes



A holistic model of the performers‘ brain



Altenmüller et al. Oxford. Univ. Press 2018 in press

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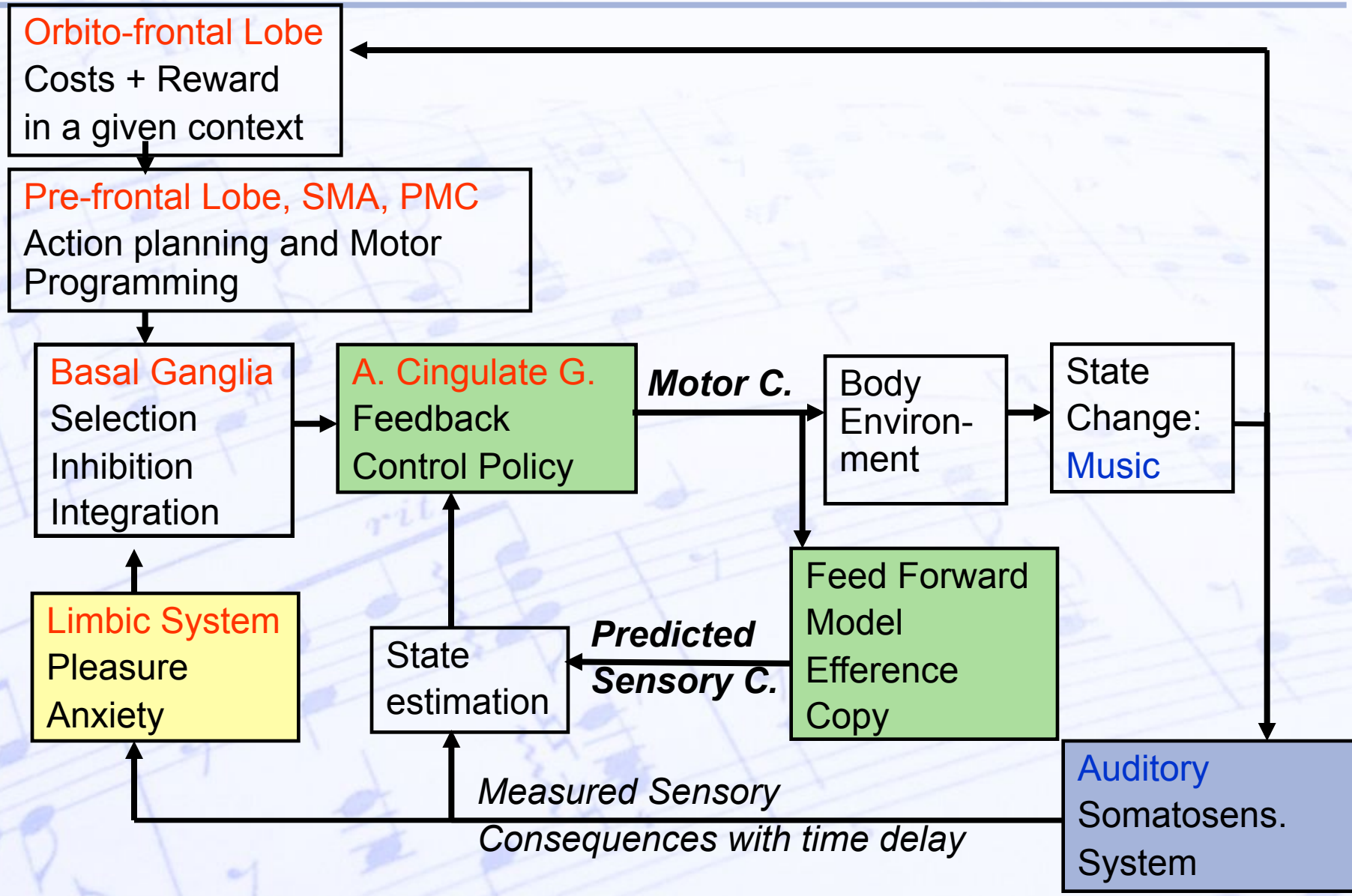

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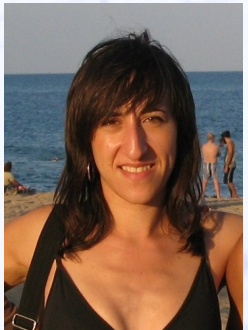
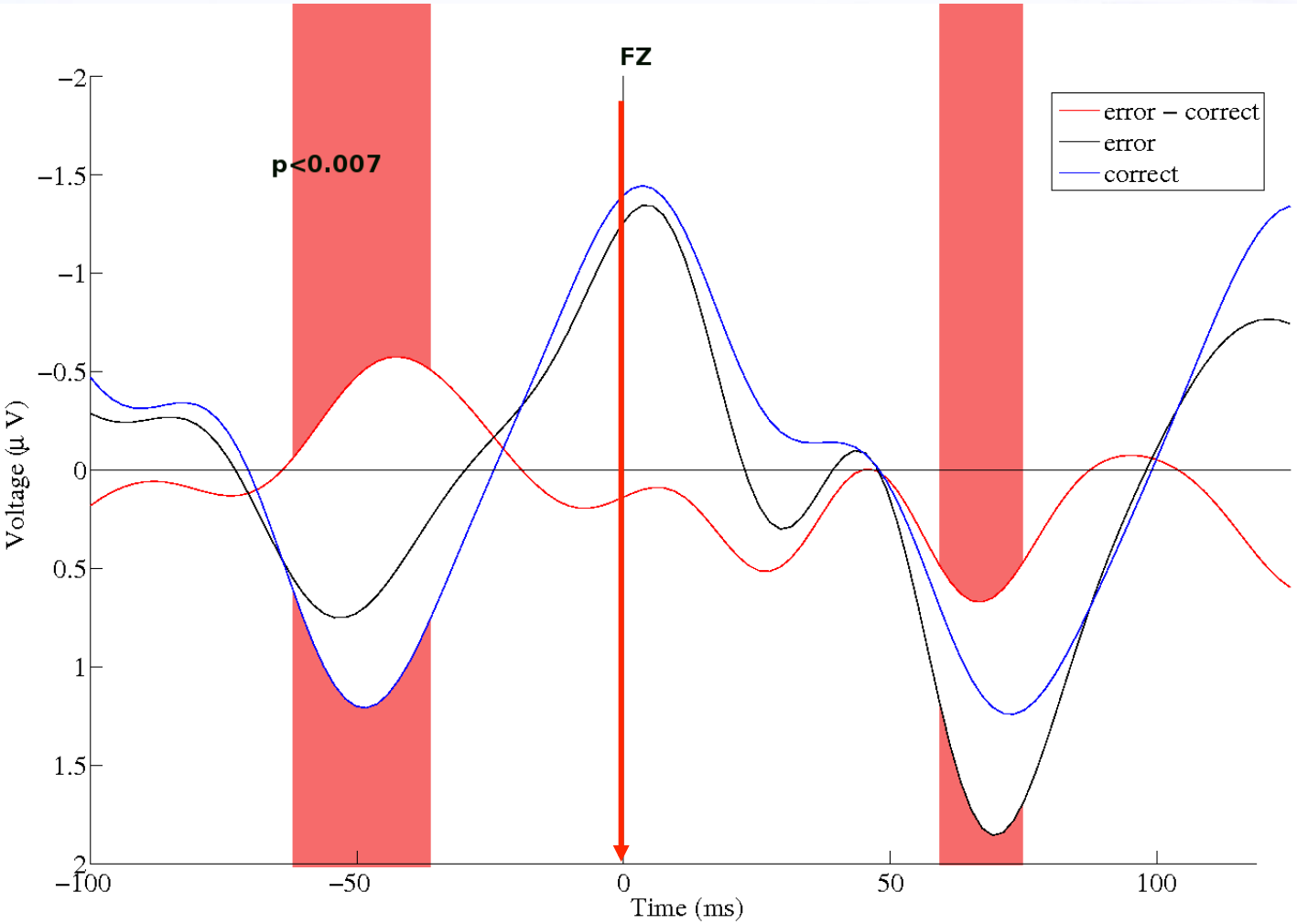
The paradigm: Driving the Brain at its limits!

Herrojo-Ruiz M, Jabusch HC, Altenmüller E. Cerebral Cortex 2009

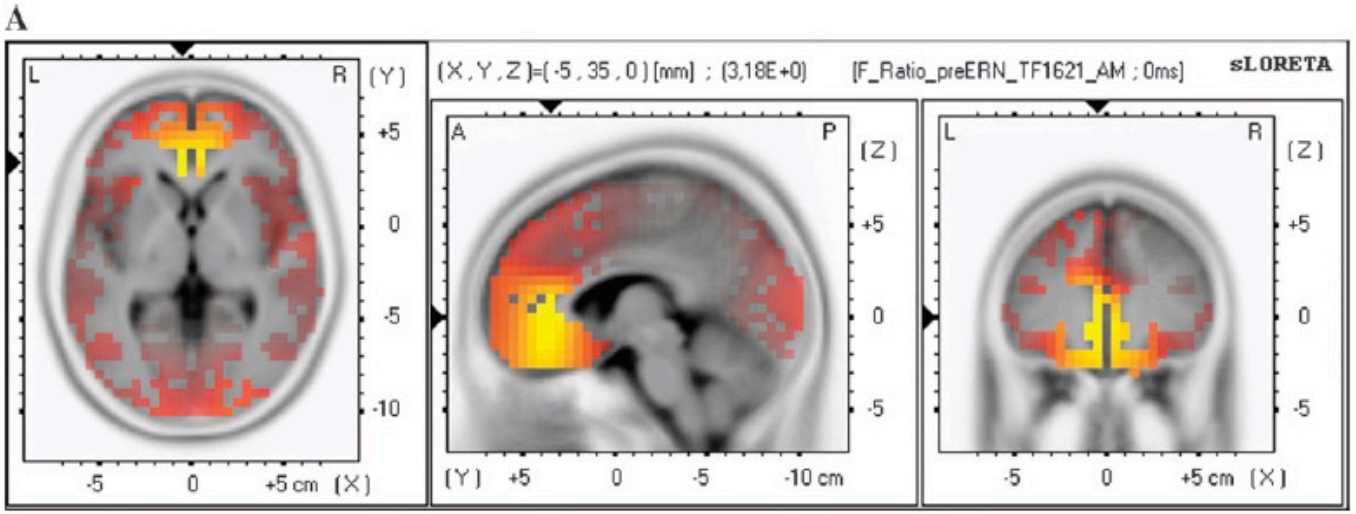


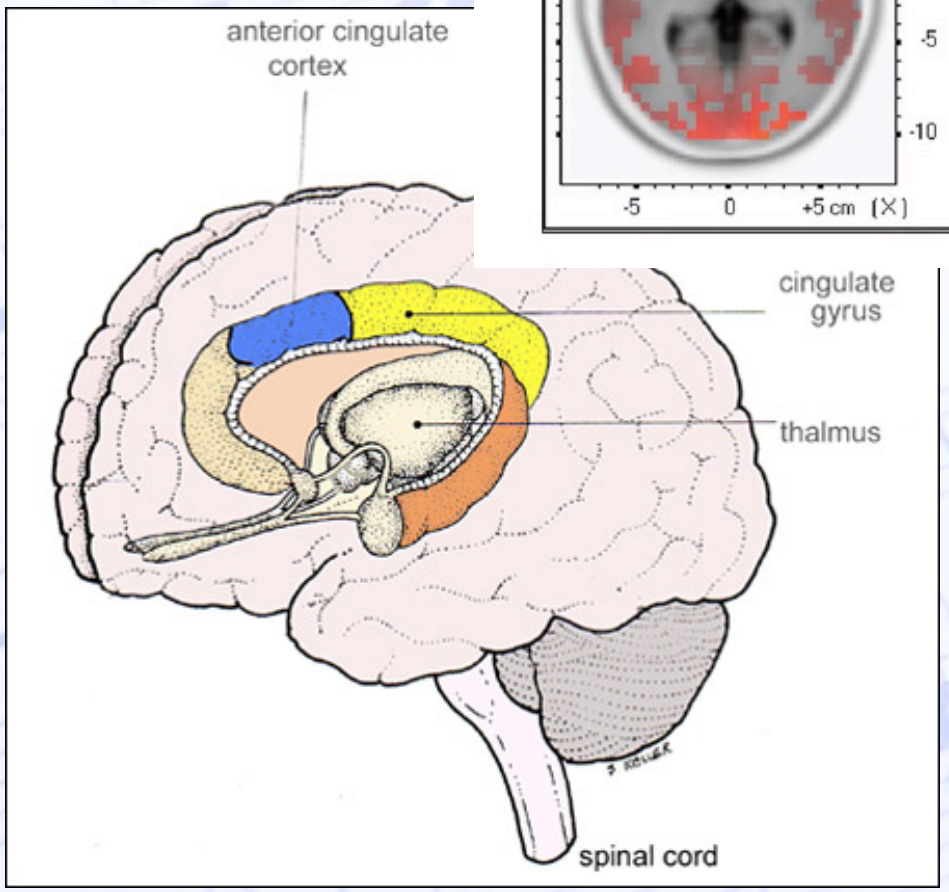
The musicians brain miracle: errors are detected, before they are committed



The wrong note

Error monitoring in the anterior cingulate gyrus





Results of „Loreta-Analysis“

Herrojo-Ruiz et al. Cerebr. Cortex 2009
Strübing et al. Ann. N.Y. Acad. 2011

Sensory feedback is not necessary in skilled players (*Cheng et al. 2016 Rest. Neurol.*)

Task: C-major scales as regular as possible synchronization-continuation paradigm (e.g.Pfordresher and Benitez 2007)

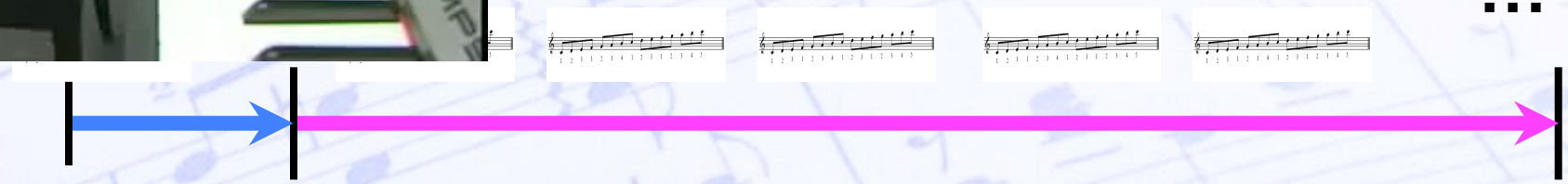
Continuation

Repeat 2 octaves of scales

1 of the 4 Conditions Applied

Conditions

1. normal
2. mute
3. delay (90ms)
4. glove



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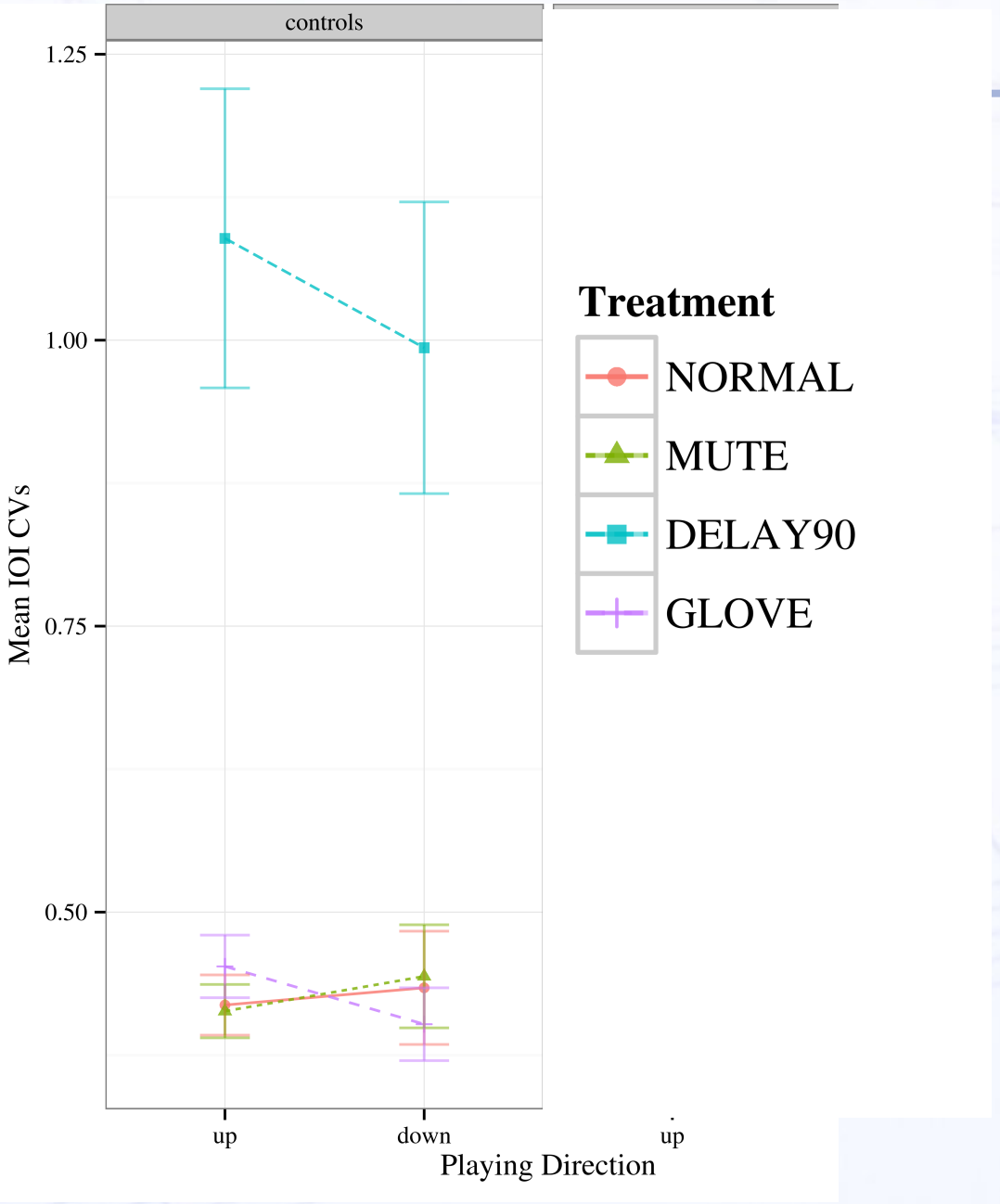
Start

End

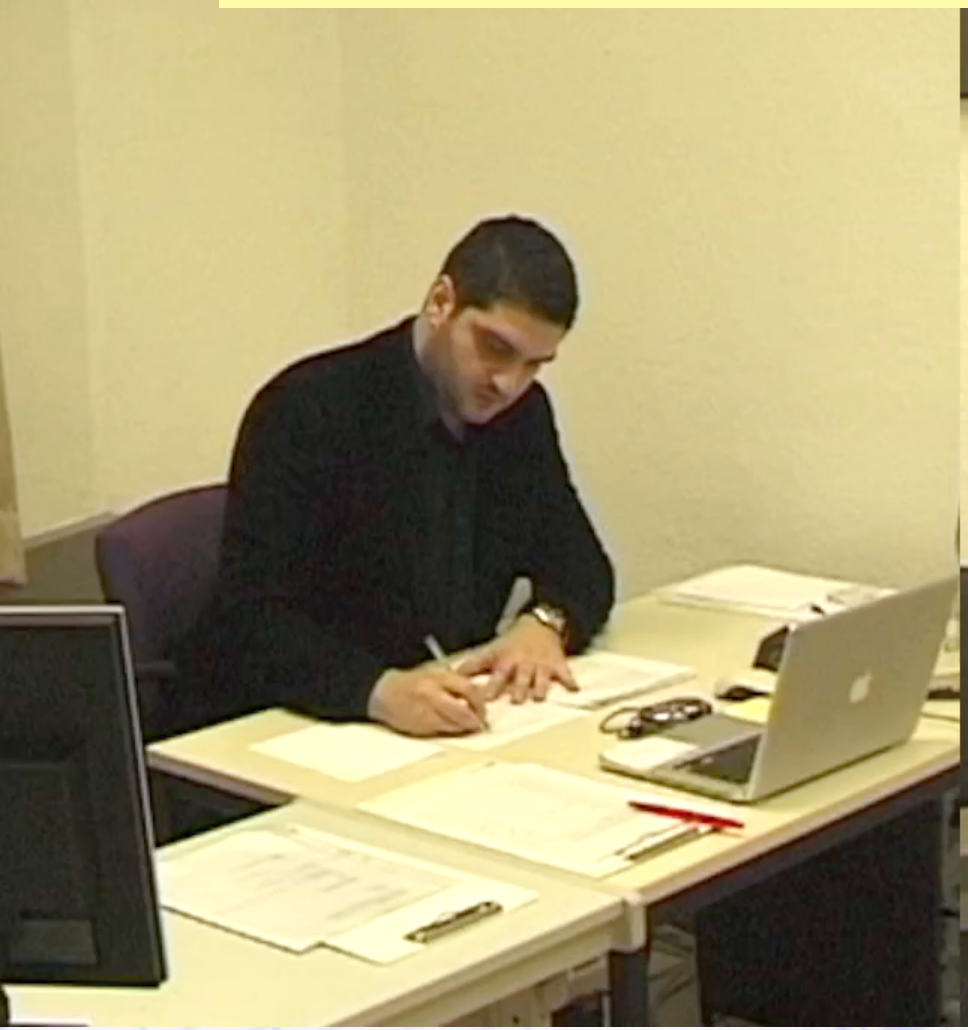
Results

Playing regularity of C-major scales in 16 professional pianists

(*Cheng et al. 2016 Rest. Neurol.)*



The impact of stress on motor performance

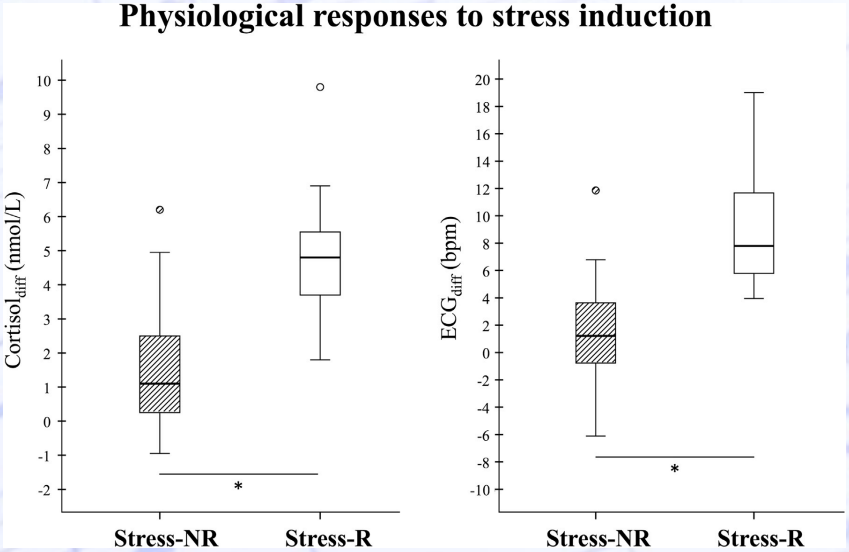


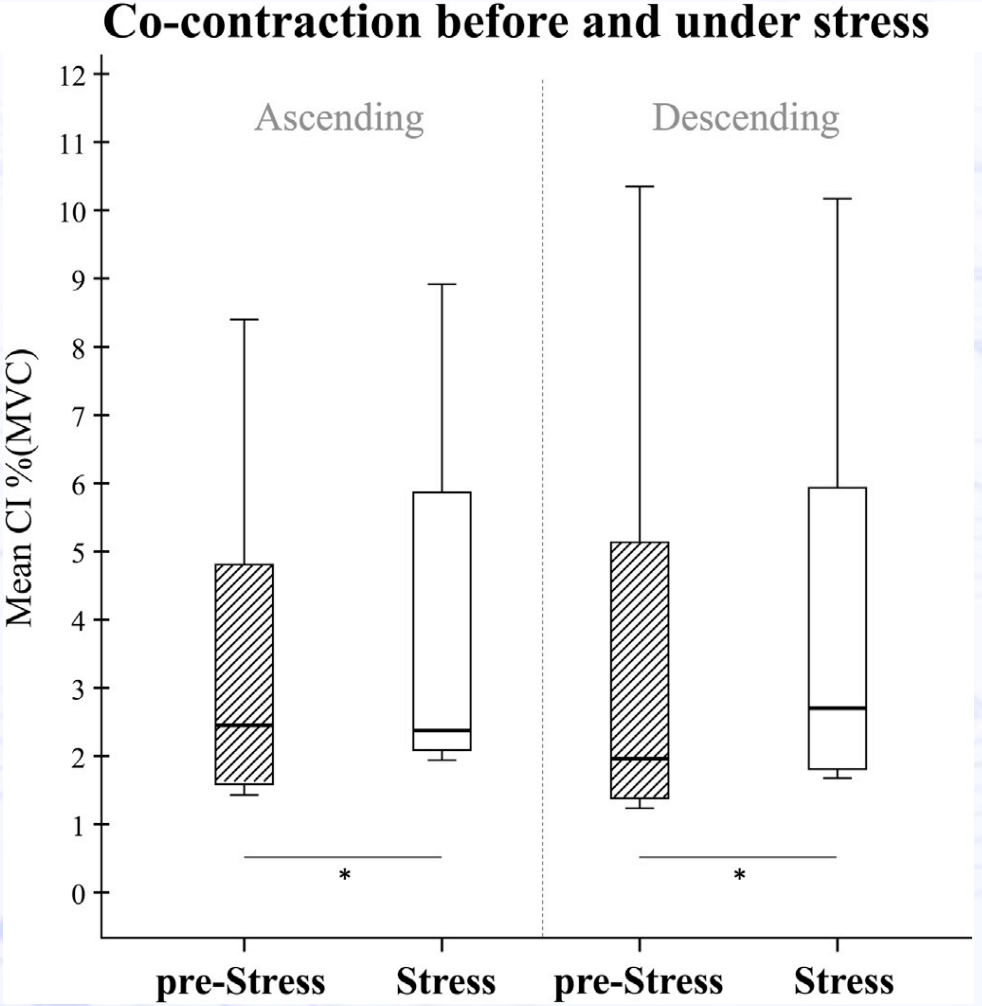
Ioannou, Furuya and Altenmüller, Neuropsychologia 2016

Stress does not affect playing in healthy pianists

No difference in
Scale playing precision

Although some pianists were quite stressed:





Ioannou, Furuya and Altenmüller, Neuropsychologia 2016

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Why practice?

Improvement of auditory, sensory-motor and mental skills

Primary Goals:

Improvement of co-ordination, touch, sonority, etc.
Improvement of memory and mental representations
Improvement of performance skills, “Bühnenpräsenz”

Secondary Goals:

Improvement of practising:
Improvement of self awareness and critical self-evaluation

Like playing, practising is mainly a “procedural” skill

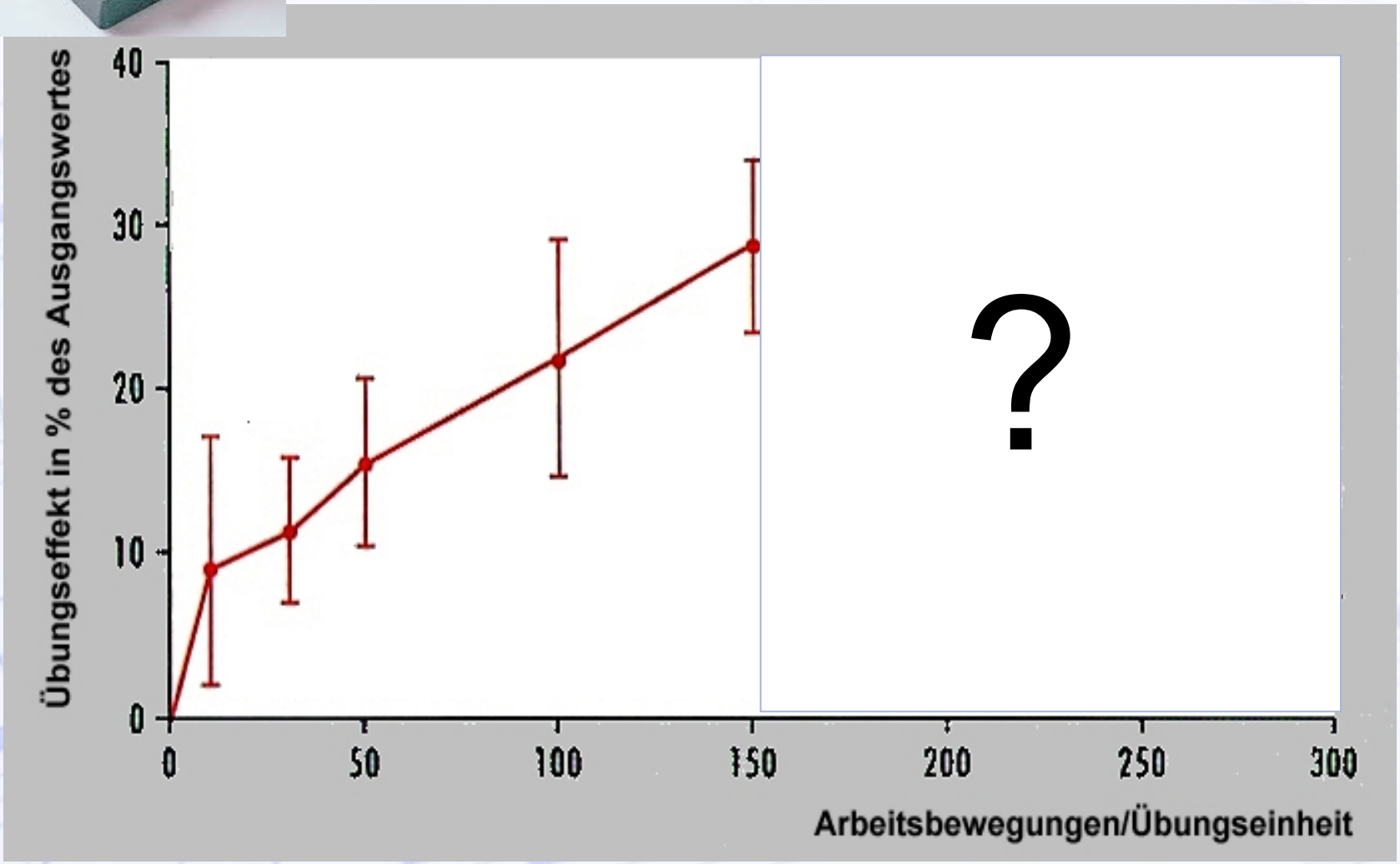
How to Practice?

How long?

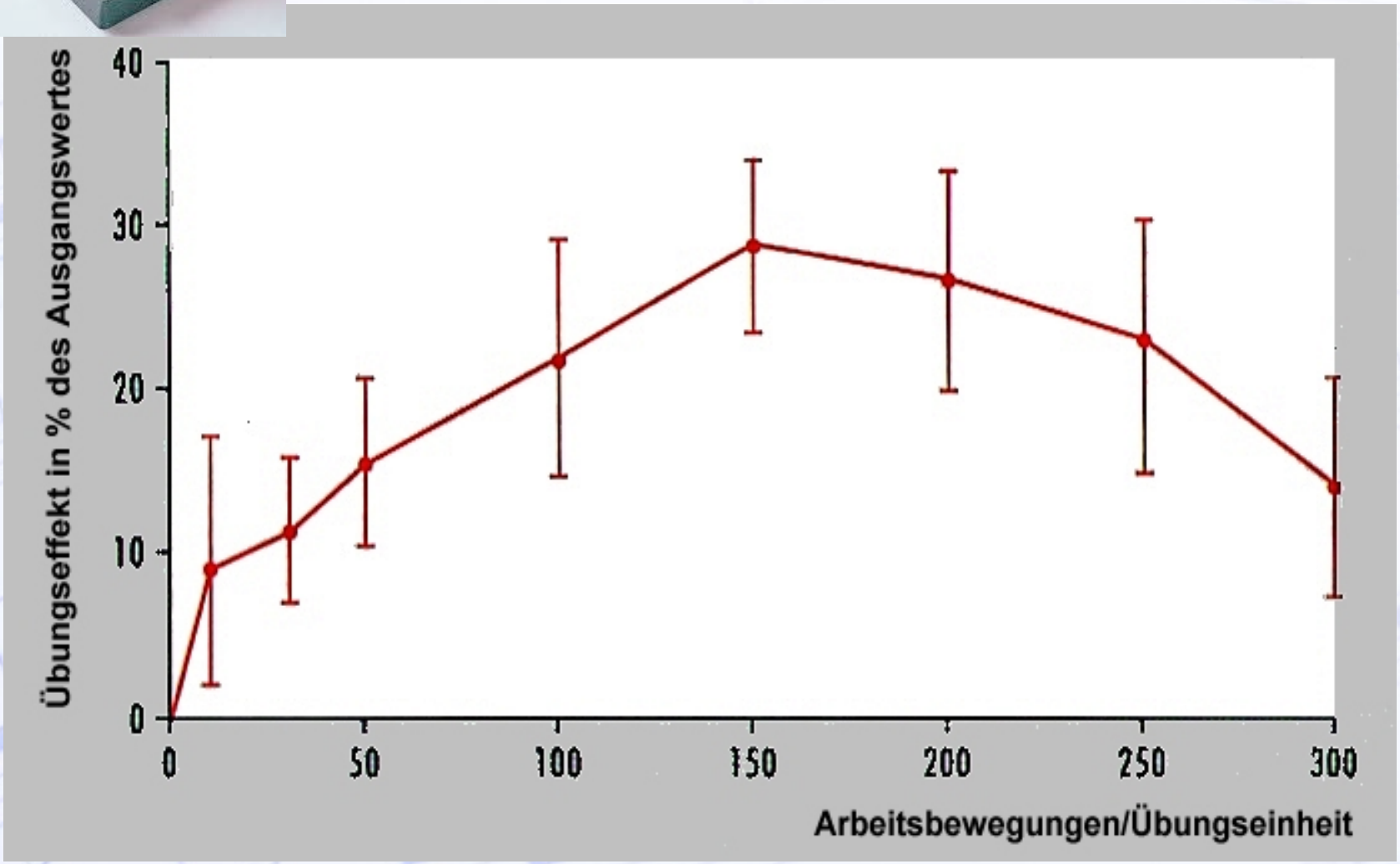
How can I increase speed?

How many pieces should I practice in one session?

Is variable practice better than blocked?



(*Hettinger et al. Geschicklichkeit und deren Übbarkeit. Z.Arbeitswiss.1975;29:223)*

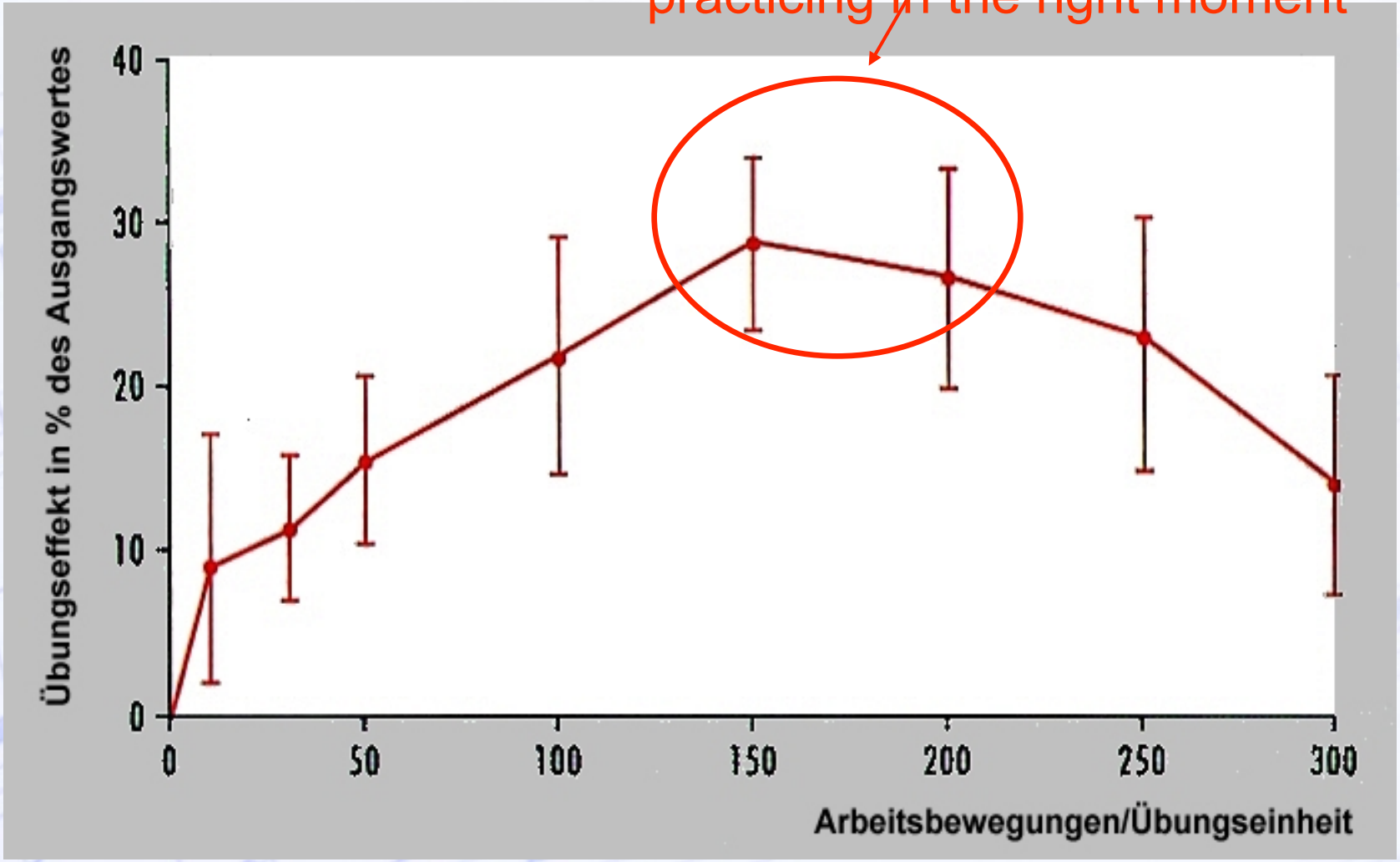


(Hettinger et al. Geschicklichkeit und deren Übbarkeit. Z.Arbeitswiss.1975;29:223)

John Williams Waterhouse: Penelope and the suitors (1912)

The Penelope-effect

Teach the art to stop practicing in the right moment



(*Hettinger et al. Geschicklichkeit und deren Übbarkeit. Z.Arbeitswiss.1975;29:223)*

Reasons for Deterioration

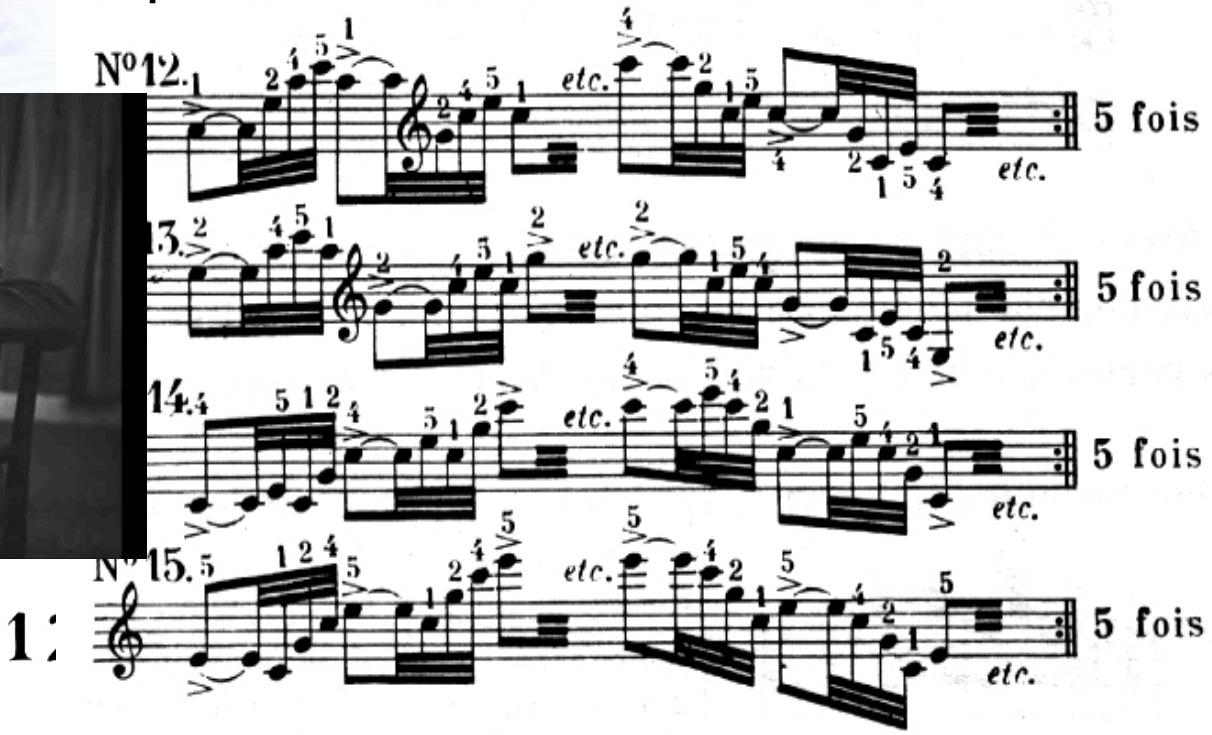
1.) Reduced motivation
2.) Reduced attention
3.) Fatigue of the muscles

Conclusion:

Organize your practice sessions interesting
Try not to practice un-attentively
Stop practice when fatigued (exception: endurance training)

→ Include pauses in your practice schedule

How to increase speed?

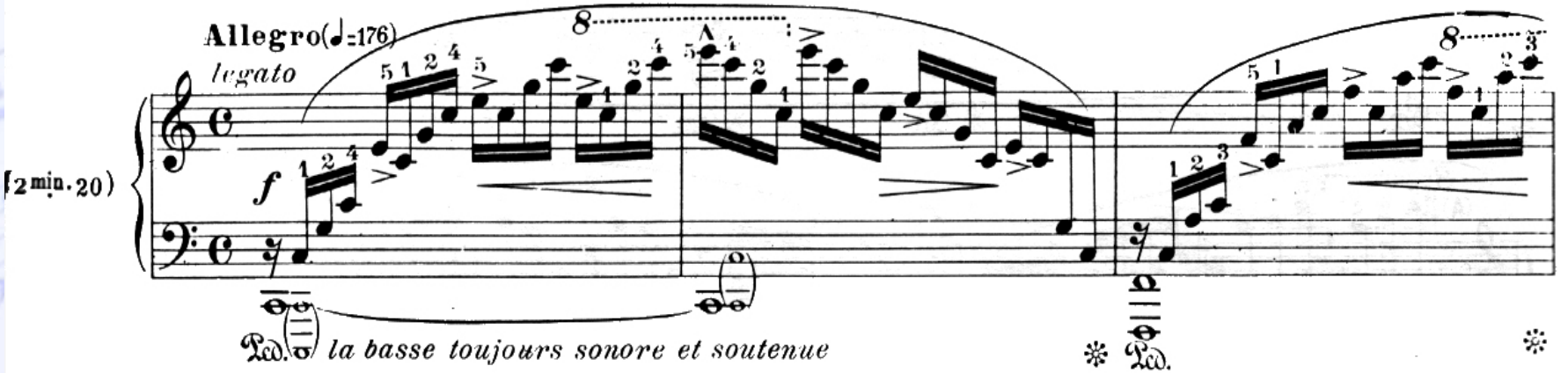


dédiées à Franz LISZT

Édition de Travail par
Alfred CORTOT

Frédéric CHOPIN

ÉTUDE Nº1



slow movements

rapid, “ballistic” movements

closed loop

feedback for any note

in the execution phase:

correction possible at any time

open loop

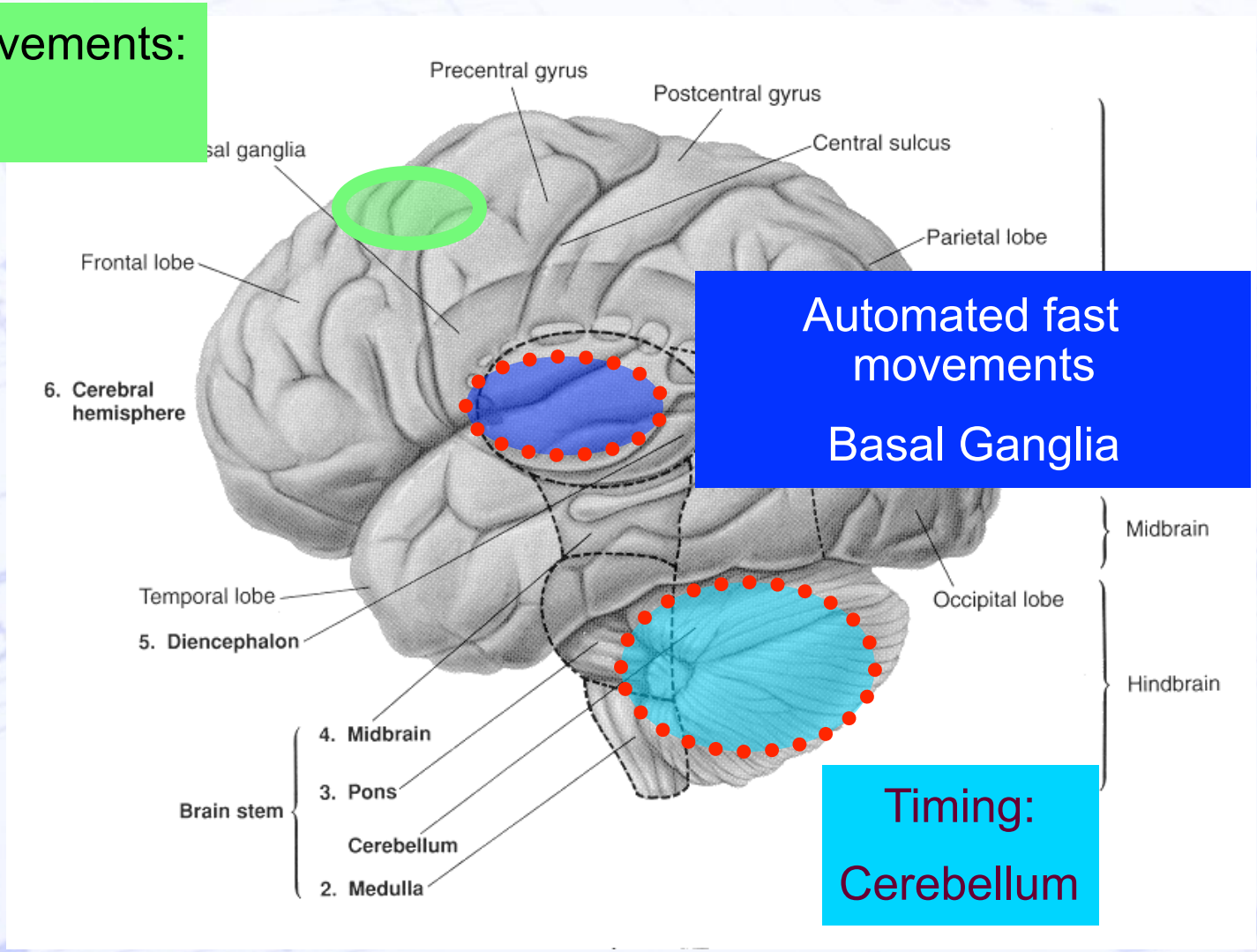
no immediate feedback

no correction possible in the early execution phase

There are different places in the brain, where slow and fast movements are stored:

Slow, guided movements:

SMA



Automated fast movements

Basal Ganglia

Timing:

Cerebellum

Teachers know and knew this:
Example: P. L. Graf, *Work-Up, Schott-Verlag*

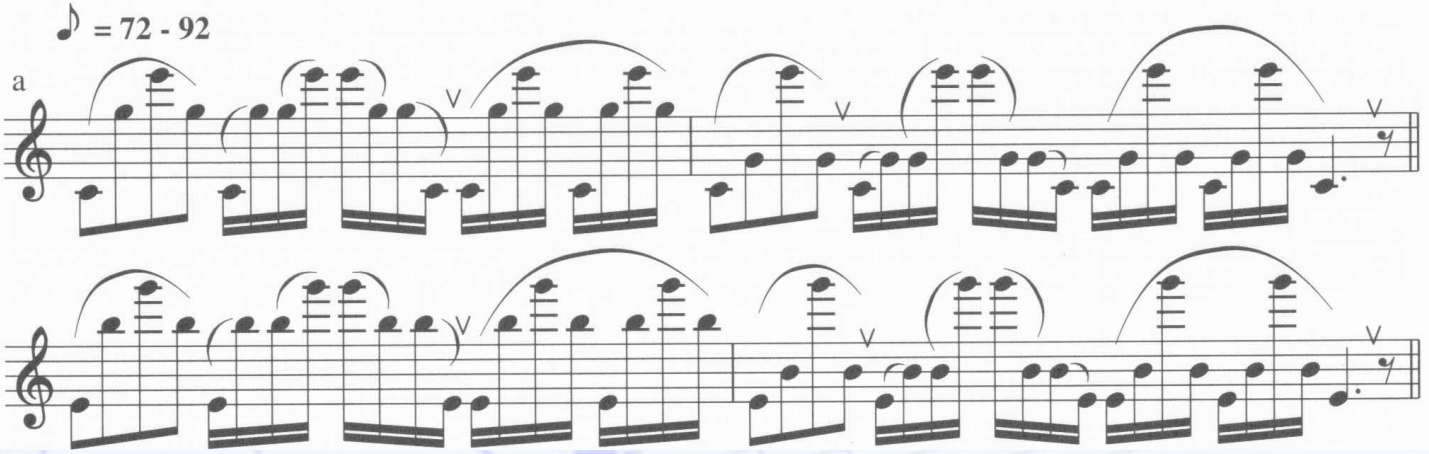
13 Registers I · Registerwechsel I

Exercise 13: Large Intervals

Purpose:
- A fluent change of register
- An even sound
- Good intonation

Übung 13: Große Intervalle

Ziel:
- Nahtloser Registerwechsel
- Ausgeglichener Klang
- Gute Intonation



Optimizing Music Learning: Exploring How Blocked and Interleaved Practice Schedules Affect Advanced Performance

Christine E. Carter[1] and Jessica A. Grahn[2]*

frontiers in Psychology

ORIGINAL RESEARCH
published: 18 August 2016
doi: 10.3389/fpsyg.2016.01251

10 Clarinetists:

Task:

a.) blocked 12. min Concerto exposition
blocked 12. min Etude

b.) interleaved 4x 3 min (other) Concerto exposition
mixed with 4 x 3 min (other) Etude

Measures: Expert video rating after sight-reading, before and after practice day 1 and practice day 2

mh...not so clear, raters judge differently

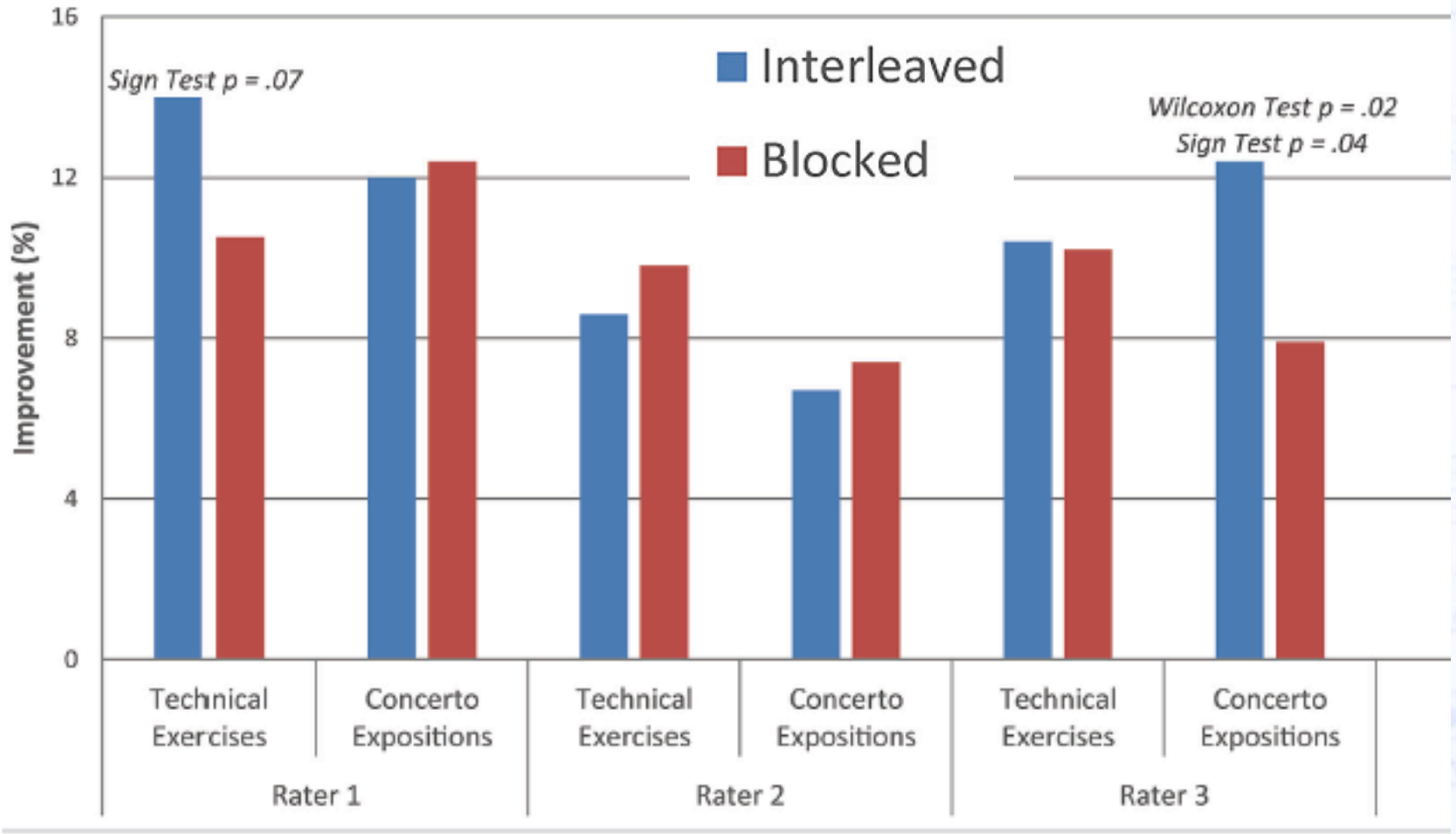
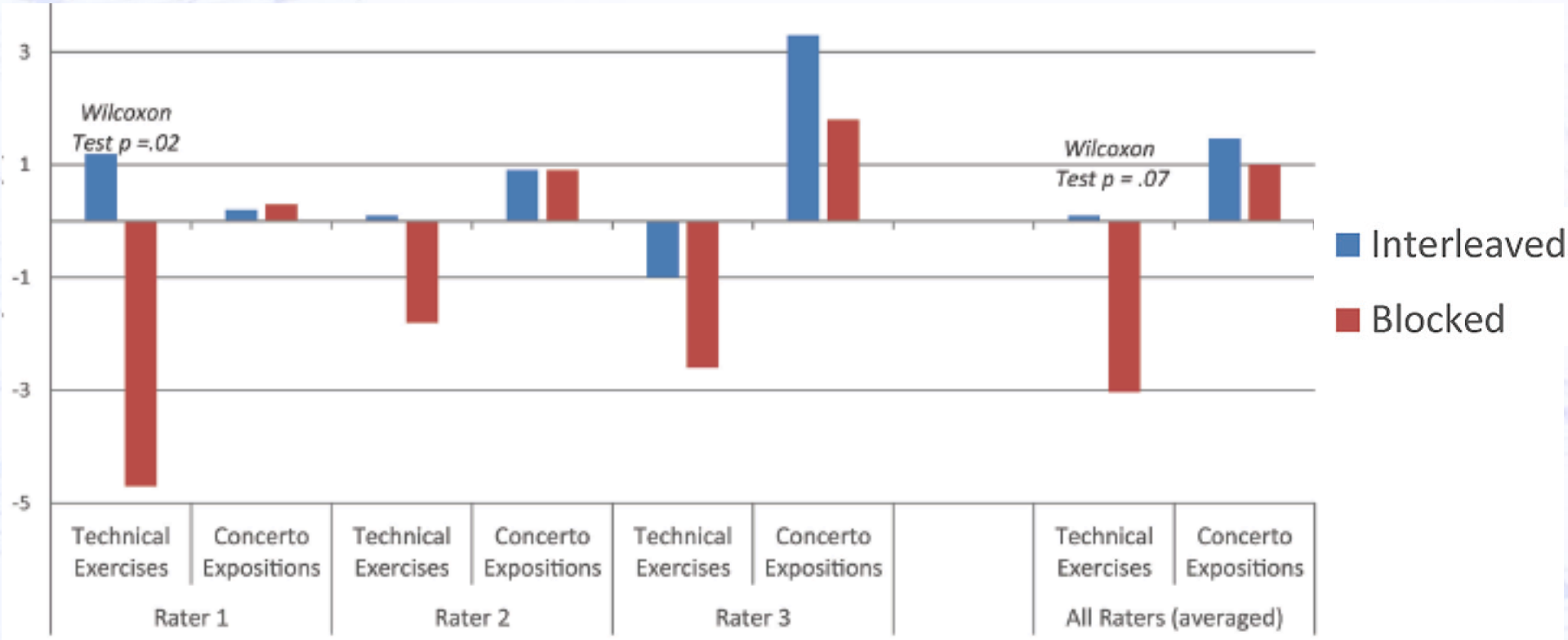


FIGURE 1 | Average overall improvement from sight-reading to day 2.

C. Carter, J. Grahn, Frontiers 2016

Interleaved practice seems to be slightly better in retention-tests



Average improvement from the end of day 1 to day 2:
= retention test

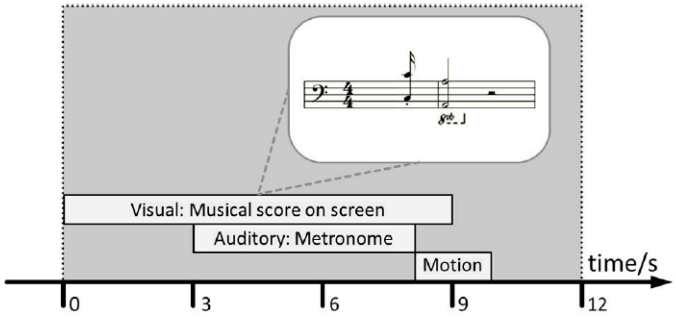
C. Carter, J. Grahn, Frontiers 2016

Variability and practice

Spatial variability of movements during learning is believed to enhance learning rate through action

Exploration, retention and transfer of motor memories

However,
In music practicing not so clear:



frontiers in
HUMAN NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE
published: 11 August 2014
doi: 10.3389/fnhum.2014.00584

Effects of variability of practice in music: a pilot study on fast goal-directed movements in pianists

*Marc Bangert, Anna Wiedemann and Hans-Christian Jabusch **

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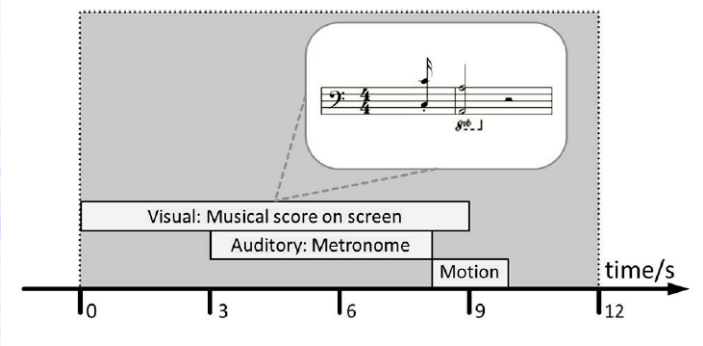


Participants

20 right-handed music students (11 male, 9 female)

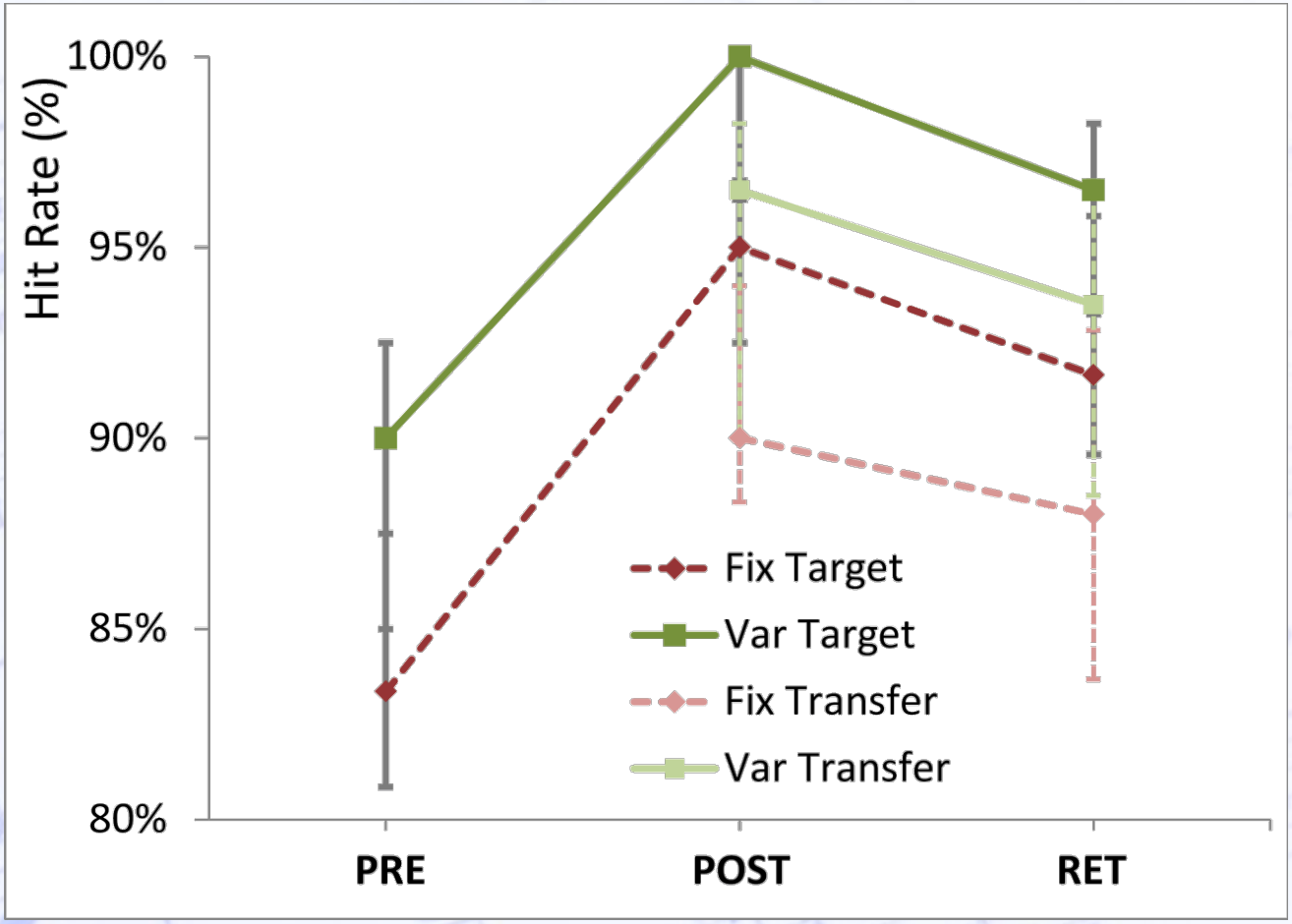
piano as their minor subject

	Median	min	max
Age /yrs	**19.9**	18.1	27.6
Age at Commencement (piano) /yrs	**13.0**	6	22
Cumul. years (piano)	**5.3**	1.4	19.5
Cumul. hours (piano)	**824**	151	4625
Handedness (Oldfield)	**100**	69	100
LH active digit 1-5 span /cm	**19.5**	16.5	24.0

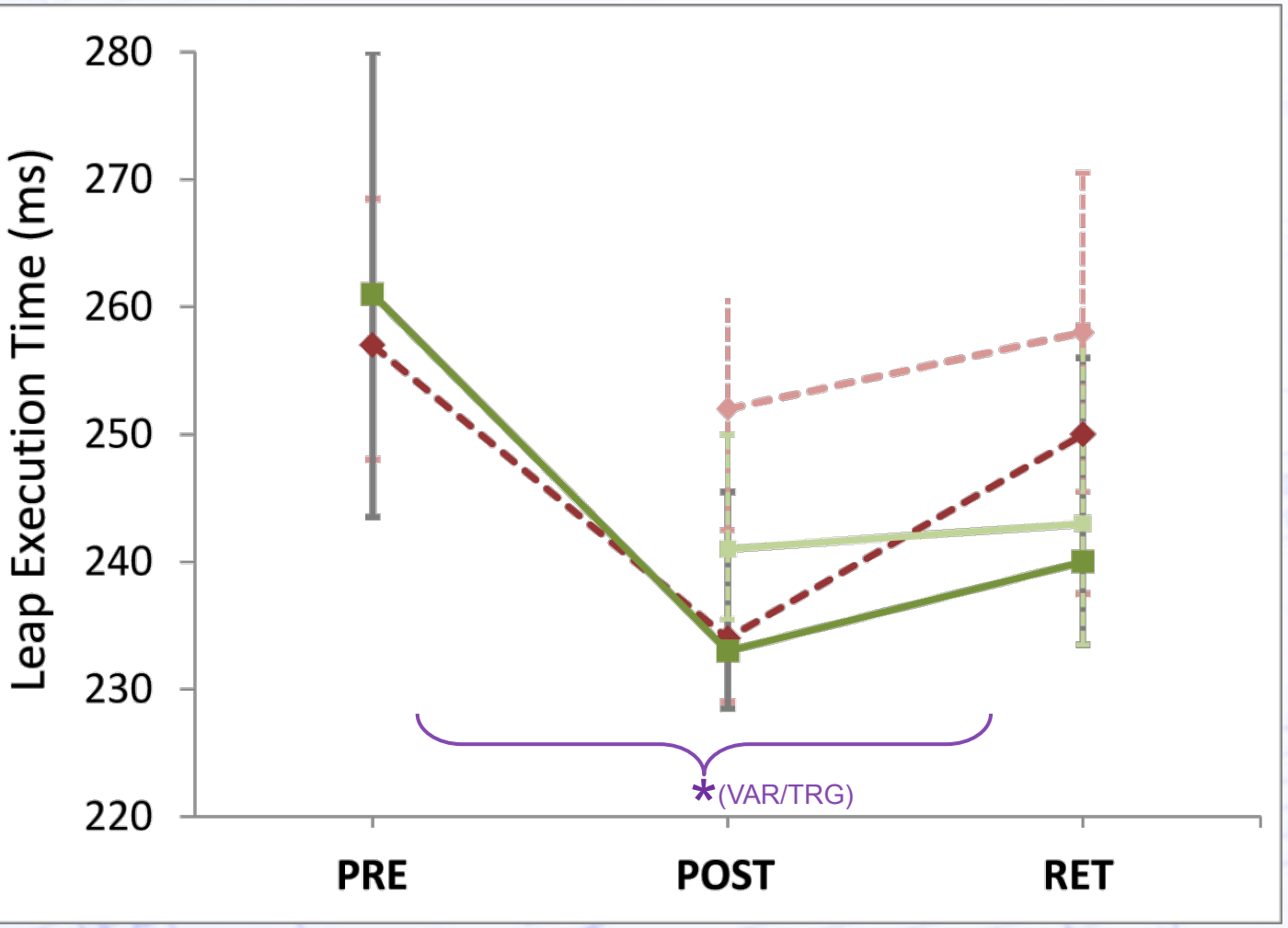
Randomly assigned to one of two matched groups

(between-groups Mann-Whitney tests for any of the above metrics $p > 0.05$)

Results: Hit Rate



Results: Leap Execution Time: slightly better in variable practice



Across-Session Effects:

* p_{corr} = 0.024 (Friedman)

Between-Session Effects:

* p_{corr} = 0.048 (Wilcoxon)

After Bonferroni-correction

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Psychon Bull Rev
DOI 10.3758/s13423-015-0999-9

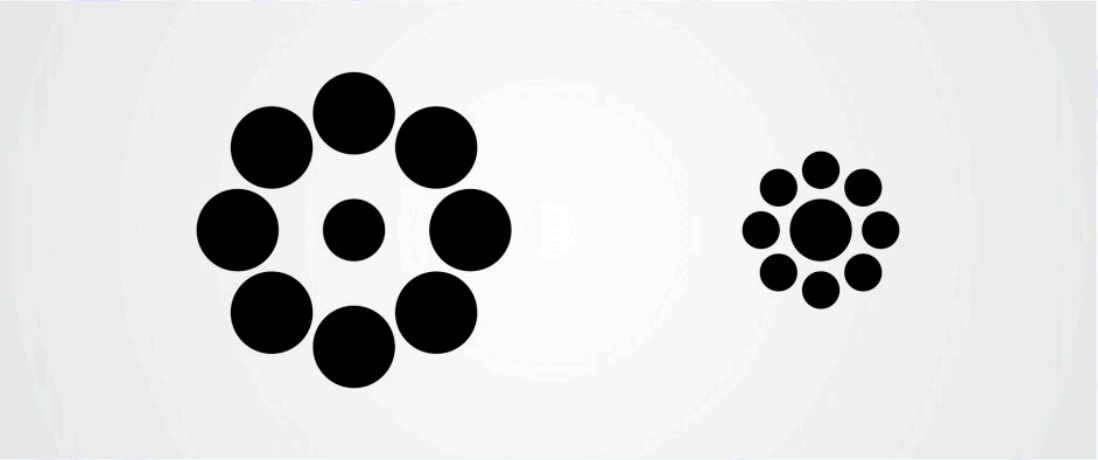
THEORETICAL REVIEW

Optimizing performance through intrinsic motivation and attention for learning: The OPTIMAL theory of motor learning

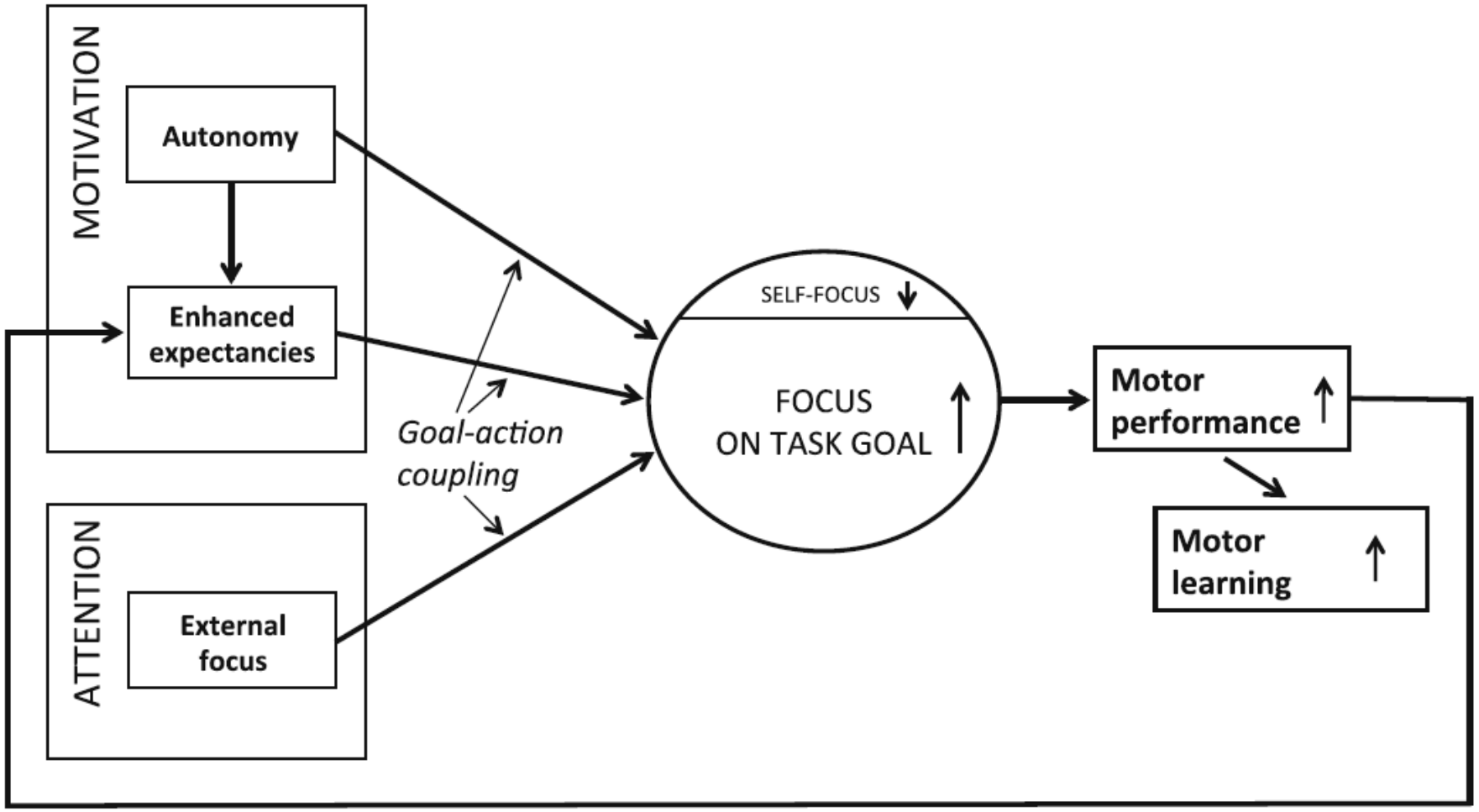
Gabriele Wulf[1] · Rebecca Lewthwaite[2,3]

Theory is based mostly on tests in sport psychology

e.g. Golf
Putting:
Who will hole in



The optimal theory



the OPTIMAL theory

Summary:
Some ingredients for optimal practice

Encourage autonomy of the student

Encourage “high” goal-setting

Provide positive feedback

Provide social comparative feedback: *e.g. joint concerts*

Encourage self-modeling: *“I am a Chopin-freak”*

Reduce perceived task difficulty: *sheet music editors!*

Conceptions of ability: *proudness of being a performer*

Extrinsic rewards: *well coached competitions*

Positive affect: *your optimism is contagious*

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hmtmh
Hochschule für Musik
Theater und Medien Hannover