中国科学技术大学
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High-Performance Practice Processes

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Guillaume Roels

- Education:
  - Catholic University of Louvain, Belgium
    - MS degree in Management Engineering
  - MIT
    - PhD in Operations Research
- Work:
  - Timken Chaired Professor at INSEAD
  - Research Director of the INSEAD-Wharton Alliance
  - Department Editor for M&SOM and Service Science
- Research Areas:
  - Supply Chain Management
  - **Service Management**
  - Entrepreneurial Operations Management
- Reward
  - One of the Poets & Quants 2015 Best 40 Business School Professors under 40.

Guillaume Roels

Publications:

- Before 2009: **Supply Chain Management**

Journal Article

Perakis G., Roels G. (2008). **Regret in the Newsvendor Model with Partial Information .** *Operations Research*, *56*(1), pp188-203.

Journal Article

Perakis G., Roels G. (2007). **The Price of Anarchy in Supply Chains: Quantifying the Efficiency of Price-Only Contracts .** *Management Science*, *53*(8), pp1249-1268.

Journal Article

Perakis G., Roels G. (2006). **An Analytical Model for Traffic Delays and the Dynamic User Equilibrium Problem .** *Operations Research*, *54*(6), pp1151-1171.

- After 2009: **Service Management**

Journal Article

Roels G., Su X. (2013). **Optimal Design of Social Comparison Effects: Setting Reference Groups and Reference Points .** *Management Science*, *60*(3), pp606-627.

Journal Article

Martinez-de-Albeniz V., Roels G. (2011). **Competing for Shelf Space.** *Production and Operations Management*, *20*(1), pp32-46.

Journal Article

Roels G., Karmarkar U. S., Carr S. (2010). **Contracting for Collaborative Services .** *Management Science*, *56*(5), pp849-863.

- **20** papers in UTD journal
  - **7** Management Science
  - **3** Operations Research
  - **6** Manufacturing and Service Operations Management
  - **2** Service Science
  - **2** Production and Operations Management

Insights

- Similar to our research.
  - Research problem;
  - Utility and disutility.
- Generalize the **research problem** to a wider area.
- Introduce the **model construction** process in detail.
- Fit the model with real **training program data**.

Practice Process Optimization

- Scenarios: "Practice makes better"
  - A runner training for a marathon;
  - A machine operator learning to operate a new machine;
  - A student preparing for a GMAT test.
- The **type** and **timing** of practice matter.

一周训练计划

适用于(大基数人群)

大基数人群一周4练训练计划				
	周一 全身训练	周三 推类+心肺	周五 拉类+心肺	周天 心肺
热身	全身热身5min 动态伸展	全身热身5min 动态伸展	全身热身5min 动态伸展	全身热身5min 动态伸展
训练	最伟大伸展 (1组)	史密斯卧推 (12个X6组)	壶铃硬拉 (15个X4组)	VIPR左右移动 (20sX4组)
	平板支撑 (30sX4组)	跪姿俯卧撑 (12个X6组)	高位下拉 (12个X6组)	vipr蹲推 (20sX4组)
	TRX深蹲 (10个X4组)	VIPR推肩 (12个X4组)	TRX划船 (15个X4组)	战术绳 (30sX5组)
	登山走 (5min)	折返跑	药球反应接球	波速抛传球 (20次X4组)
	臀桥 (15个X6组)	平板支撑 (30sX4组)	药球击地 (12个X6组)	深蹲开合跳 (15个X4组)
	山羊挺身 (15个X4组)	战术绳 (30-60s,休息等长时间共10min)	壶铃摇摆 (15个X4组)	跪姿俯卧撑 (10个X3组)
				波比跳 (15个X4组)
拉伸	全身拉伸	全身拉伸	全身拉伸	全身拉伸

考研周计划

时间：2022年5月16日-5月23日

计划	目标清单	可控时间
重要任务	一、考研专业课（每天学习4小时） 1、法律硕士《考试分析》：刑法第5-15章（共150页） 2、《配套刑法》：刑法第5-15章 （共80页） 3、网课：刑法第5-15课（共7.5小时） 二、英语（每天学习2小时） 1、阅读理解100篇：（每天2篇做题，对答案，翻译文中5个长难句） 2、真题：周末做2021年真题，各个文章选出5个长难句翻译出来 3、晨读：背诵单词，长难句 4、作文：写一篇大作文，背诵两个模板 三、政治（每天学习2小时） 1、徐涛的政治网课：马原1-14课（共10小时） 2、读配套讲义：马原1-14课（共89页） 3、做配套练习：马原1-14课（共70页） 四、大学课程 英语文学：周二下午3-5点 英语翻译：周四上午10-12点	7:00：起床 7:30：早餐 7:30-11:30：学习（4h） 12:00：午餐 13:30：午休 13:30-17:00：学习（3.5h） 17:00-18:00：锻炼 18:30：晚餐 18:30-22:30：学习（4h） 23:30：休息
临时任务	1、5月17日 交入党思想汇报 2、4月18日 晚上7点 参加考研培训会 3、4月20日 晚上9:00 给家里打电话 4、4月23日下午 洗衣服	战略目标
生活	锻炼：每天下午6-7点，跑步 周六下午到晚上：逛街、看美剧、出去玩	总分400分 专业课：125分 综合课：125分 英语：75分 政治：75分
问题复盘	1、专业课进度慢，下周安排5个小时学习时间 2、晚上睡得晚，应按时作息	

Research Problem:

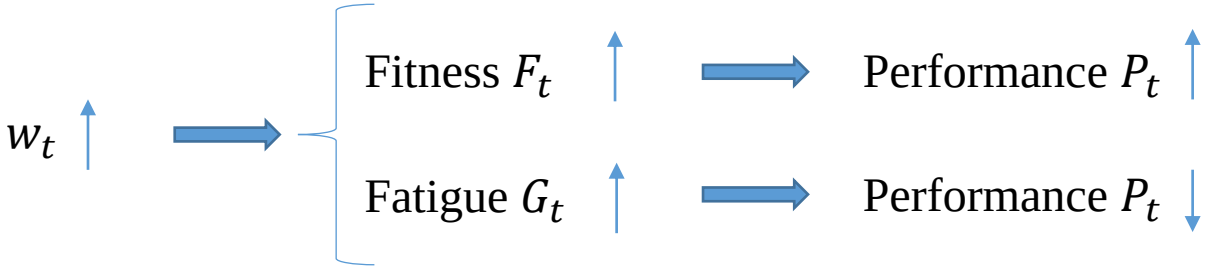
- What is the **optimal practice process** to **maximize performance** on a given date?
  - Should the practice involve breaks? Should it be massed or distributed? Should it be pulsed?
  - Should there be a decrease in practice intensity before the final performance test?

Research Gap

Related area	Published research	Research content	Contribution
Training for Endurance Sports	Ladany (1975); Zwols and Sierksma (2009)	• More focus on in-game strategies, drafting, and team scheduling; • **Static** training models.	Bringing a **dynamic optimization** perspective to training and learning.
Learning	Newell and Simon (1972);Brown et al. (2014);Cepeda et al. (2006);	• "Power law of practice"; • "Power law of forgetting"; • There is **limited guidance** on the optimal amount of spacing or optimal intensity of each practice.	
People-Centric Operations Management	Kc and Terwiesch (2009);Powell et al. (2012);Green et al. (2013).	• Fatigue and adaptation on employee productivity.	Developing a **novel process model** for optimizing learning and performance, incorporating the effects of fatigue and adaptation.

Fitness-Fatigue Model (Banister et al.,1975)

- $\boldsymbol{w} = (w_1, \dots, w_T)$: intensities of the activity during time T, $w_t \geq 0$ (Decision variable).



- $P_t = P_0 + k_F F_t - k_G G_t, \quad k_F, k_G > 0.$

  $F_t = \alpha F_{t-1} + w_t$

  $G_t = \beta G_{t-1} + w_t$

  $\alpha, \beta \in (0,1)$: Memory decay rate.

F-F model

- Maximize $P_T(w)$? **--Not realistic!**
  - Unbounded solution
  - Threshold policy

A Generalized Fitness-Fatigue Model

- **Adaptation:**
  - Replace $\boldsymbol{w_t}$ with $\boldsymbol{w_t/b_t}$.
  - $\boldsymbol{b_t}$: base level, $b_t = \epsilon \cdot h(w_{t-1}, b_{t-1})$
  - $h(w, b)$:
    - Geometric mean: $h(w, b) = w^{\theta} b^{1-\theta}$, (Faster adaptation to low-intensity, cognitive skills);
    - Maximum mean: $h(w, b) = \max\{w, b\}$, (Faster adaptation to high-intensity, motor skills);
- **Nonlinearities:**
  - Power functions
    - $F_t = \alpha F_{t-1} + (\frac{w_t}{b_t})^{\boldsymbol{\lambda}},\ \lambda < 1$ (Diminishing marginal returns)
    - $G_t = \beta G_{t-1} + (\frac{w_t}{b_t})^{\boldsymbol{\mu}},\ \mu > 1$ (Increasing marginal costs)

A Generalized Fitness-Fatigue Model

➢ **Additive and Multiplicative Impact of Practice.**

- $F_t = F_{t-1}(\alpha + (\frac{w_t}{b_t})^{\lambda})$
- $G_t = G_{t-1}(\beta + (\frac{w_t}{b_t})^{\mu})$
- $P_t = P_0 + \gamma \frac{F_t}{G_t},\ \gamma > 0$
- **Additive model**: skill acquisition stage.
- **Multiplicative model**: skill retention stage.

Formulation

Additive model:

$$P_t = P_0 + k_F F_t - k_G G_t$$

$$F_t = \alpha F_{t-1} + (\frac{w_t}{b_t})^{\lambda}$$

$$G_t = \beta G_{t-1} + (\frac{w_t}{b_t})^{\mu}$$

Multiplicative model:

$$P_t = P_0 + \gamma \frac{F_t}{G_t} F_t$$

$$F_{t-1}(\alpha + (\frac{w_t}{b_t})^{\lambda})$$

$$G_t = G_{t-1}(\beta + (\frac{w_t}{b_t})^{\mu})$$

- $b_t = \epsilon \cdot h(w_{t-1}, b_{t-1})$
- $h(w, b) = w^{\theta} b^{1-\theta}$ **or** $h(w, b) = \max\{w, b\}$

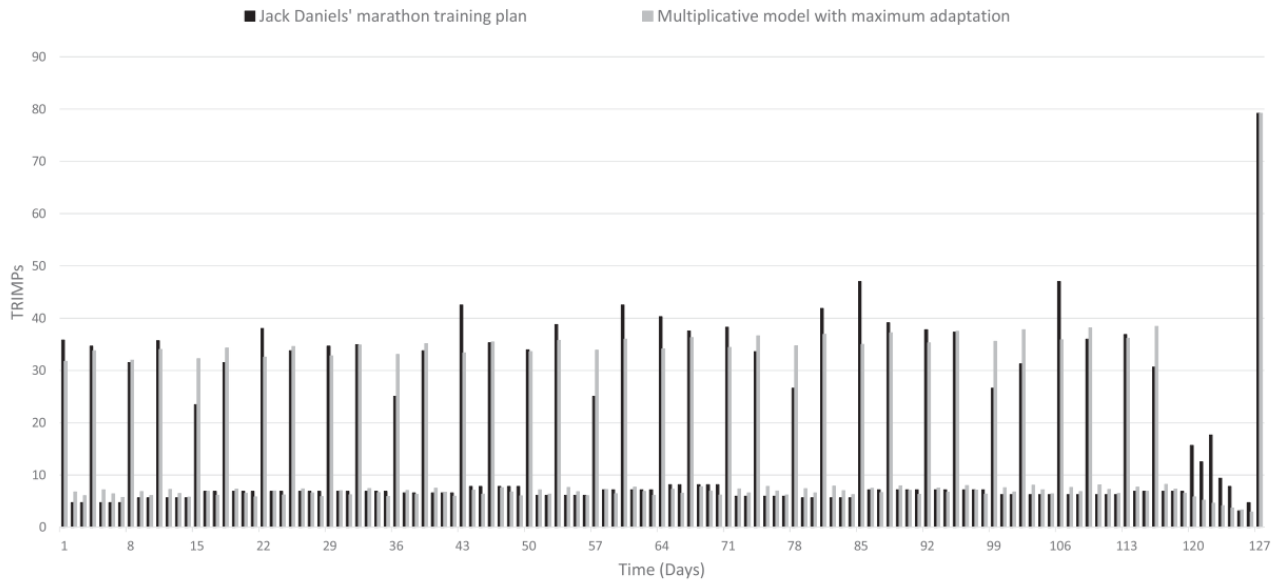
➢ **4 Cases**: Additive or Multiplicative; Geometric mean or Maximum mean.

Optimal Profiles

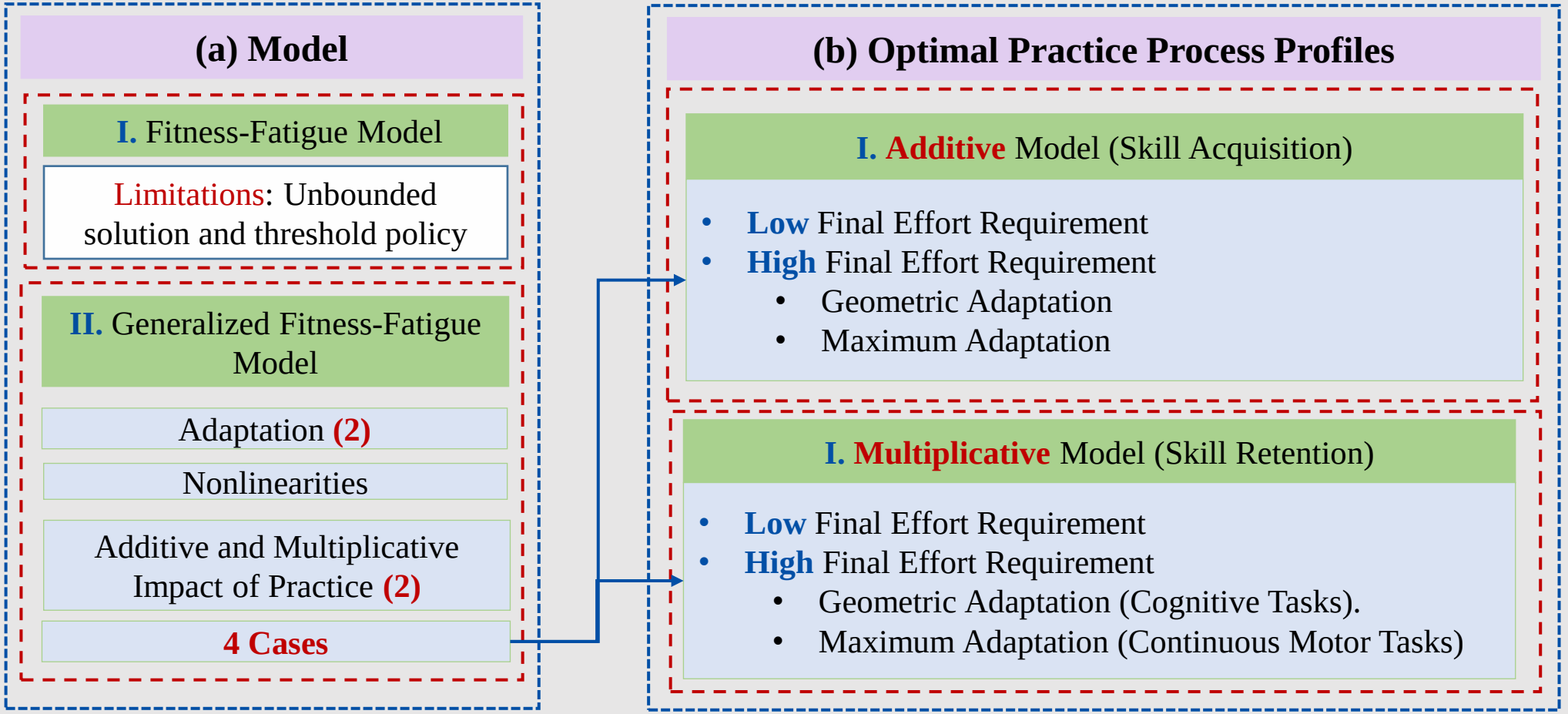
Table 1. Optimal Effort Profiles

		Performance model	
Final effort requirement	Adaptation mechanism	Additive (skill acquisition)	Multiplicative (skill retention)
Low		Monotone	Constant
High	Geometric (cognitive skills)	U-shaped (smooth)	Constant up to $T-1$ Pulsed
	Maximum (continuous motor skills)	U-shaped (abrupt)	Pulsed

Figure 7. Daniels's 18-Week Marathon Training Program and Fitted Multiplicative Model with Maximum Adaptation



Problem: ***What is the optimal practice process to maximize performance?***



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Thank you for listening!

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