Behavioral Goal Setting Models for Operations Management

Workshop Stochastic models for warehousing systems
October 29, 2009

José Antonio Larco,

Kees Jan Roodbergen, René de Koster, Jan Dul

Rotterdam School of Management

Erasmus University Rotterdam

Contact: jlarco@rsm.nl

RSM *Erasmus*
ERASMUS
UNIVERSITY

Goals are interesting for OM…

- Current assumptions of OM models:

  – People are predictable, work in a stationary way and are

    unaffected by external factors (Boudreau, 2003)

- Challenging goals *have* a positive effect on performance

  – **Meta-analysis 8-16**% performance increase over "do your

    best"" strategies; (Locke and Latham, 1990)

  – Well studied: >**239** lab experiments, > **156** field studies (Locke

    and Latham, 1990)
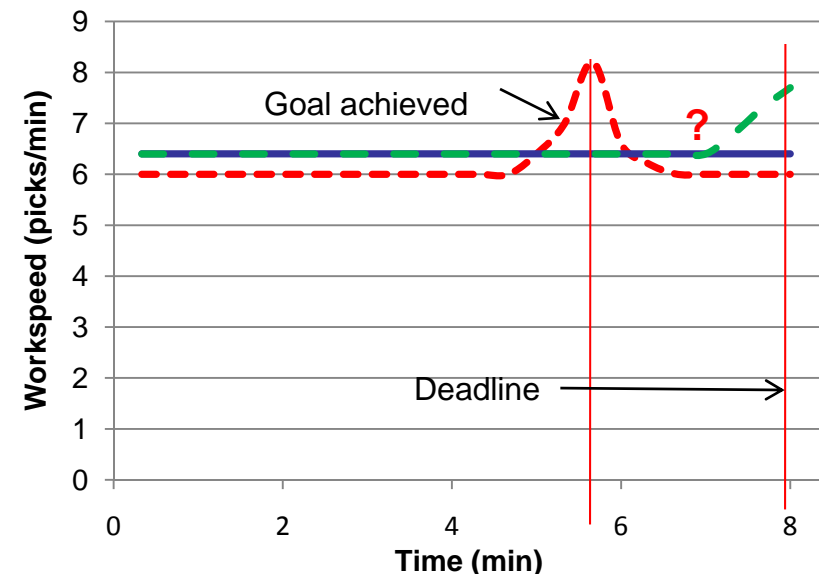
Two main questions for OM

1. How is performance related to goal difficulty?
   - Linear? (Locke and Latham, 1968)
   - Levels-off? (Locke & Latham, 1982)
   - Decreases? (See et al, 2006)
   - Effects of varying skill level?
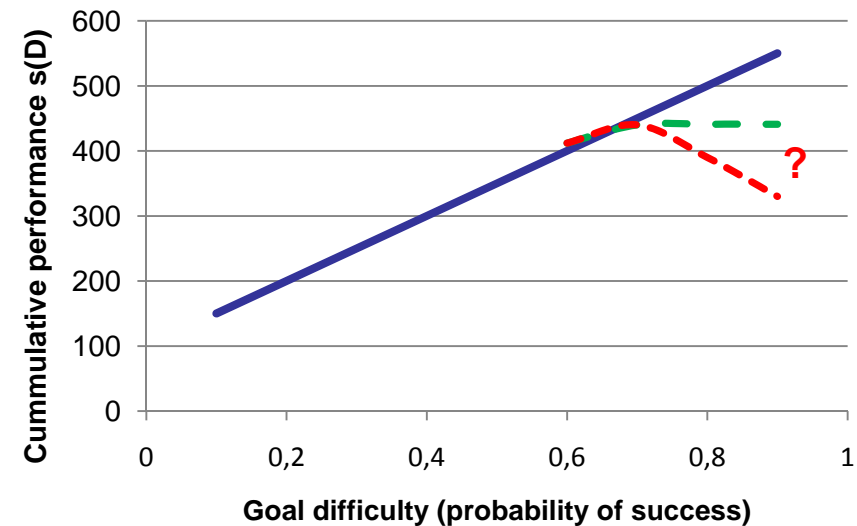
2. How do workers regulate their work pace?
   - Acceleration towards goal (Hull, 1932) or deadline?
   - A steady state pattern or irregular?
   - Effect of varying goals & skill level?

All this in OM contexts where workers have a **fixed** time to work.

Two-fold approach

1. Proposition generation: workers as decision makers

   – **Objective**: maximize utility/preference

     • Utility derived from work pace itself

     • Utility derived from evaluation w.r.t goal

   – **Decision:** what work-pace to select? (effort to exert)

   – Behavioral Economic decision models:

     • **Myopic:** Individuals focus only on the "near future".

     • **Planner:** Individuals take into account the utility for the whole period.

   – Derivation of properties from model

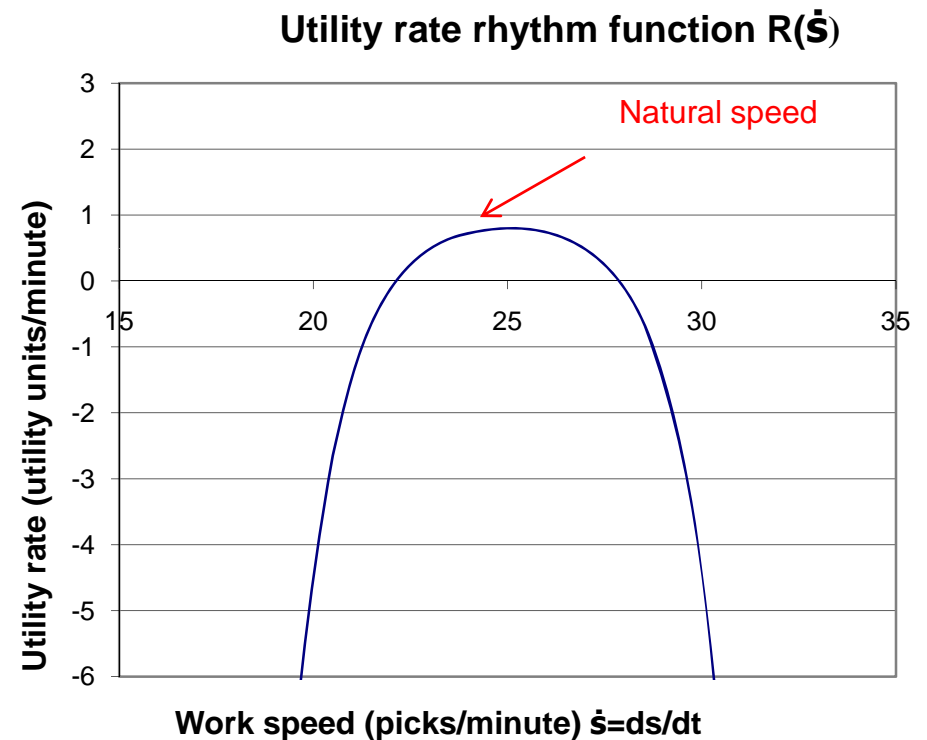2. Propositions Testing: experimental setting

   – Total performance

   – **Work pace** measurement

Scope

- Work is repetitive; i.e. work content known; cycle times short

- Workers are experienced

- Feedback is provided

- Goal G (units processed) to be achieved before deadline D

- Target G serves as reference for evaluating performance

- Workers **committed** to the goal (Locke and Latham, 1990)

- Cumulative work $s(t)$, work pace, $\dot{s}=ds/dt$

RSM *Ezafuns*
ERASMUS
UNIVERSITY

Work pace preference (Yerkes-Dodson Law (1908)

- Relates (Hancock & Warm,1989) :
  - Stressor
  - Adaptability/desirability

- Defines:
  - Maximum desirability
  - Range of tolerance

- Properties:
  - Convex function

Utility rate rhythm function R($\dot{s}$)

Natural speed

Utility rate (utility units/minute)

Work speed (picks/minute) $\dot{s}$=ds/dt

RSM
ERASMUS UNIVERSITY

Goal induced preference (Kahneman & Tversky 1979)

- Properties:

  – Strictly increasing

  $$P'(s(t)) \geq 0; t \in [0, D]$$

  – Loss aversion
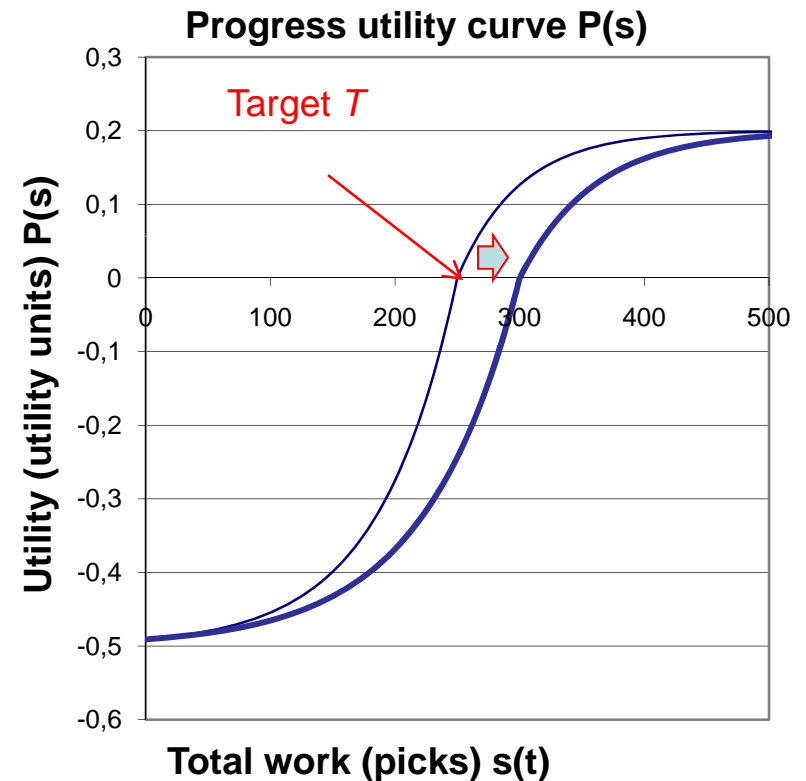
  $$P(G + \delta) < P(G - \delta); \delta > 0;$$

  – Diminishing sensitivity

  $$P''(s(t)) > 0; s < G$$

  $$P''(s(t)) < 0; s > G$$

- Usage in goal theory

  Heath et al.,1999; Steel & Koning, 2006

  and Wu, et al. 2008

Progress utility curve P(s)

Target *T*

Utility (utility units) P(s)

0,3
0,2
0,1
0
-0,1
-0,2
-0,3
-0,4
-0,5
-0,6

0   100   200   300   400   500

Total work (picks) s(t)

1. Myopic Conjecture

$$\max_{\dot{s}} R(\dot{s}) + Q(s, \dot{s})$$

Initial conditions :

$$\dot{s}(0) = 0$$

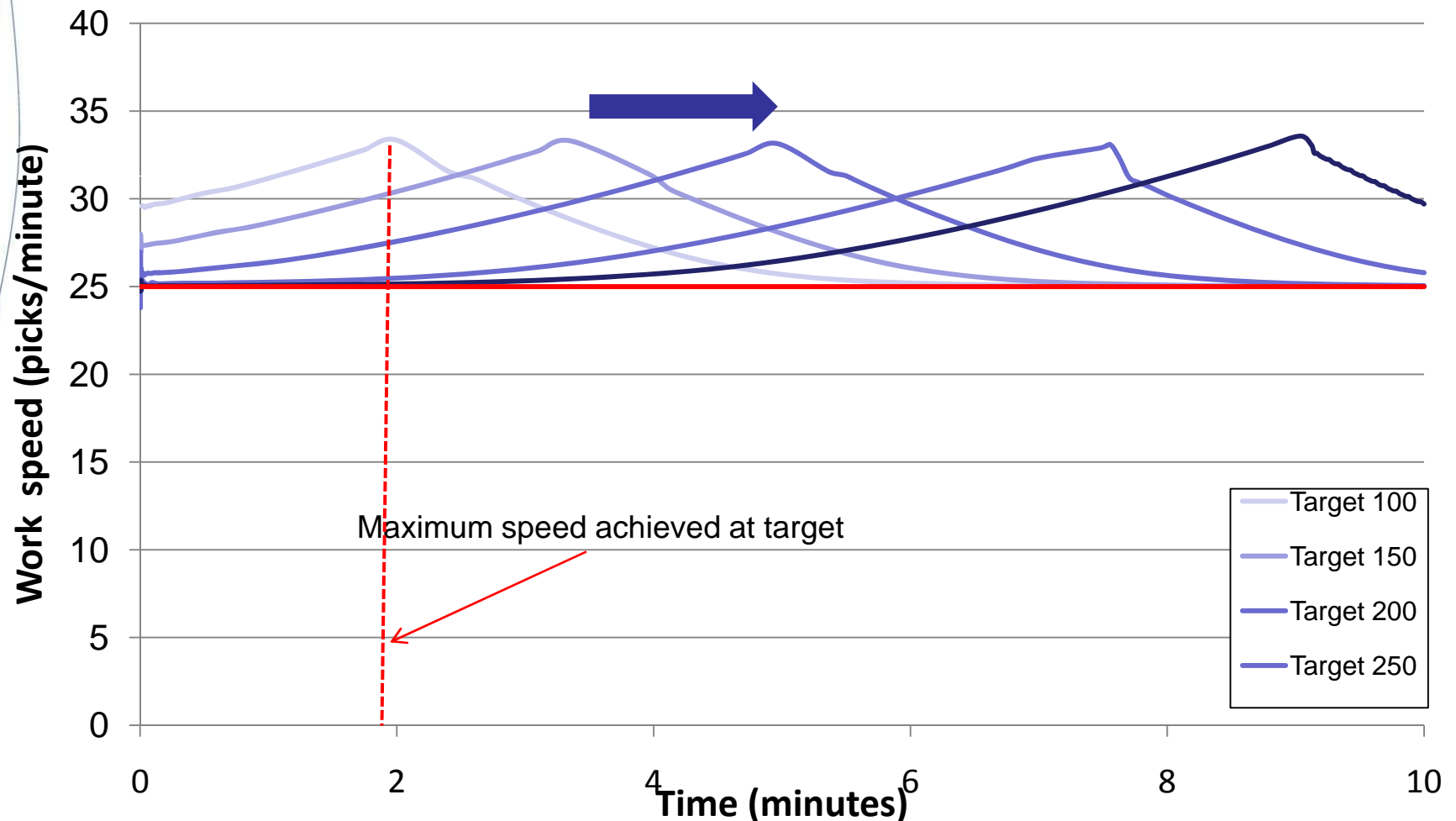Progress utility rate (apply chain rule) - unit consistency :

$$Q(s, \dot{s}) = P'(s)\dot{s}$$

First order conditions :

$$\boxed{R'(\dot{s}) = -P'(s)}$$

1. Myopic Conjecture (Work Pace Propositions)
>**Consistent with goal gradient hypothesis (Hull, 1932)**

Maximum speed achieved at target

Legend:
- Target 100
- Target 150
- Target 200
- Target 250

Y-axis: Work speed (picks/minute)
X-axis: Time (minutes)

2. Planning Conjecture

$$\max_{\dot{s}} \int_0^D (R(\dot{s}) + P'(s))dt$$

Boundary condition :

$$\dot{s}(0) = 0$$

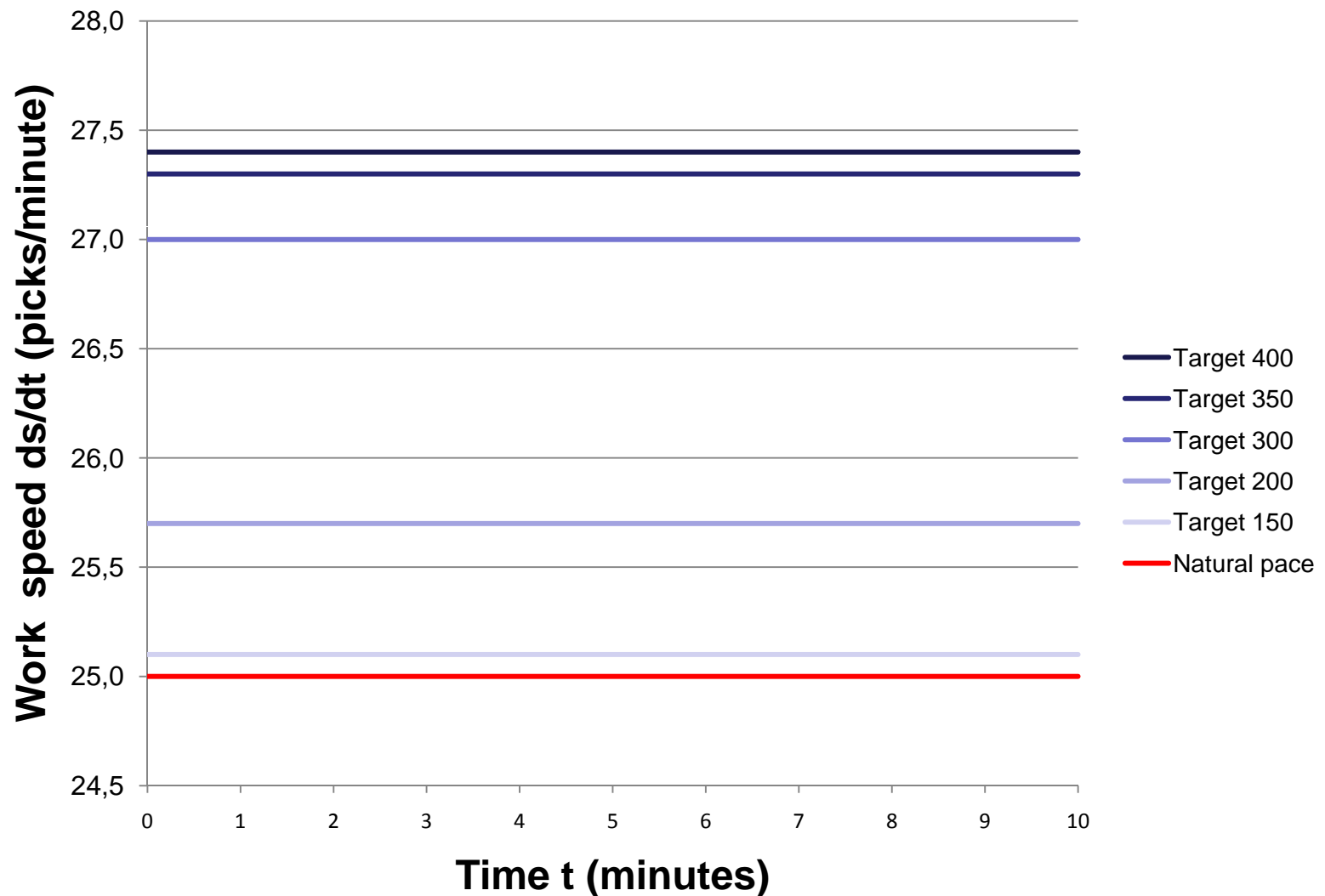Recognize that $\int_0^D P'(s)\dot{s}\,dt = P(s(D)) - P(s(0))$ <Independent of work pace!

Applying euler formula :

$$\boxed{s(t) = ct}$$ <Constant work pace!

using the fact that $\dot{s}(t) = \text{constant}$:

$$\boxed{R'(\dot{s})D = -P'(D\dot{s})}$$

RSM *Erasmus*
ERASMUS
UNIVERSITY

2. Planning Conjecture (Work Pace Propositions)

**>Consistent with Planning Conjecture (Parkinson, 1955)**

Goals and Performance: Contrasting propositions
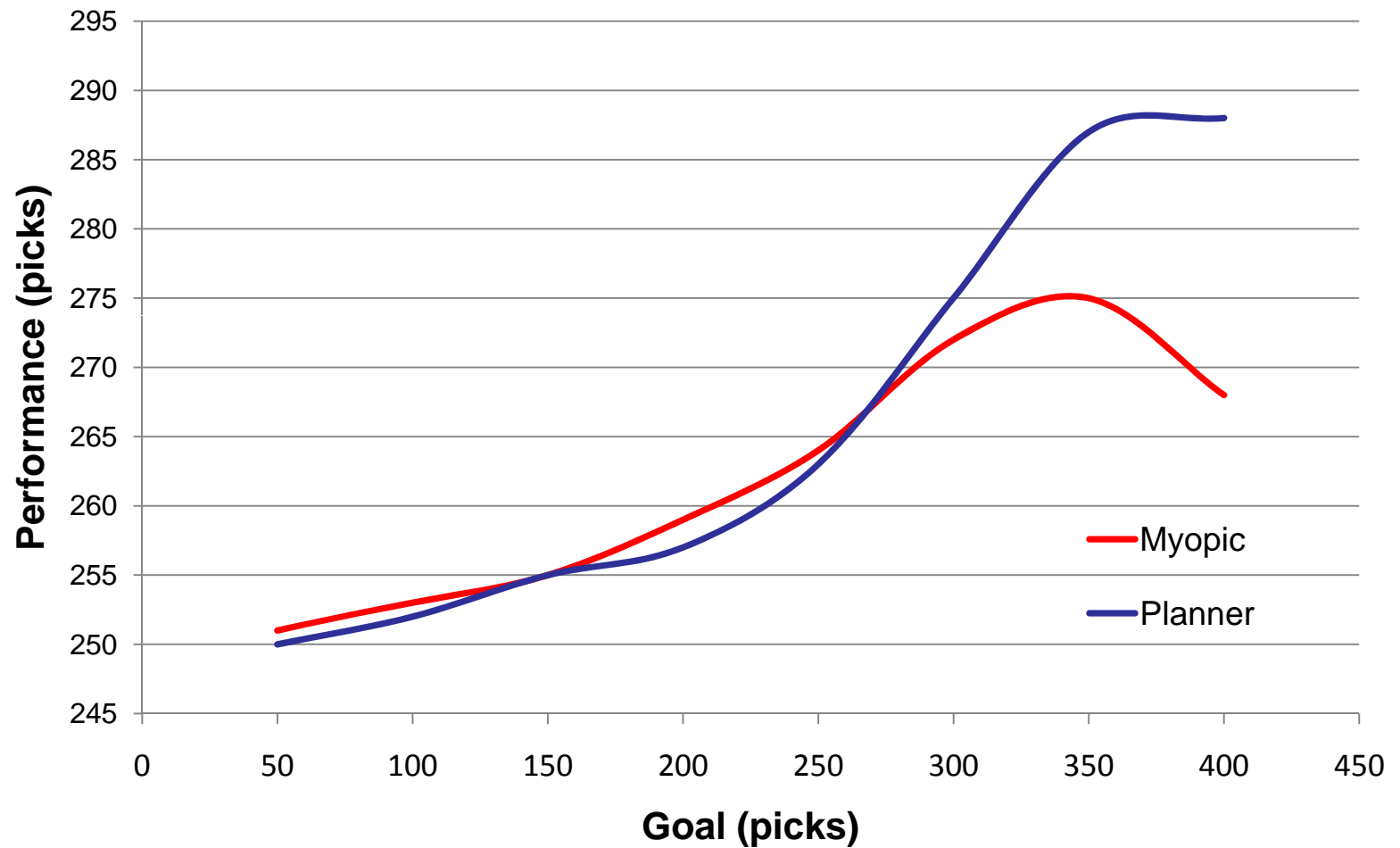
Experiment Design

- Simple order picking task, short cycled (<10 sec)

- Control for learning effects (previous picking rounds)

- **Within subject design (3x"4"):**

  – Pilot study "Do your best" control (n=36 subjects)

  – **3** randomized goal levels (10, 50, 90th percentile) **per** subject (n=81 subjects)

  – Skill proxy: Average work pace of 10 best work pace used - 4 categories constructed

  – Credit assigned to all subjects **regardless** of their performance

- **Process view**: **work pace** measured using time stamps

RSM *Erasmus*
ERASMUS
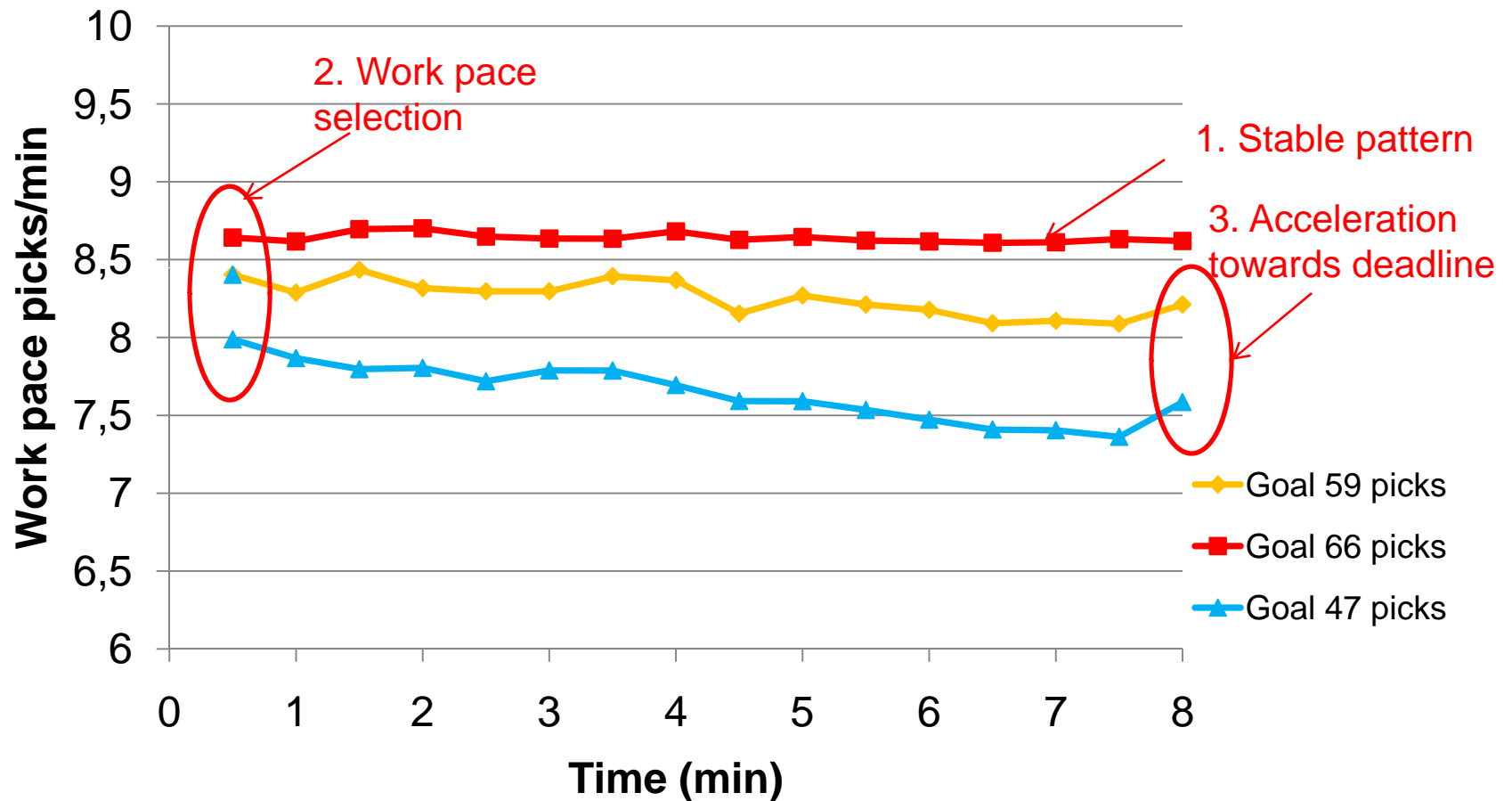UNIVERSITY

Experiment : Task description
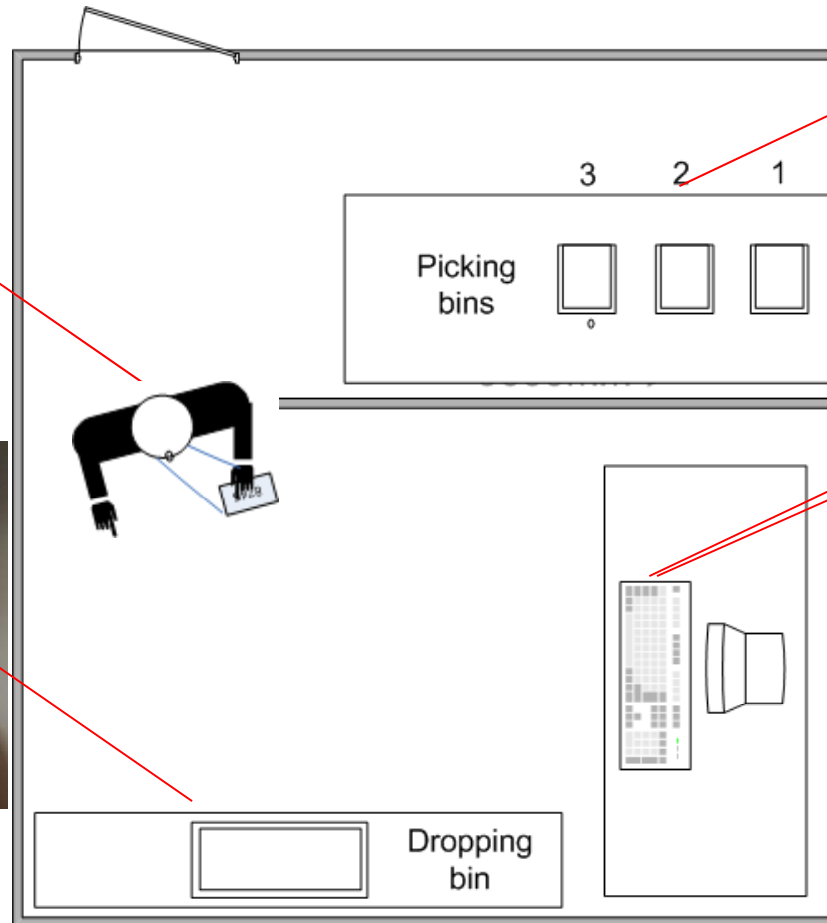
Results 1: Goal difficulty-performance
> Level-off (Locke and Latham (1982)) (Goal/skill Interaction F (1,77)=7.4; p<0.01)
> Consistent with planner results
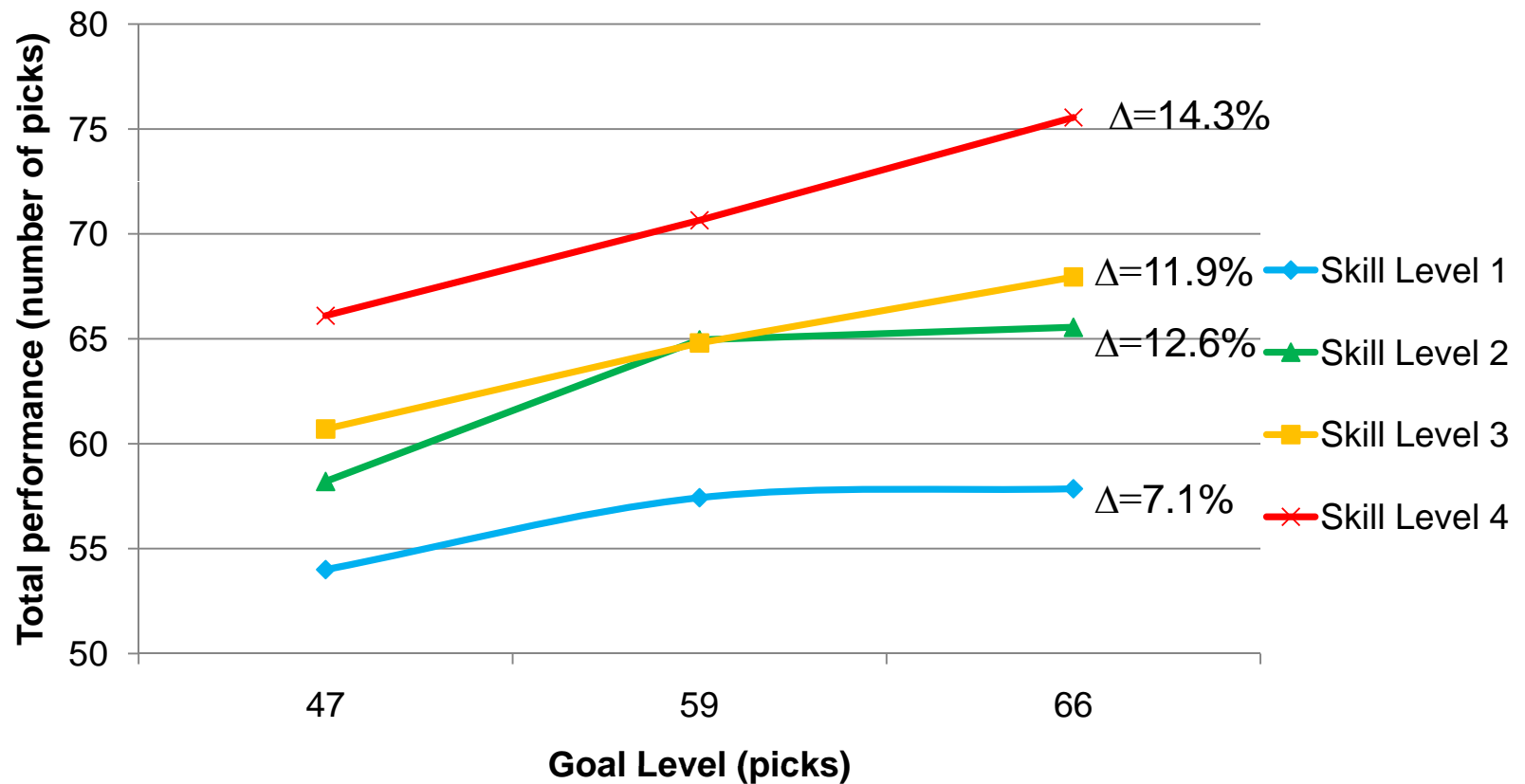
Results 2: Work speed-stationary behavior

Results 3: Multi-level analysis (pick<round<subject)

DV: Work pace: picks/min	MLM Model (picks=3631, rounds=3, subjects=81)			OLS Model (n=3631)		
Factor	Coeff	S.E.		Coeff	S.E.	
Intercept	7.7878	0.1458	***	7.8331	0.0678	***
Time	**0.0089**	**0.0202**		-0.0148	0.0186	
Goal Level 47 Picks	**-0.6757**	**0.0894**	***	-0.6933	0.0682	***
Goal Level 59 Picks	**-0.2273**	**0.0894**	*	-0.2347	0.0683	***
Skill Level 2	**0.6841**	**0.1952**	**	0.6445	0.0785	***
Skill Level 3	**1.0170**	**0.1952**	***	0.9799	0.0784	***
Skill Level 4	**1.7094**	**0.1952**	***	1.6724	0.0784	***
Time x Goal Level 47 Picks	**-0.0826**	**0.0287**	**	-0.0342	0.0223	
Time x Goal Level 59 Picks	-0.0229	0.0242		-0.0240	0.0222	
Time x Skill Level 2	-0.0074	0.0285		0.0047	0.0238	
Time x Skill Level 3	-0.0204	0.0285		-0.0011	0.0238	
Time x Skill Level 4	-0.0132	0.0285		0.0369	0.0238	
Time x Goal Level 47 Picks x Skill Level 2	-0.0093	0.0402		-0.0451	0.0246	.
Time x Goal Level 47 Picks x Skill Level 3	0.0040	0.0402		-0.0354	0.0246	
Time x Goal Level 47 Picks x Skill Level 4	0.0042	0.0402		-0.1020	0.0246	***
Time x Goal Level 59 Picks x Skill Level 2	0.0144	0.0335		0.0409	0.0246	.
Time x Goal Level 59 Picks x Skill Level 3	-0.0202	0.0335		-0.0151	0.0245	
Time x Goal Level 59 Picks x Skill Level 4	**-0.0666**	**0.0335**	*	-0.0871	0.0245	***
R2					**0.3965**	
AIC		**6338**				
BIC		**6512**		**6180**		

***$p<0.001$, **$p<0.01$, *$p<0.05$ Reference values: Goal Level 66 Picks, Skill Level 1

MLM Random effects

Factor	Variance of coefficients	S.E. of coefficients	Corr
By Pick Round j within Subject I (Intercept)	0.265087	0.514866	
By Pick Round j within Subject I Time	0.003444	0.05869	-0.306
By Subject (Intercept)	0.282252	0.531274	
By Subject Time	0.002298	0.047939	-0.195
By Subject Time x Goal Level 47 Picks	**0.005494**	**0.074119**	
By Subject Time x Goal Level 59 Picks	**0.000433**	**0.020806**	
Residual	0.242124	0.492061	0.619

RSM *Erasmus*
ERASMUS
UNIVERSITY

Conclusions

- Confirmation of **"leveling off"** effect in goal difficulty-performance relationship

- Challenging goals induce **steady state behavior** (explanations for this? -Carver & Shreier, 1998?)

- Acceleration towards **deadline** not towards goal

- General support for **planner** conjecture model

RSM Erasmus
ERASMUS
UNIVERSITY

Implications for OM:

- Confirmation that challenging goals work

- Usage of different goals as source of **variable capacity**: (demand fluctuations and deadlines)

- New advantages of challenging goals: **steady state behavior** and enhanced **predictabilility**

- **Verification** of steady-state work pace to identify whether goal is **adequately** set.

- Monitor progress towards the goal

RSM

ERASMUS
UNIVERSITY

Further research…

- Vary time frames

- Study feedback effects

- Prediction of performance

- Trade-off with other OM goals: quality, fatigue, safety

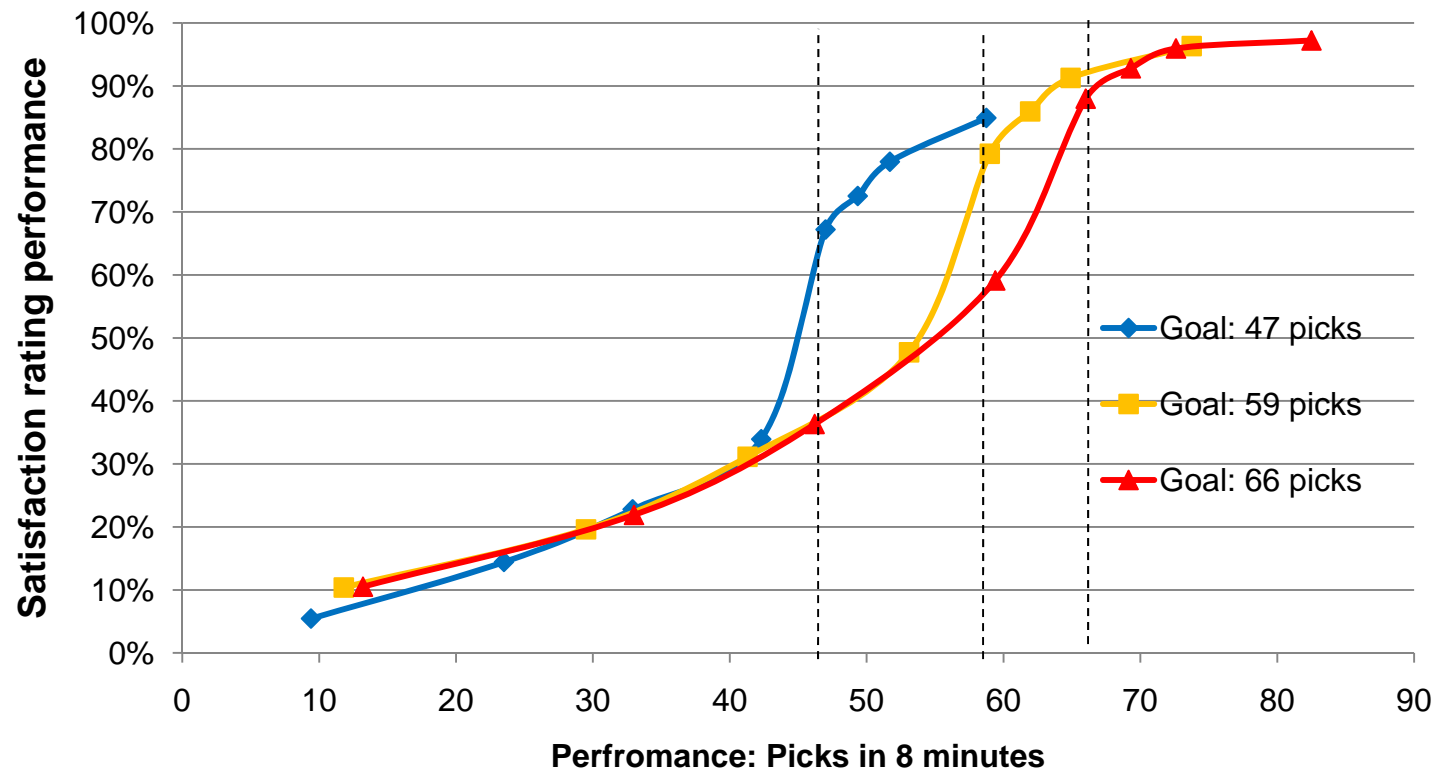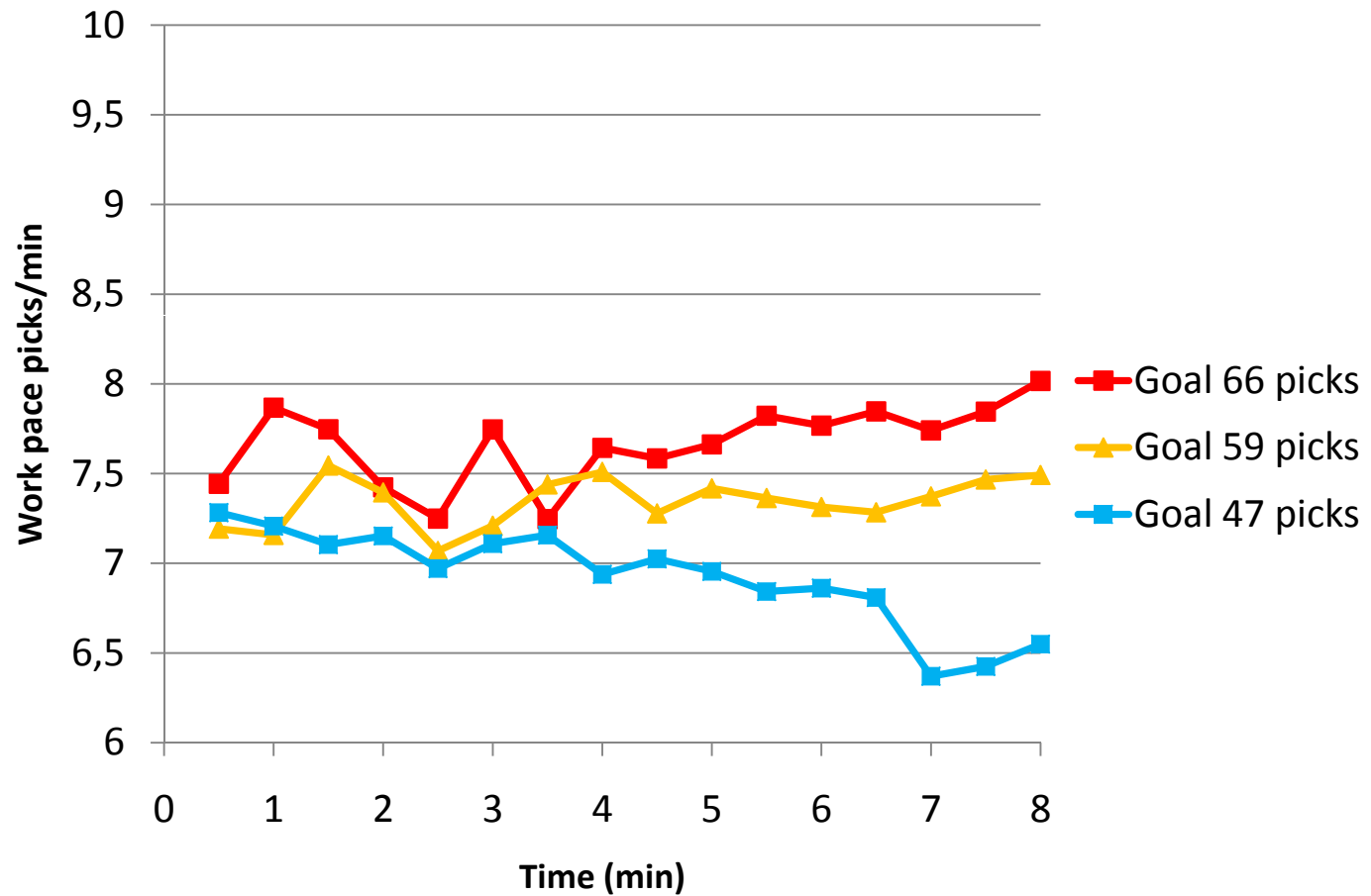- Replications in "real world" settings

RSM *Erasmus*
ERASMUS
UNIVERSITY

Performance Distribution
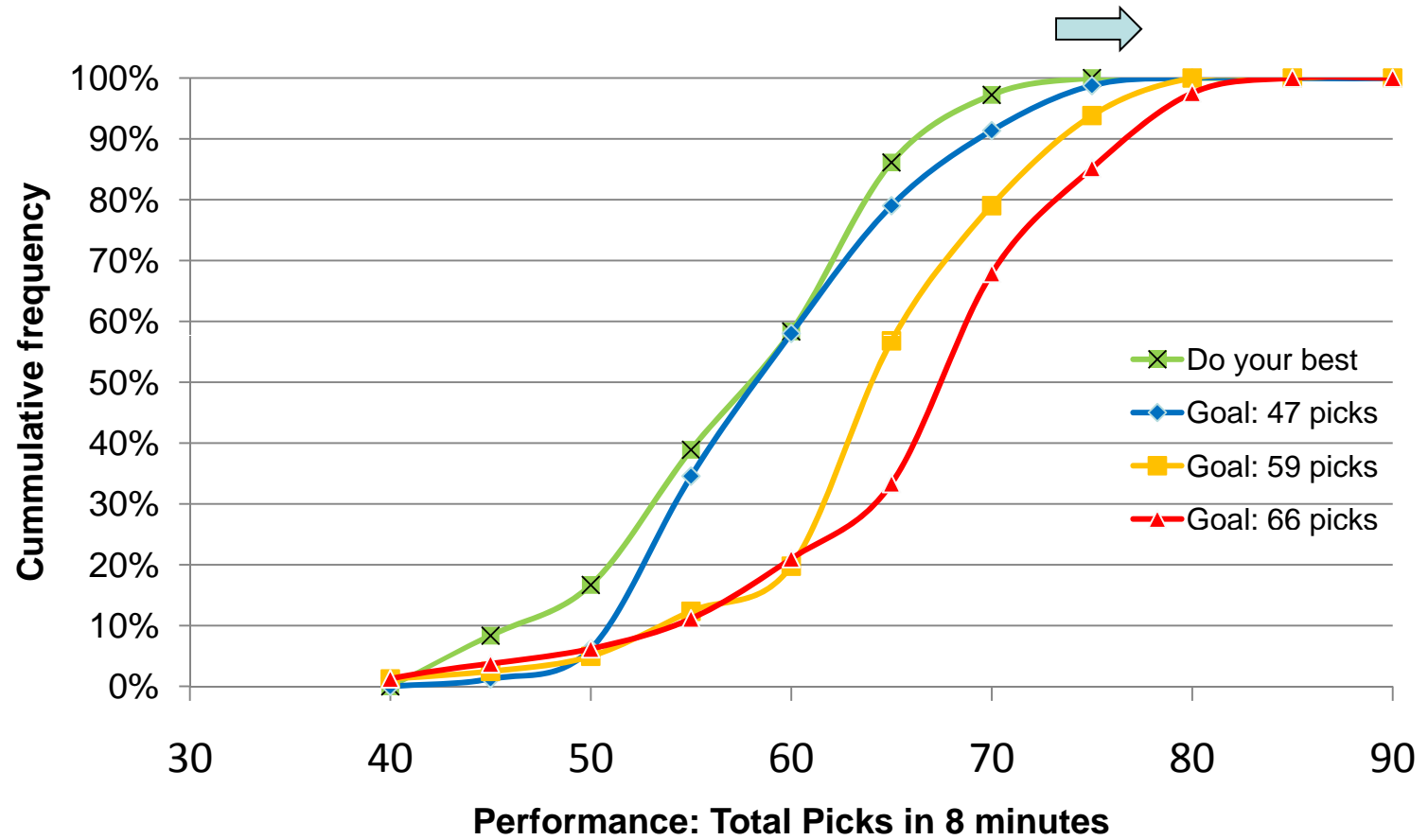
Prospect theory for goals!

In Depth: Skill Level 1

In Depth: Skill Level 2

In Depth: Skill Level 3

In Depth: Skill Level 4