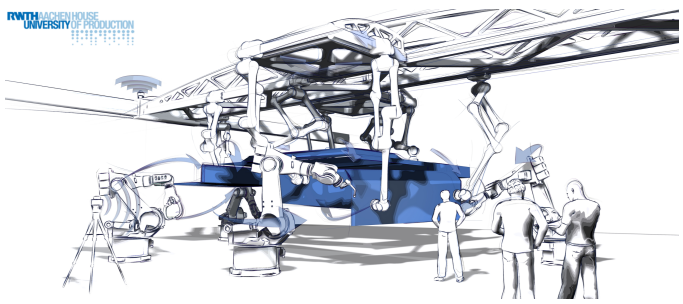

On the visual design of Enterprise Resource Planning Systems –

The role of information complexity, presentation and human factors

16th International Conference on The Human Aspects of Advanced Manufacturing – Tuesday, July 28, 2015

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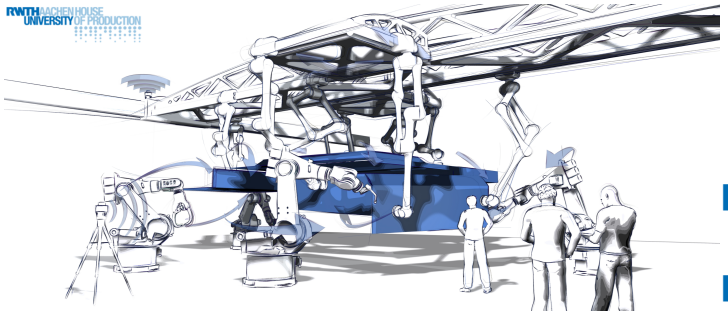
Outline

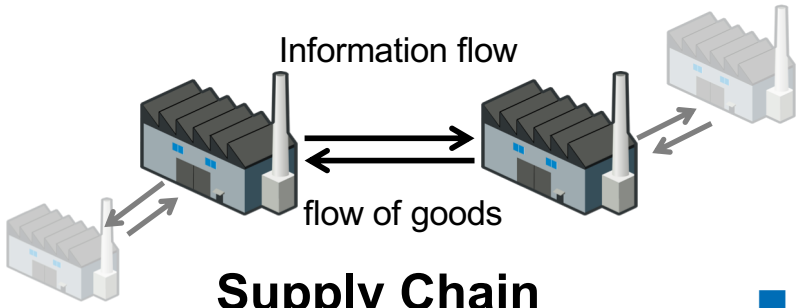
- Motivation and research context
- research agenda
- Experiment 1:
  - Do User Interfaces related to decision performance?
- Experiment 2:
  - Which factors of User Interfaces relate to performance?
- Outlook

Context: Part of the Cluster of Excellence “Integrative Production Technology for High-Wage Countries”

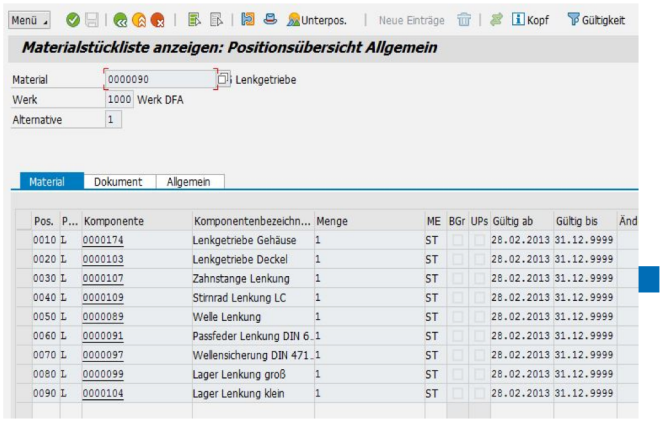


- Goal:
  Strengthen competitiveness of high wage countries
- Engineering of future production systems
  - New materials
  - Improved and smarter machinery
  - Optimization of the shop floor & cross company cooperation
- > 25 Institutes, > 100 researchers
- Funded by German Research Foundation (DFG)

Research goal of the project: Optimize cross-company cooperation



Supply Chain



- Optimize cross-company supply chains (SC) by understanding
  - Technical factors influencing performance of SCs
  - Human factors influencing performance of SCs
  - Influence of Interface Factors on SCs
  - Interrelationship of technical, interface, and human factors
- Why are humans considered?
  - Humans make final decision
  - Overview over not explicitly modelled relationships (e.g., closed-world assumption)
  - Complexity increases, less time for making decisions
- Goal:
  - Understand ***system*** and ***user*** factors that influence ***efficiency, effectivity, and user satisfaction***

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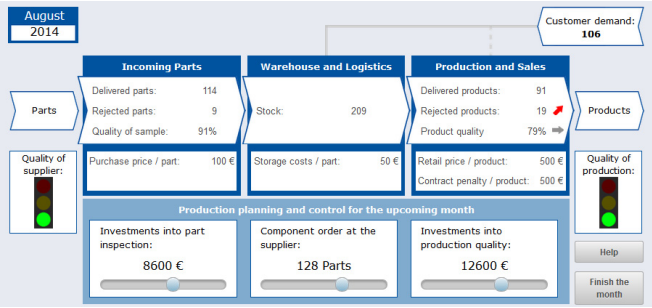
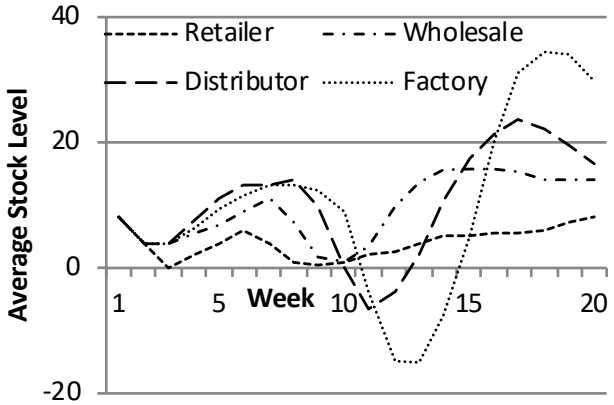
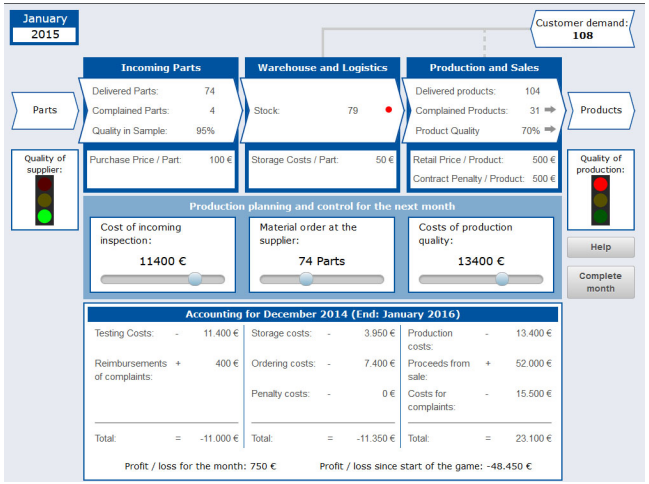
Business Simulation Games

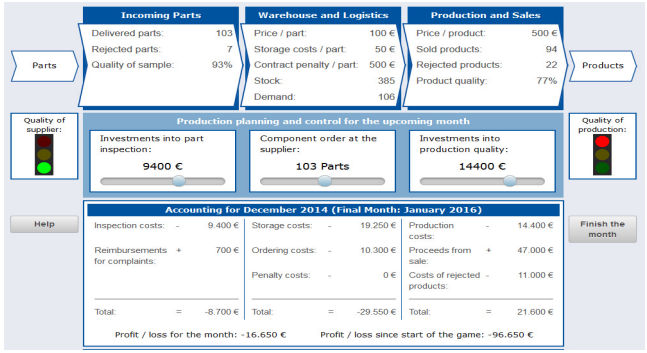




- Interactive Business simulations
  - Forrester's Beer Distribution Game, Goldratt's Game
  - Quality Management Game
- Several studies
  - Relationship between human factors and game performance
- Questions addressed
  - Replication of similar studies? ✓
  - Raises awareness for Quality Management? ✓
  - Do human factors exist that explain performance? ✓
  - Which human factors influence performance?
  - Do interface aspects influence performance?
  - Which interface aspects influence performance?
  - How can users be supported to make better decisions?
- Follow up necessary
  - User factors
  - Interface factors

QM–Game Interface Refinements: Users can be supported?

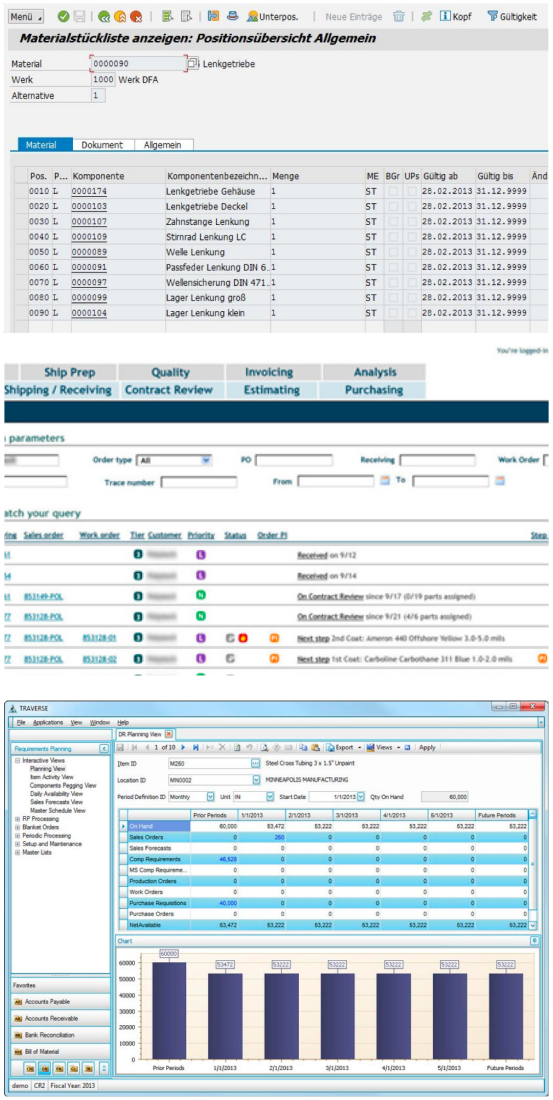




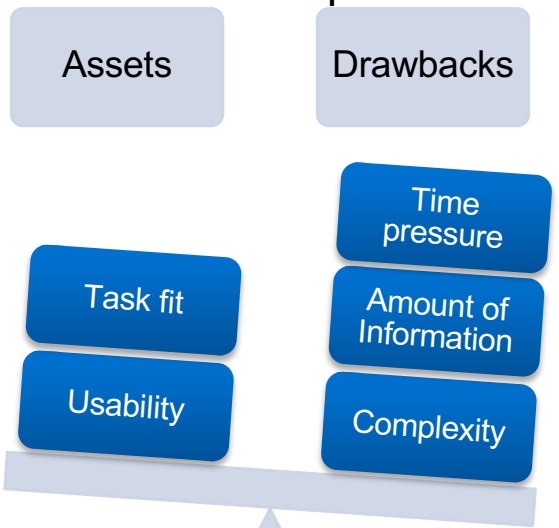
(V = 0.263, F(1, 38) = 13.548, p = .001 < .05*)

- Research question:
  - Do suitable interfaces support players and increase their game performance?
- Interface optimizations based on user feedback
  - Better spatial layout
  - Highlighted Key Performance Indicators (e.g., stock level)
- Method
  - Web-based study (N=40) with user interface as within-subject variable
    (new interface randomly present in 1st or 2nd round)
  - Post-round surveys for user interface evaluation
- Conclusion
  - Users preferred revised user interface
  - New user interface caused significant higher profits and higher product quality
  - Users can be supported to make better decisions
  - But: Weighting of interface factors not understood

Follow up study: Focus on singular decisions



- Focus on single decisions
  Context: material disposition
- Narrow down factors that influence
  decision quality and *decision speed*
- Research Questions
  - Which factors explain performance
  - Quantify costs of the user interface
  - Understand interrelationships between factors



Experimental setup

Lager	Produktion	Woche	Nachfrage
12	3	0	4
15	9	1	22
11	1	9	12
17	8	2	39

Lager	Produktion	Woche	Nachfrage
11	9	0	2
13	6	2	23
18	0	7	9
19	2	9	31
12	1	5	9
11	7	2	19
16	8	0	10
19	1	5	17

- Controlled experiment in Supply Chain context
- Independent variables
  - Task complexity (within subj.)
  - Information Amount (within subj.)
  - Presentation format / Usability (between subj.)
- Explanatory variables:
  - Age, Gender, Experience
- Dependent variables
  - Performance (time in ms)
  - Correctness (correct / no correct)
  - Instruction: Correctness
- Task: D > W*P+L
  Order necessary in ANY for any of the lines? (Y/N)

  (**D**emand greater than weekly **P**roduction by **W**eeks plus current stock **L**evel)

Factor TASK COMPLEXITY

Lager	Produktion	Woche	Nachfrage
15	0	5	9
16	6	0	8
18	3	0	15
17	0	7	11

Low complexity

Lager	Produktion	Woche	Nachfrage
15	1	3	13
12	7	1	14
19	1	9	36
15	3	1	17

Medium complexity

Lager	Produktion	Woche	Nachfrage
18	5	2	22
13	2	3	13
15	2	9	30
13	2	7	24

High complexity

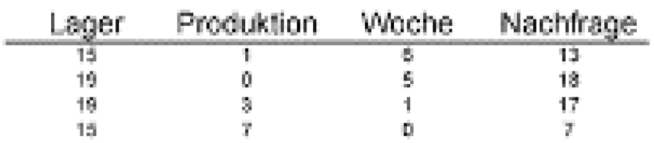
- Decision complexity

  D > W*P+L

  (**D**emand greater than Weekly **P**roduction by **W**eeks plus current stock **L**evel)

- Three levels of task complexity
  - Low (W or P = 0)
  - Medium (W or P = 1)
  - High (W and P > 1)

Factor PRESENTATION (Usability / Display Clutter)



Lager	Produktion	Woche	Nachfrage
15	1	5	13
19	0	5	18
19	3	1	17
15	7	0	7

Lager	Produktion	Woche	Nachfrage
12	3	0	4
15	9	1	22
11	1	9	12
17	8	2	39

- PRESENTATION modelled by different font sizes
  - 6pt
  - 12pt
- One representation of bad usability and display clutter of many many software interfaces

Factor INFORMATION AMOUNT

- Number of lines
  - 4 lines of data
  - 8 lines of data

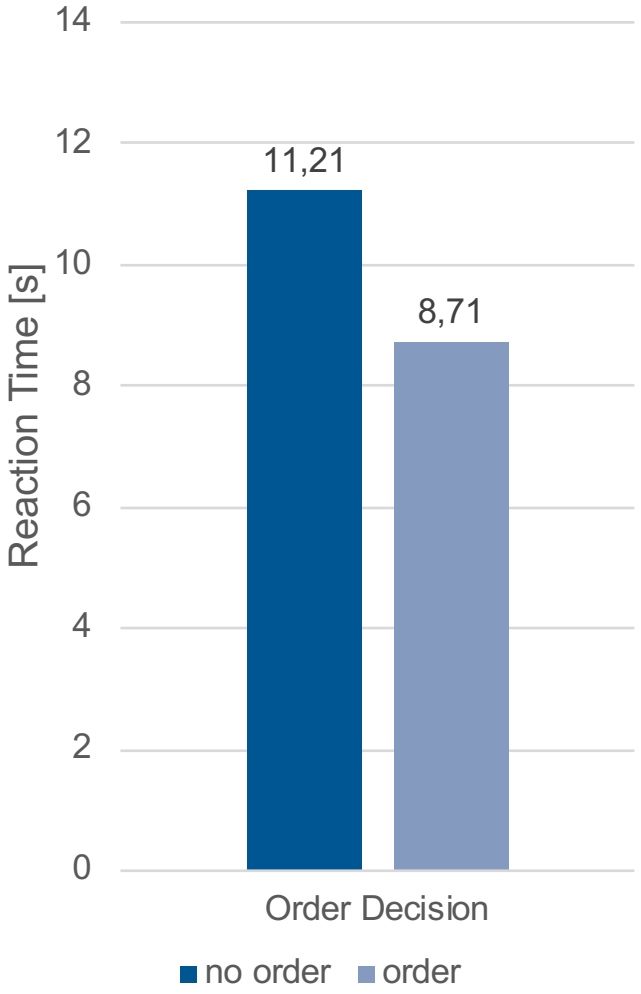
Lager	Produktion	Woche	Nachfrage
12	3	0	4
15	9	1	22
11	1	9	12
17	8	2	39

Lager	Produktion	Woche	Nachfrage
11	9	0	2
13	6	2	23
18	0	7	9
19	2	9	31
12	1	5	9
11	7	2	19
16	8	0	10
19	1	5	17

Results: Overview

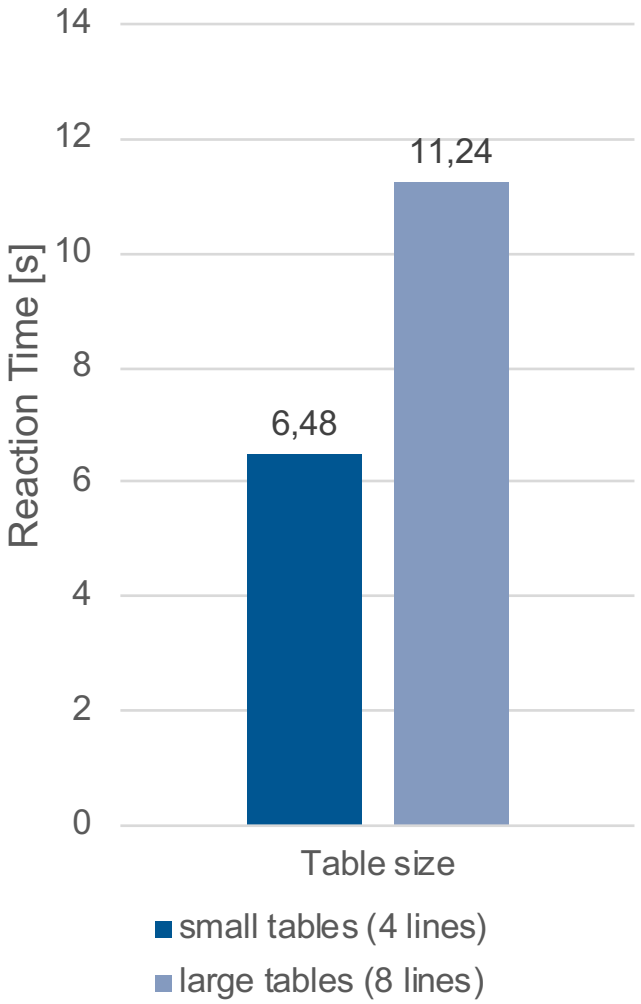
- 20 Participants
  - Young sample, gender balanced
  - One participant excluded (RT > 1.5SD)
  - On avg. 2 x 20minutes
- Reaction times (per table)
  - RT_{Mean}=10.2s (±6.6s)
  - RT_{Median}=8.2s
- Errors
  - 92.9% correct decisions (7.1% errors)
  - No influence of the investigated factors on errors

Results: Factor DECISION



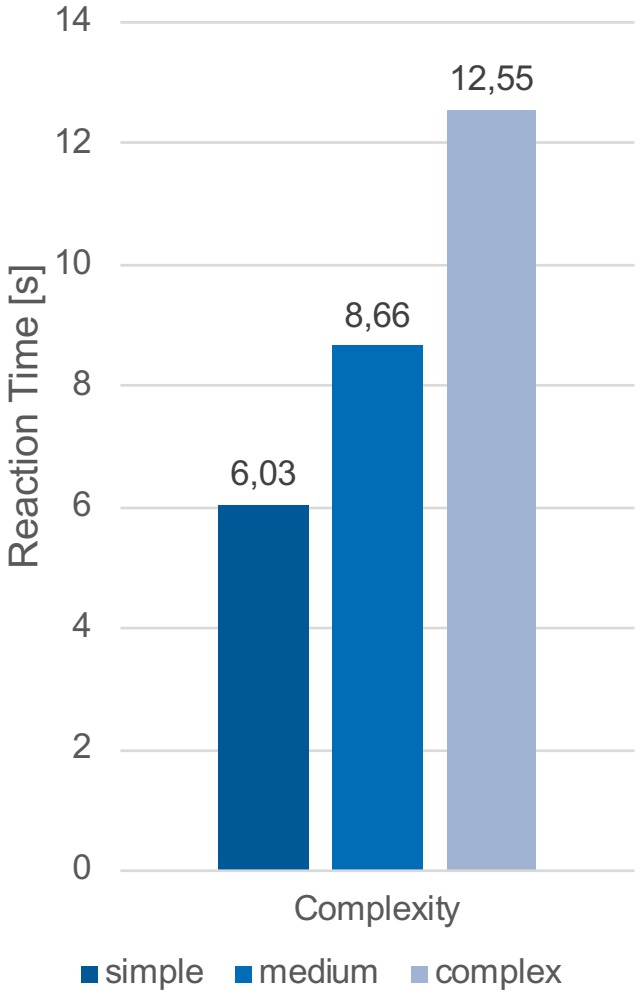
- Sig. Main Effect of factor DECISION
  - $F_{1,28}=4.87$, $p<.05$, $\eta^2=.15$
- Reaction times
  - Order: RT = 8.71s
  - No order: RT = 11.21s (+28.7%)
- ⇒ Searching stopped on buying decision

Results: Factor AMOUNT OF INFORMATION



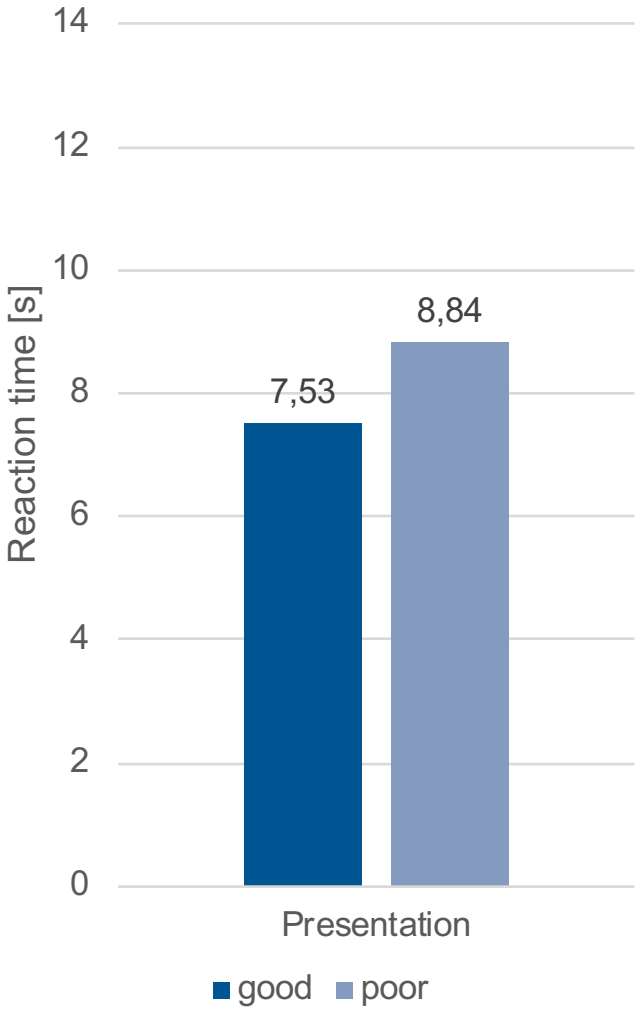
- Sig. main effect of factor AMOUNT OF INFORMATION
  - $F_{1,28}=18.94$, $p<.001$, $\eta^2=.40$
- Reaction times
  - Small tables: RT = 6.48s
  - Large tables: RT = 11.24s (+73.4%)
- ⇒ Scanning longer tables takes longer

Results: Factor TASK COMPLEXITY



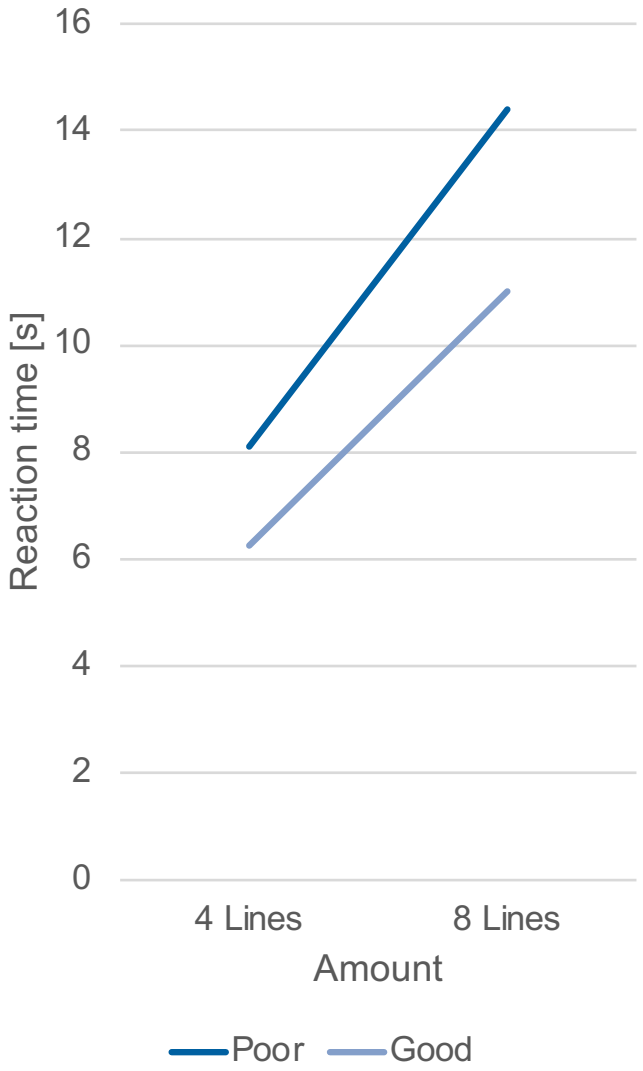
- Sig. Main Effect of factor TASK COMPLEXITY
  - $F_{1.59,44.43}=11.76$, $p<.001$, $\eta^2=.30$
- Reaction times
  - Simple tasks (0x): RT = 6.03s
  - Medium tasks (1x): RT = 8.66s (+43.6%)
  - Difficult tasks (2x): RT = 12.55s (+108.1% / +44.9%)
- ⇒ More complex tasks increase reaction times

Results: Factor PRESENTATION



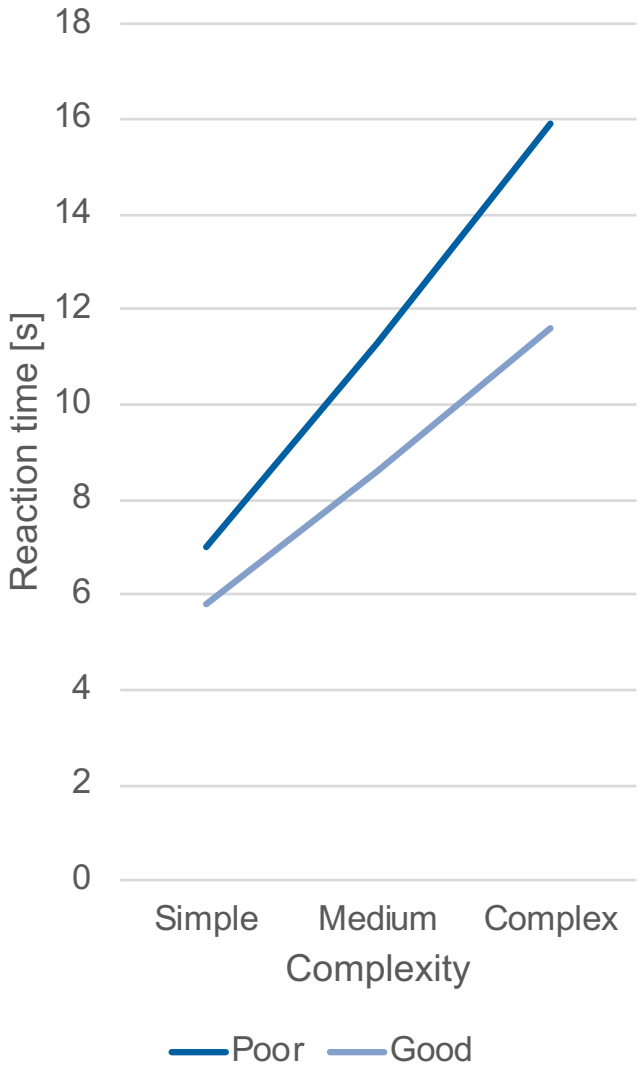
- sig. main effect of factor PRESENTATION
  - $F_{1,28}=9.48$, $p<.05$, $\eta^2=.25$
- Reaction times
  - Good presentation: RT = 7.53s
  - Poor presentation: RT = 8.84s (+17.4%)
- ⇒ Poor usability comes at a cost

Results:
Interaction PRESENTATION x AMOUNT OF INFORMATION



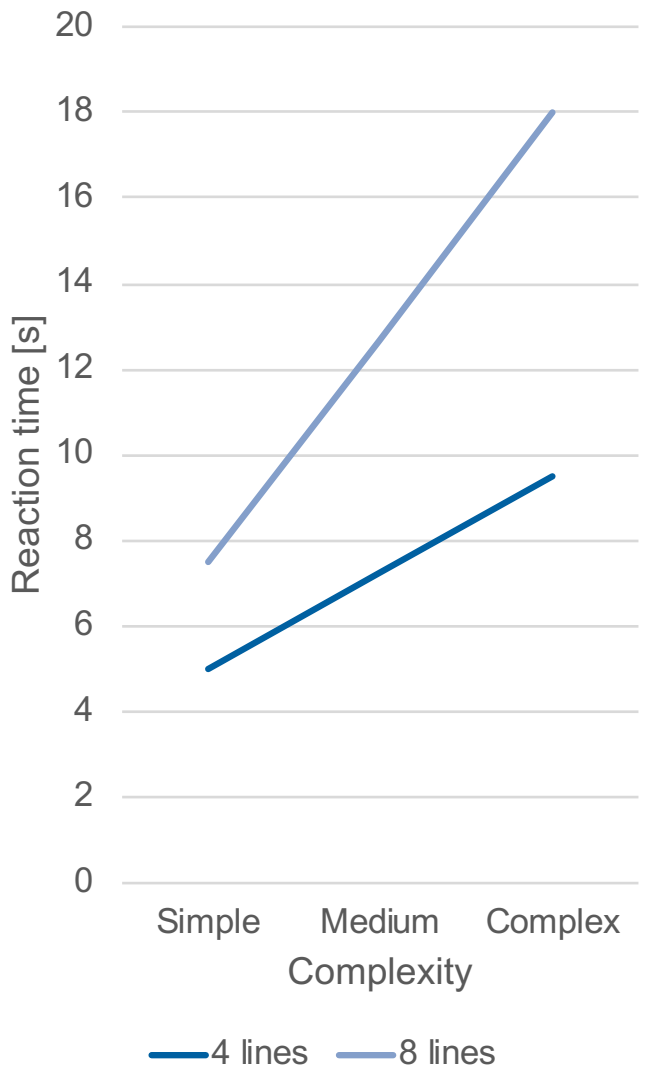
- sig. interaction
  PRESENTATION × AMOUNT OF INFORMATION
- ⇒ Extra costs for poor usability when information increases

Results:
Interaction TASK COMPLEXITY x PRESENTATION



- sig. Interaction
  TASK COMPLEXITY × PRESENTATION
- Impact of information amount on performance
  - Simple complexity (0x): RT +20%
  - Medium complexity (1x): RT +31%
  - Difficult complexity (2x): RT +37%

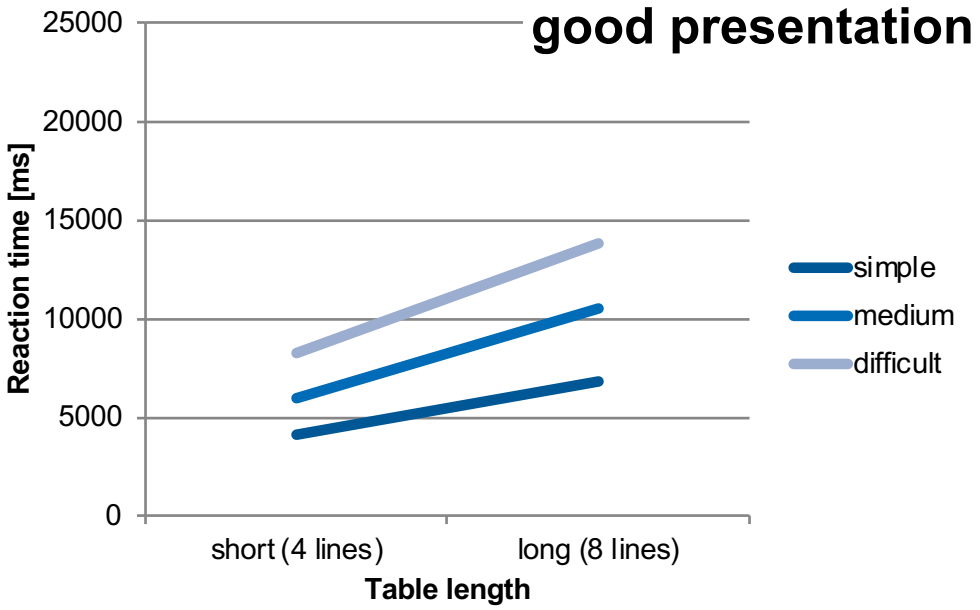
Results:
Interaction TASK COMPLEXITY x AMOUNT OF INFORMATION

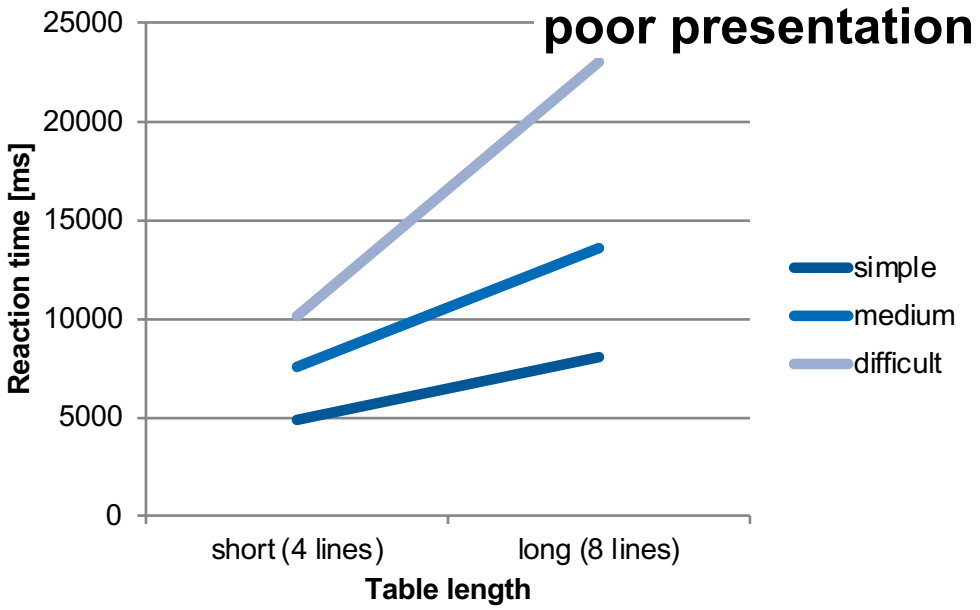


- sig. Interaction TASK COMPLEXITY × AMOUNT
- Impact of information amount on performance
  - Simple complexity (0x): RT +50%
  - Medium complexity (1x): RT +74%
  - Difficult complexity (2x): RT +89%

Results:
3-way Interaction: PRESENTATION x AMOUNT x COMPLEXITY

- Poor usability (e.g., presentation) especially pricy in complex environments

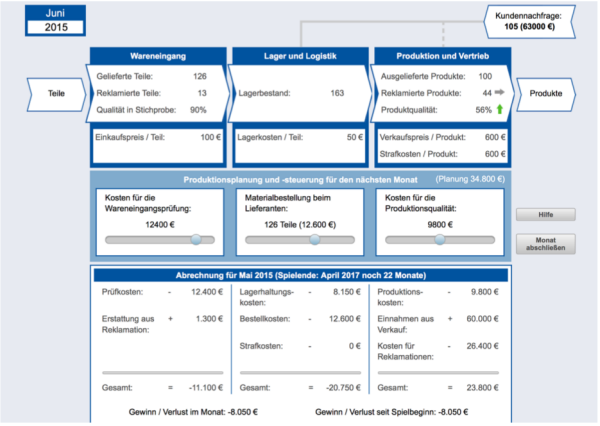




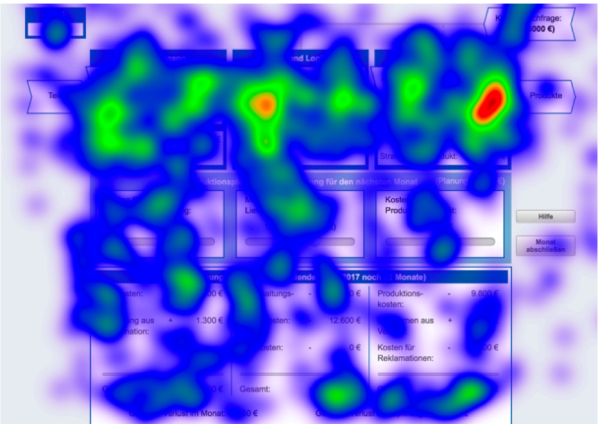
Summary & Outlook

- All considered factors influence performance
  - Higher Complexity ⇒ higher reaction times
  - Poor Presentation ⇒ higher reaction times
  - More information ⇒ higher reaction times
- Presentation × Info. Amount
  Presentation × Complexity
  Presentation × Info. Amount × Complexity
  - Poor presentation especially pricy for complex tasks and much information
- Outlook
  - Larger sample
  - More detailed weighting of the considered factors
  - Young and fit subjects vs. realistic workforce, domain knowledge, time on task, …
  - Long term effects instead of 20 minute experiment
  - Re-validation in complex environments

Summary and Outlook



- Different perspective on information processing in material disposition and supply chain management
- Identification and quantification of interface costs
- Poor usability comes at (hidden) costs



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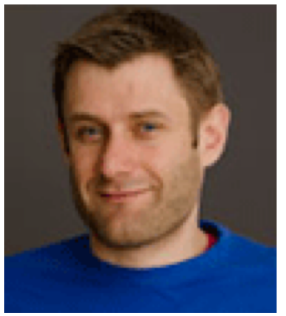


Factor: SECONDARY TASK

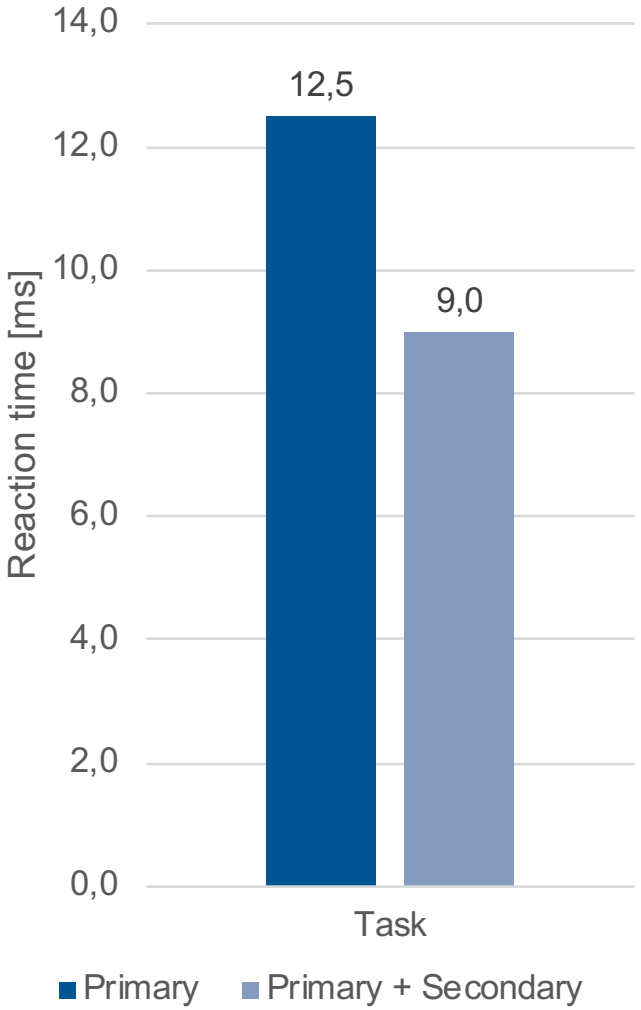
Lager	Produktion	Woche	Nachfrage
11	9	0	2
13	6	2	23
18	0	7	9
19	2	9	31
12	1	5	9
11	7	2	19
16	8	0	10
19	1	5	17

random interval [1-2]s

Lager	Produktion	Woche	Nachfrage
11	9	0	2
13	6	2	23
18	0	7	9
19	2	9	31
12	1	5	9
11	7	2	19
16	8	0	10
19	1	5	17

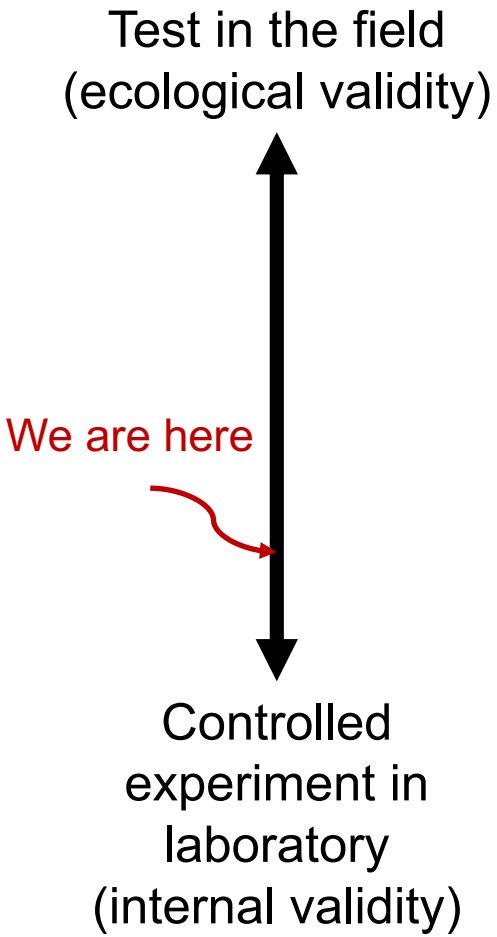
- Primary task managing stock levels
- Secondary task simulates typical interruptions in the job
  - Telephone calls, emails, …
- Participants instructed to press a key as fast as possible if the screen changes (if black box turns red)

Results: Factor SECONDARY TASK



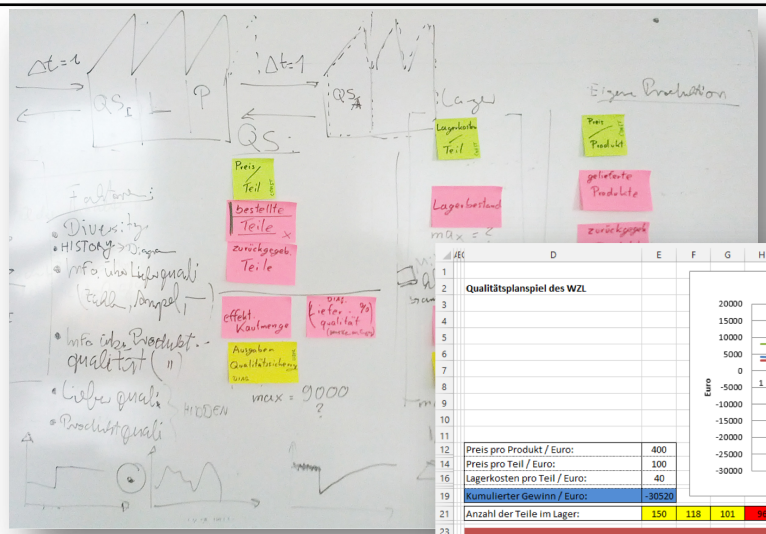
- sig. main effect of factor SECONDARY TASK
- Reaction times
  - Without secondary task: RT = 12.5 s
  - With secondary task: RT = 9.0 s (-28.0%)
- Secondary task not distracting the subjects as designed
- Actually stimulating for higher performance

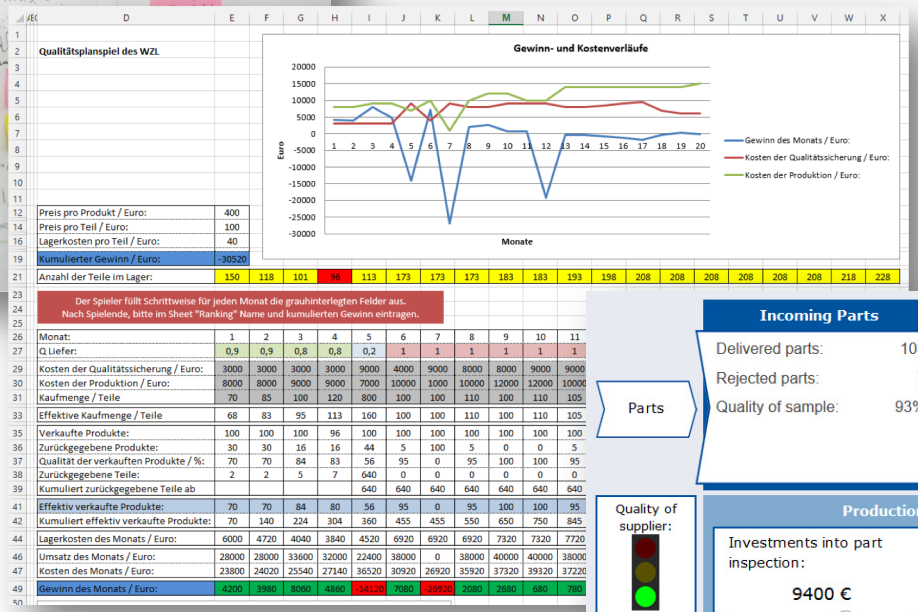
How can human decision making be investigated?

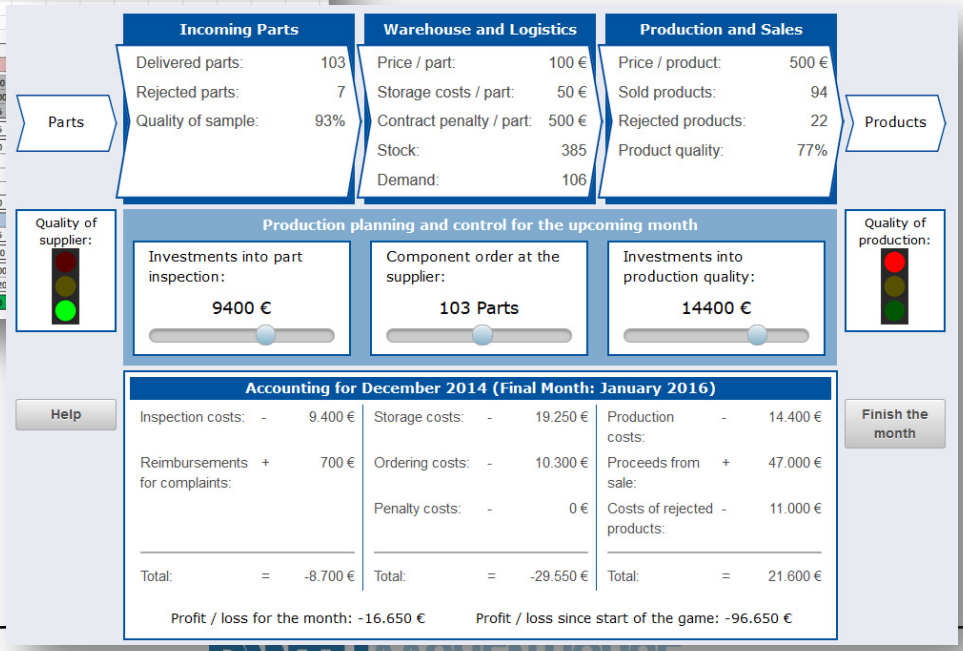


- Convergence between field and laboratory study
- Simplified & controllable (game-based) environment needed to experimentally control aspects that contribute to complexity
- Empirical methodology to quantify human influence on decision making and performance
  - Identify and measure influencing personality factors
  - Build a formal model that explains performance
- Side-effect: Usable for game-based learning (GBL) in professional trainings

User-centred Design Process







1st prototype:

- Paper based
- Layout arrangement

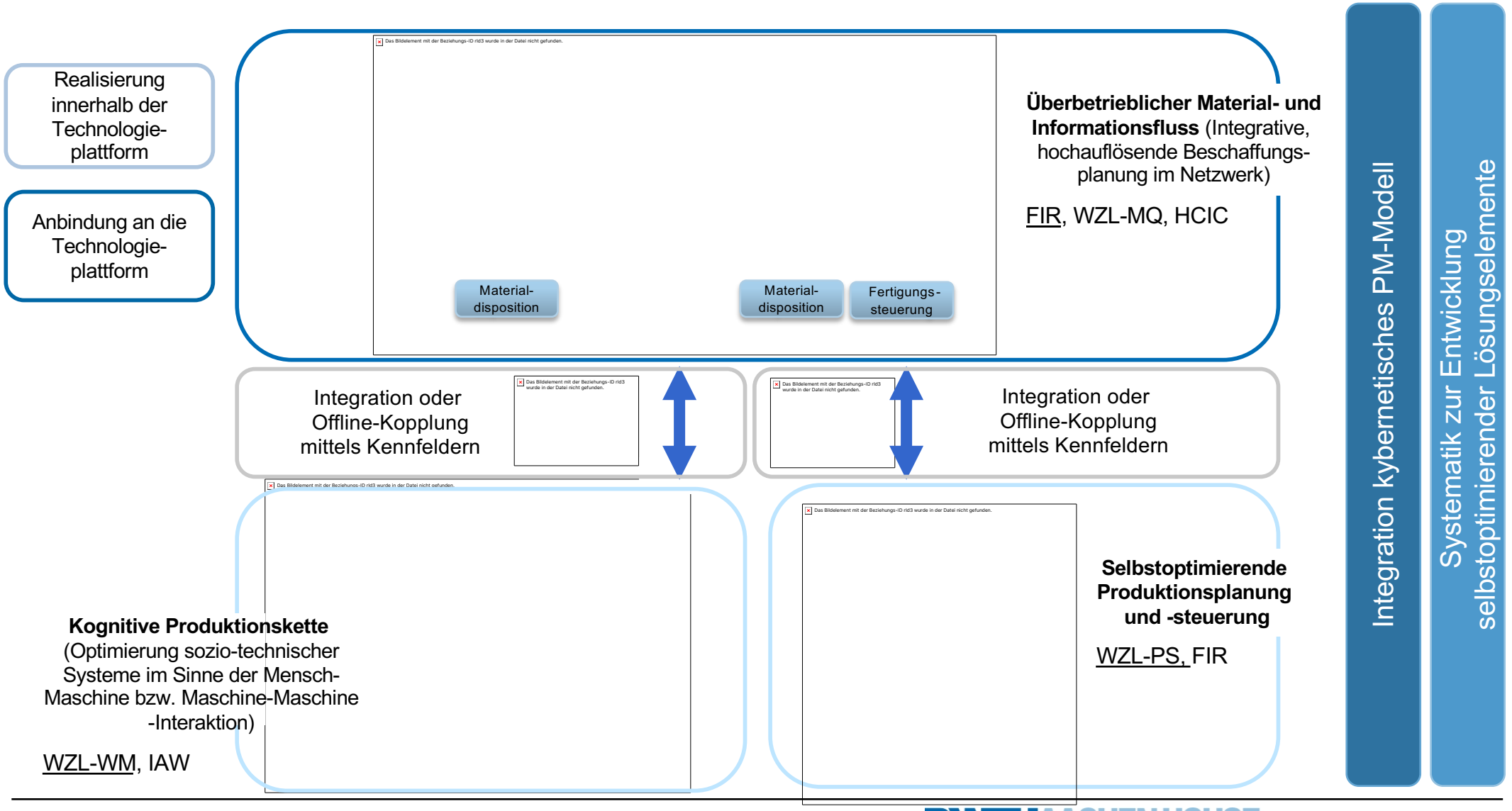
2nd prototype:

- Spreadsheet-based
- Definition of game model, indicators, …

3rd prototype:

- Functional
- Large web-based user study (N>120)
- Laboratory study with experts and amateurs (N = 24)

Context:
ICD D1 – Cognition enhanced, Self-Optimising Production Networks



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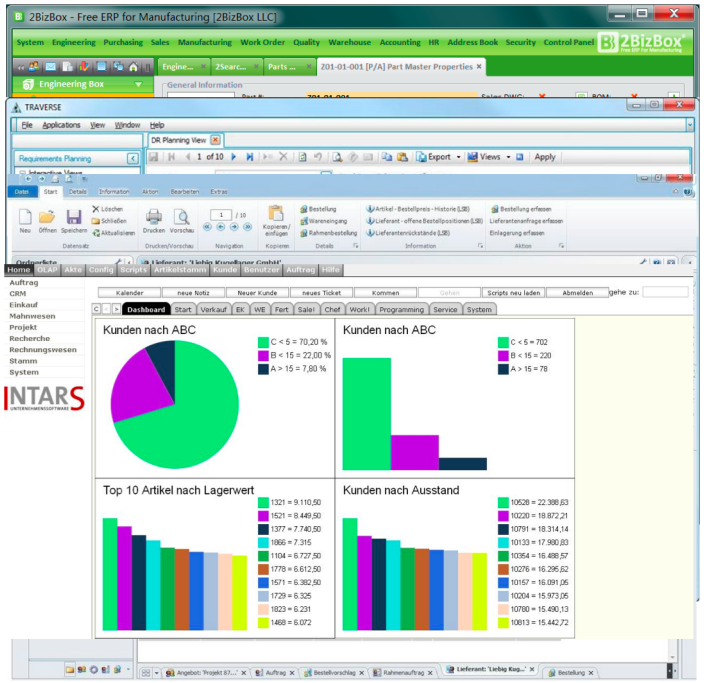
ERP systems



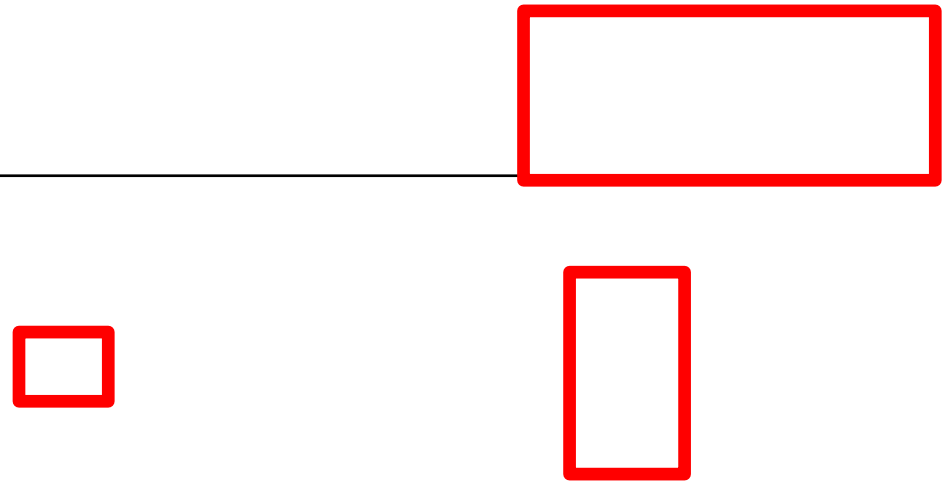
- Enterprise Resource Planning System (ERP)
- Tools for management of
  - Production resources, materials, supplies
  - Capital and personal planning
  - Suppliers and customers
- Essential part of viable companies
  - High complexity, often tailored to companies' need
  - Systems grow with companies
  - Usually high complexity, steep learning curve
- Highly diverse
  - From Excel & Google Docs to SAP, Oracle, …
- How can human decision making be investigated here?
  - Simplified, but controllable environments

Das Bildelement mit der Beziehungs-ID rId2 wurde in der Datei nicht gefunden.

First version

Original interface

Das Bildelement mit der Beziehungs-ID rId2 wurde in der Datei nicht gefunden.



Revised interface